CITIZEN SCIENCE IN A HIGH SCHOOL SCIENCE CLASSROOM

by

Sean David McAndrews

A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2019

©COPYRIGHT

by

Sean David McAndrews

2019

All Rights Reserved

DEDICATION

This work would not have been possible without the patience and support of my wife, Wendy. My Principal/Superintendent and my freshman students at Joliet Public Schools also were instrumental in the completion of this research. My deepest thanks and appreciation to all of them. I would also like to thank John Graves, Diana Paterson, Daniel Lawvers and everyone in the MSSE program who helped make this happen.

TABLE OF CONTENTS

1. INTRODUCTION AND BACKGROUND 1

2. CONCEPTUAL FRAMEWORK 4

3. METHODOLOGY 7

4. DATA AND ANALYSIS 12

5. INTERPRETATION AND CONCLUSION 21

6. VALUE 26

REFERENCES CITED 28

APPENDICES 31

APPENDIX A IRB Approval 32
APPENDIX B Basic Assessment of Research Knowledge 34
APPENDIX C Motivation and Self-Efficacy Surveys 36
APPENDIX D Student Journaling Focus Questions 40
APPENDIX E Sample Teacher/Observer Journal entry 43
APPENDIX F Exit Interview Questions 45

LIST OF TABLES

1. Data Triangulation Matrix 12

LIST OF FIGURES

1. Screenshot of Zooniverse Web Site....2
2. Pre and post-test Scores on the Basic Assessment of Student Knowledge....13
3. Distribution of Scores on the Pre-test and Post-test....14
4. Average Scores For Portion of CLOMMS Focusing On Extrinsic and Intrinsic Motivation For Learning and Doing Science....15
5. Student Responses to Question Asking If They Choose To Learn Science For recognition or Respect From Others....16
6. Student Answers To Question Asking Them How Quickly They Believe They Learn New Concepts Compared to Peers....18
7. Student Answers To Question Asking Them How Confident They Are in Their Ability to Explain Science Concepts....19

ABSTRACT

This study was conducted to determine the impact of adding citizen science projects into a high school science classroom. The primary question of interest was what impact does the inclusion of citizen science projects have on student achievement? I was also interested in evaluating student attitudes about science before and after taking part in citizen science projects, as well as student perceptions of taking part in "real science" activities in class.

Students participated in a pre-treatment test and survey to measure their knowledge and interest in science. They participated in online citizen science projects for three weeks. At the end of the treatment, students completed a post-test and post-survey to measure changes in knowledge, attitudes, and confidence. Observations of student behavior in class during participation in the project were documented. Finally, randomly-chosen students participated in exit interviews about the project.

Student scores on the assessment did show a small increase when compared to pre-treatment values. Measures and observations of student attitudes such as the survey, student journals, and post-treatment interviews did indicate that many students enjoyed participating the project, and that they did perceive that they were assisting with authentic science projects. These results align with previous research studies on the value of incorporating citizen science projects into classrooms.

This project allowed me to incorporate new activities and ways of teaching into my science classroom. I was able to test these new activities and methods and evaluate their effectiveness. This will serve as the basis for similar future projects.

INTRODUCTION AND BACKGROUND

I teach Earth and physical sciences for grades eight through twelve at Joliet Public Schools, located in Joliet Montana. Joliet is a small rural school district in south central Montana about 40 miles from Billings, Montana. There are 367 students total in K-12, and 114 students in grades 9-12. The school district is more than 90% Caucasian, with about 21% of the students qualifying for free or reduced lunches. The student-to-staff ratio in the high school is 10:1 (Montana Office of Public Instruction, 2017). Many of the families in this district earn their living through ranching and mining occupations. The average household income is $48,752 (Montana Hometown Locator, 2018). Most students and their families in our district take school grades and athletics very seriously. However, like all schools, there is a small group of students who struggle with success at school for a variety of reasons.

My project will look at incorporating citizen science into the curriculum as a supplement to, or replacement for, some of the activities currently used. Replacements will be incorporated for pre-made labs, and for questions and worksheets from the textbooks. I want to see if the addition of citizen science activities will increase student interest in science classes, and in pursuing a science-related field after high school.

Citizen science has been around in a variety of forms for many years, yet it has gained renewed interest through advances in technology. Citizen science allows people from all over the world, from every background and socioeconomic status, to assist researchers with projects. It harnesses the power of large numbers of people who have access to computers and the internet to complete tasks. Tasks that people can participate

in could include analyzing large amounts of data, looking for patterns, importing past documents into computer databases, or participating in bird counts.

My interest in citizen science projects began several years ago, while looking for activities to use with a high school astronomy class. I was asked to develop astronomy as an alternative class for students who may not want, nor need, chemistry or physics during their junior and senior year. An article in a National Science Teachers Association magazine provided information and outlined activities and sites that would allow students to participate in citizen science. These citizen science projects are real, ongoing research projects that need help in various ways.

I chose a pre-made set of activities based around a citizen science project called Planet Hunters, which used data collected from the Kepler Space Telescope and other sources to look for potential planets around other stars. My students were first required to visit the host site, called Zooniverse which hosted the project and set up a free account. Figure 1 shows a screenshot of the website.

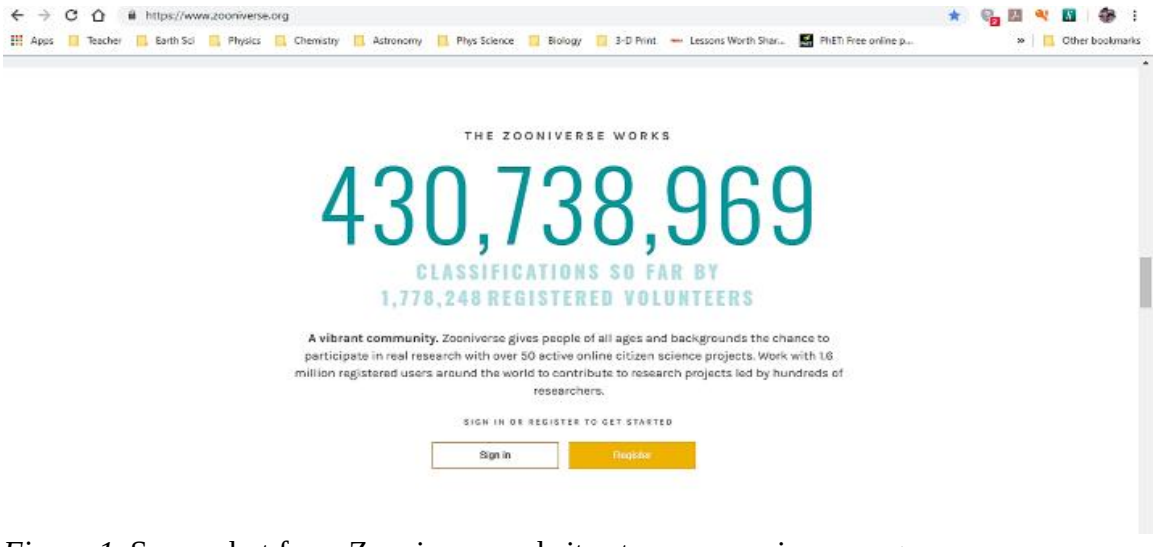


Figure 1. Screenshot from Zooniverse website at www.zooniverse.org.

Zooniverse is a web site where researchers post projects in almost any field. The projects vary in complexity from relatively simple ones where volunteers identify animals in pictures, to more complex ones where people are asked to transcribe full documents from the past or evaluate signals to look for gravitational waves. It has an area to help people build and post their own research project for volunteers to help with. The ongoing research on the site has already been used in a variety of science publications. Another similar site with a large variety of projects available is called SciStarter. While the projects on Zooniverse are all carried out over the internet, SciStarter has a mix of online and in-person projects.

The students in astronomy class indicated that they enjoyed the activity. In fact, several of the students, on their own and with their leisure time, got involved in other projects on Zooniverse. It was enjoyable to see students excited to learn and engage in real-life science. Since that time, I have used several projects from the Zooniverse site with classes, however I had not formally incorporated citizen science into my curriculum. I found citizen science projects to be useful and meaningful, but I had not made a serious effort to evaluate the impact of citizen science activities on students' learning.

The initial experiences with citizen science led to the development of my focus statement: What impact does the inclusion of citizen science projects have on students' achievement in class, and on their interest in science? I want to evaluate student attitudes about science, to see if incorporating real science activities would change their interest levels, so that they might seek out science socially or vocationally after taking part in citizen science projects. I am also interested in evaluating student perceptions about how

capable they feel they are at science before and after the project, and whether they have more interest in taking part in “real science” activities afterwards.

CONCEPTUAL FRAMEWORK

Citizen science is a collaboration between professional scientists and non-professionals in scientific investigations. Citizen science has been around in one form or another, for as long as people have been curious about themselves and the world around them. In fact, people all over the world have been gathering data for a variety of reasons for centuries. As fields of science became more rigorous and professionalized from the 1700s onwards, and especially from the 1800s until today, the input of non-scientists was reduced or ignored for many years (Miller-Rushing, Primack, & Bonney, 2012). Comparatively, recent developments in computers and other forms of technology, combined with an increased interest in science, technology, engineering, and math (STEM) fields has led to an explosion of both citizen scientists and citizen science projects (Miller-Rushing 2017). A renewed interest in citizen science began ten to fifteen years ago. It started as a discussion, which defined citizen science, identifying why it would be utilized, and how it could be implemented.

Citizen science projects have been developed all over the world and in local communities. Projects tied to the local community can engage students in meaningful research, which can provide benefits for the students and the community (Council & Horvath, 2016). An example of a citizen science project incorporated into schools, is a cell biology project used in secondary schools in Spain and Portugal. Biology students, who were between the ages of 15 and 18, looked at cells which had been treated with a

variety of experimental cancer drugs. The goal of the project was to look for evidence of the effectiveness of the drugs. The students could apply topics and material from their class to the Cell Spotting Project, thus allowing the students to see a connection between what they were learning in their class and a real-world research project (Silva, Montero, Manahl, Lostal, Holocher-Ertl, Andrade, & Brito, 2015).

Another citizen science project was carried out in Spain from 2012 through 2015. Researchers in neuroscience worked with secondary students to develop and carry out a long-term research project. The project looked at the relationship between the colors that classrooms were painted and student learning. The results showed a boost in student knowledge, self-confidence in carrying out scientific research, and motivation to go into a scientific career (Ruiz-Mallen, Riboli-Sasco, Ribrault, Heras, Laguna, & Perie, 2016).

A citizen science project implemented at the University of Western Australia in Perth, Australia involved first-year university students in a biology class conducting research, writing articles, peer-reviewing each other's work, and then publishing in an online student journal. Students in this project showed increased engagement in environmental issues, and a greater understanding of the process of conducting a scientific study and then producing a product for publication (Mitchell, Triska, Liberatore, Ashcroft, Weatherill, & Longnecker, 2017). Additional ecology-related citizen science projects in Japan, the United States, and the United Kingdom have all shown benefits for both researchers and the volunteers who have helped with the projects (Kobori, Dickinson, Washitani, Sakurai, Amano, Komatsu, & Miller-Rushing, 2016). One benefit for the researchers included access to large pools of volunteers to assist with

their research. Volunteers benefited by being able to assist with, and develop a greater understanding of, scientific research.

A fact sheet released by the White House and the Office of Science and Technology Policy in 2015 indicated that citizen science projects could help provide students in the U.S. with skills and knowledge needed to excel in STEM fields (The White House-Office of Science and Technology Policy, 2015). The fact sheet went on to highlight a wide variety of projects that could be undertaken by interested individuals. It also included a list of relevant web sites.

Citizen science projects can allow participants to learn more about authentic scientific inquiry, as well as helping the participants develop a better understanding of the topic of the project (Meyer, Scott, Strauss, Nippolt, Oberhauser &, Blair, 2014). Citizen science projects in classrooms can allow students to communicate and collaborate with other students, who are engaged in the same project from other parts of our world. This helps build a global awareness, as well as an increase in understanding of the project topic (Nugent, Smith, Cook & Bell, 2015). Citizen science projects can even allow students to conduct research on controversial topics, such as evolution or climate change. Students can analyze data on these topics and develop a greater understanding of them, all the while helping with a real scientific project (Yoho & Vanmali, 2016).

Incorporating citizen science projects into classrooms can help students develop critical-thinking skills and confidence in conducting scientific research and analyzing data. More benefits include a greater understanding of scientific topics, and a stronger connection to the community, when local citizen science projects are undertaken. An

advancement of scientific research, as well as an increase in the number of students considering STEM fields for careers could also result (Shah & Martinez, 2016).

Tools to measure the benefits of students participating in citizen science projects are necessary. The tools which could help teachers and researchers measure the impacts of these programs on participants are described as limited (Hiller & Kitsantas, 2016). Feedback on the benefits of many projects comes from student interviews or surveys. One group of researchers set out to develop a tool called the Citizen Science Self-Efficacy Scale to evaluate the benefits students receive from participating in citizen science projects. They also wished to provide a guide for other researchers who want to develop a similar scale to evaluate their own projects (Hiller & Kitsantas, 2016). Other topics recommended for future research related to citizen science projects include, determining how and why people participate in citizen science projects, and the benefits they obtain from their participation (Kobori, et. al, 2016).

Citizen science has been described as having the potential to drive transformative learning experiences (Ruiz-Mallen, et.al, 2016). Presently, there is a lack of studies focusing on the possible benefits of the incorporation of citizen science project in American High Schools in fields other than biology and ecology.

METHODOLOGY

Methods

The purpose of my study was to determine the effects that inclusion of citizen science projects would have on student achievement in class. I was also interested in evaluating how students' attitudes about science changed, and how their perceptions

regarding their participation in authentic science activities in school changed after participating in this project.

Twenty-nine high school students participated in this study. All the students were freshmen, except one sophomore who was retaking Earth science, and one senior who had not previously taken the class. Two students moved during parts of the study, leaving a final sample size of 27. The students were in two sections of Earth science. Both sections were taught using the standard curriculum and activities for the first 15 weeks of the school year. Near the end of the second quarter, both groups participated in a pre-test and a pre-treatment survey. The treatment period began at the start of third quarter in one section, while the other section continued with normal curriculum and activities. In the treatment group, the Earth science curriculum was supplemented with lessons on scientific research and examples of authentic research carried out in various settings. The students' regular quarter projects were replaced with a three-week project where they participated in online citizen science projects that they chose from two approved sites. During that period, they were asked to journal about their activities and to reflect on the projects in which they participated.

Observations, which included the student's time on task and student behaviors, were made by me on the days when they were given class time to participate in the citizen science projects. On these days we went to a computer lab, and all the students were asked to engage in citizen science activity for the full period. I made notes about which students were on task at ten-minute intervals for one minute. I also occasionally walked around amongst them to interact with them and see what they were working on.

At the end of the three weeks, the students in the treatment group were asked to come up with an idea for a potential project that they would be interested in developing and carrying out. Students in the treatment group also participated in a post-test, and a post-treatment survey. Finally, five of the students were chosen randomly to participate in follow-up interviews about the project. After the initial treatment period, the other section received the identical treatment process, while the first section returned to normal curriculum and activities. The research methodology and data collection instruments used in this study received an exemption by Montana State University Institutional Review Board, and all relevant and appropriate rules for working with human subjects were followed (Appendix A).

Data Collection Instruments

The Basic Assessment of Research Knowledge was given to students in both groups as a pre and post-test (Appendix B). The Basic Assessment of Research Knowledge was an assessment consisting of ten questions. Five of the questions required a short answer, while the other five consisted of true and false questions, plus an explanation. These questions were designed to measure students' understanding of basic research principles and their understanding of citizen science and its purposes. The Basic Assessment of Research Knowledge values were analyzed using mean and median scores, and they were also evaluated for normalized gains. Based on the work of Richard Hake, normalized gain shows the amount a student improved compared to the amount they could have improved from a pre-test to a post-test. Values below 0.3 are considered

low, while values from 0.3 to 0.7 are medium. The highest gains are equated with values above 0.7 (Hake, 1998).

Students also completed The Cornell Lab of Ornithology Motivation and Self-Efficacy Surveys before and after the project (Appendix C). The first part of the survey consisted of sixteen questions assessing motivation for learning and engaging in science. The second part of the survey contained eight additional questions measuring self-efficacy for learning and engaging in citizen science. These surveys were created by The Cornell Lab of Ornithology for use in their citizen science projects. They have primarily been used on adult subjects up to this point but are suitable for use with students also. There were questions within each set that focused on intrinsic versus extrinsic motivations for participating in science, as well as questions examining respondents' level of self confidence in their ability to learn and understand scientific information.

Answers on these surveys range from strongly disagree, which is scored as a 1, to strongly agree, which would normally be assigned a value of 5. The original surveys contained a neutral choice, with an assigned value of 3. The neutral option was removed in this version of the survey, and the numbers for agree and strongly agree were shifted down one. The survey was modified to encourage the students to either agree or disagree for a question rather than just having the option to select neutral. This modified version of the survey is in appendix C.

The results of the Cornell Lab of Ornithology Motivation and Self-Efficacy Surveys were grouped and averaged, and the scores for each group were compared. The

resulting means were further analyzed with a Wilcoxon Signed Rank Test to see if there were significant differences in pre-and post-treatment attitudes.

As the students worked on their chosen citizen science projects, they were also asked to record their time spent working on their project, and the things they liked and disliked about the project. In addition to their own writing, they were given questions each week to answer, and then a final set of questions at the end of the three weeks. The Student Focus Questions they were asked to respond to related to their understanding of what citizen science is, and what projects they chose to focus on (Appendix D). Their journal entries were used to gather qualitative data on their attitudes and their perceptions on what they were learning.

On the days when the students were given class time to work on citizen science projects, observations were made by myself at ten-minute intervals for one minute. I recorded which students were on task, what they were working on, and how engaged they were during that time (Appendix E). This data served as another source of qualitative data to supplement the information students supplied regarding their time spent on the project.

The final source of data for the study consisted of interviews with five of the students from each section chosen at random. The data from these Exit Interview Questions was used to get student feedback on the citizen science projects and what gains they experienced from their participation. One of my focus statements related to any changes in their attitudes that occurred because of their participation in the project. The questions asked during the interview related to that goal, and they served as another

supplementary source of qualitative data (Appendix F). All data collection instruments and their associated focus statements are summarized in the data matrix below (Table 1).

Table 1
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Primary Question: How will participating in citizen science impact students' achievement and attitudes in science class?	Student pre-test and post-test	The Cornell Lab of Ornithology Motivation and Self-Efficacy Surveys	Student responses to questions
Secondary Question: How will participating in this project affect students' perceptions that they participate in authentic science at school?	Student responses to questions	The Cornell Lab of Ornithology Motivation and Self-Efficacy Pre-treatment Surveys	Student Follow up Interviews
Secondary Question: Will participating in citizen science projects impact student confidence in their ability to carry out scientific research?	The Cornell Lab of Ornithology Motivation and Self-Efficacy Pre-treatment Surveys	Teacher Observation Journal	The Cornell Lab of Ornithology Motivation and Self-Efficacy Post-Treatment Surveys

DATA AND ANALYSIS

Student scores on the Basic Assessment of Student Knowledge (BASK) increased from a pre-test average of 63.1% to a post-test average of 76.2% (N=26). This reflects a normalized gain of 0.29. In addition, the number of students receiving a score of 100% increased from two on the pre-test, to eight on the post-test. The median value on the

pre-test was a 70%. The median value on the post-test was a 90%. The pre-test and post test scores for the students are shown in Figure 2.

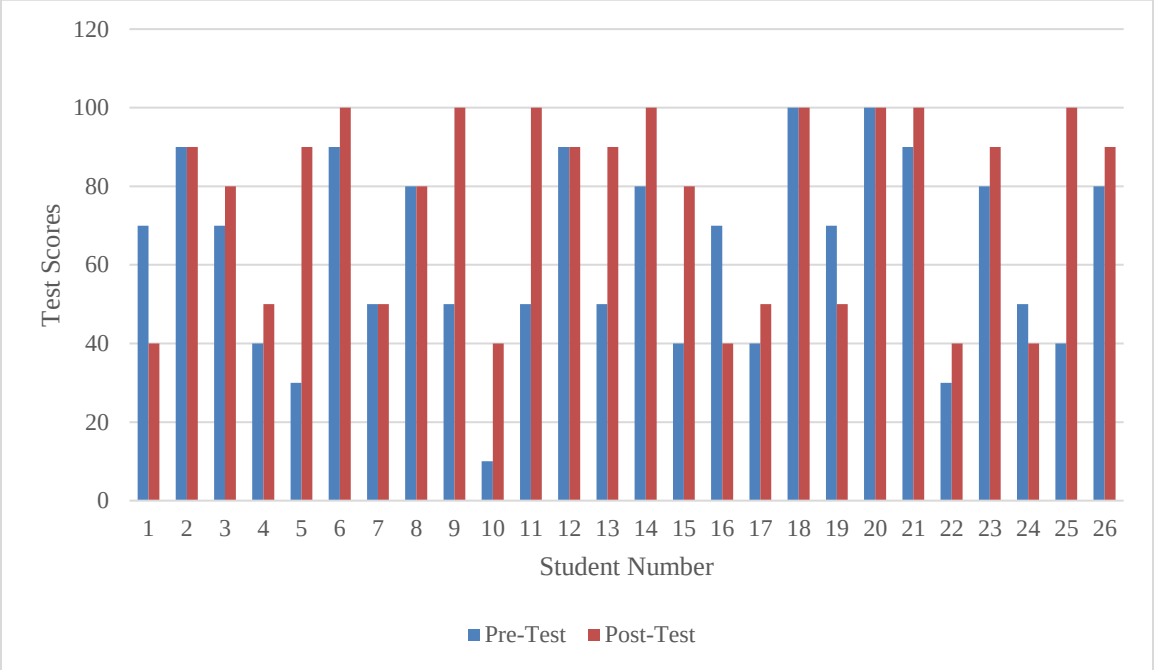


Figure 2. Pre and post-test scores on the Basic Assessment of Student Knowledge, (*N* = 26).

Sixty-one percent of the students increased their scores on the post-test compared to their values on the pre-test after completing the treatment period. The overall distribution of scores for the pre-test and post-test, along with their averages are shown in Figure 3.

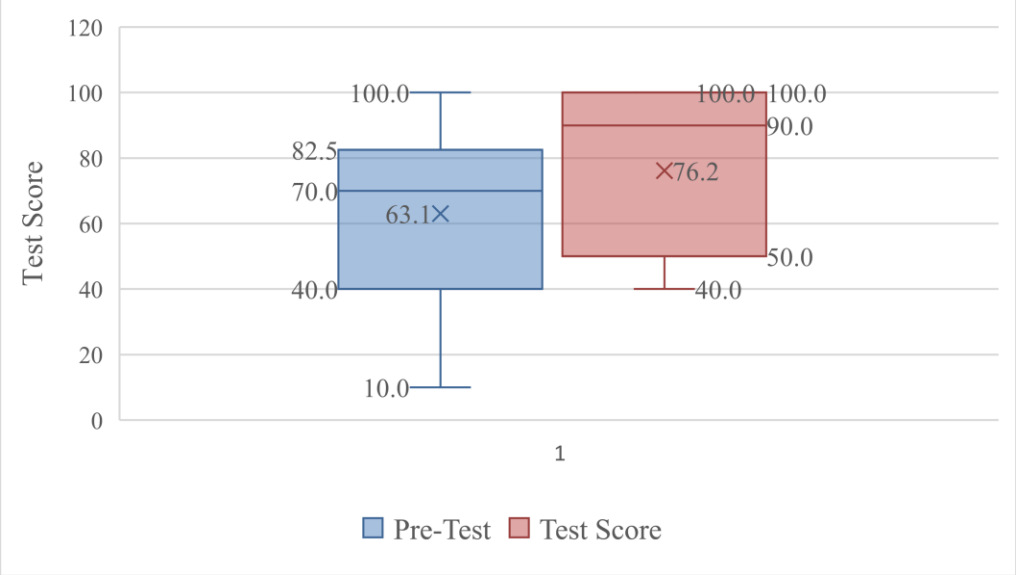


Figure 3. Distribution of scores on the pre-test and post-test, (*N*=26).

All 27 students in both treatment groups completed the Cornell Lab of Ornithology Motivation and Self-efficacy Survey (CLOMSS) prior to the treatment period and at the completion of the study. The survey consisted of two unequal parts. The first part of the survey had sixteen questions, while the second part had only eight. The two parts of the survey were analyzed separately. Questions related to intrinsic and extrinsic motivational factors from the first section were averaged and compared to each other. The questions related to self-efficacy, in the second section, were evaluated individually, then as a whole, using the methods suggested by the developers of the survey, the Cornell Lab of Ornithology. Finally, the surveys were evaluated in sections using the Wilcoxson Signed-Rank Test for significance. None of the parts, separately or as a whole survey, yielded a significant difference at a 0.05 level.

The first portion of the survey related to student motivation for learning and doing science. Half of the questions focused on intrinsic factors, while the other half focused on extrinsic motivators. Analysis of the pre-treatment survey data showed that all

students, except one, were extrinsically motivated to learn about and participate in science. Analysis of the post-treatment survey data shows a small, but not significant change towards intrinsic motivation, summarized in Figure 4. Negative scores indicate predominately extrinsic motivational factors, while positive score match intrinsic sources of motivation.

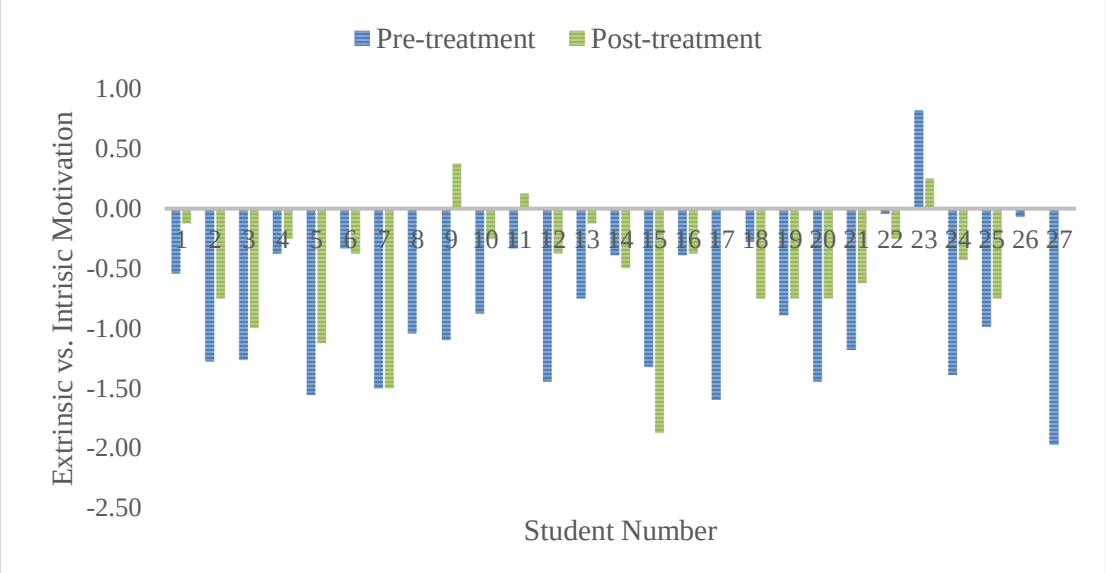


Figure 4. Average scores for portion of CLOMMS focusing on extrinsic and intrinsic motivation for learning and doing science, (*N*=27).

One of the questions, emphasizing intrinsic sources of motivation for the students, asked students if they chose to learn and understand science topics because understanding science would help them achieve things that were important to them. On both the pre-treatment survey and the post treatment survey 85% of students agreed or strongly agreed.

Of the questions in part one of the CLOMMS, a question asking if the student engaged in science activities because they are required to, showed the smallest number of students who changed their answers from the pre-survey to the post-survey. On the pre-

treatment survey 85% of the students either agreed or strongly agreed. Participating in the treatment did not change answers. This further emphasizes that most students participating in this project were extrinsically motivated.

The largest change in average scores for this part of the survey came from a question asking the students if they chose to learn and understand science topics because of the respect they will get from others. The average value on the pre-treatment survey was a 2.63. Fifty-six percent of the students agreed or strongly agreed with this statement. On the post-treatment survey, eight students agreed, but none strongly agreed. This produced an average of 2.19. The values and numbers of students answering are shown in Figure 5.

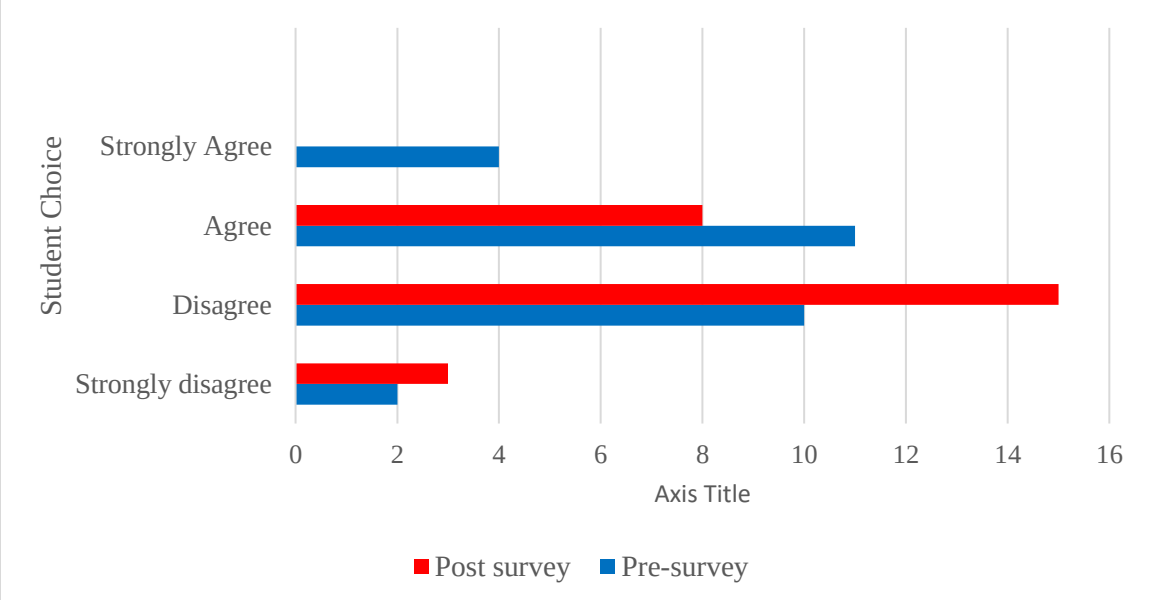


Figure 5. Student responses to question asking if they choose to learn science for recognition or respect from others, (*N*=27).

The second largest change in the average score for this part of the survey was on a question asking if students chose to learn about and understand science because it was fun. The average score on the pre-treatment survey was 3.15. On the post-treatment

survey, the average changed to 2.89. Nineteen students agreed with this statement on the pre-treatment survey and an additional six strongly agreed. On the post-treatment survey, sixteen students agreed and four strongly agreed. In fact, one student stated, "I enjoy working on citizen science projects because it makes me feel like I am contributing to science." In the post-treatment follow-up interviews, one student stated that the projects he/she chose to participate in were "fun and informational." However, another student disagreed and stated, "many of the projects were hard to figure out, which did not exactly help the enjoyment factor."

The second section of the study consisted of eight questions that evaluated student's self-efficacy for both science and citizen science. Four questions focused on learning and understanding general science content, while the other four asked specifically about citizen science content and activities. Two of these eight questions showed comparatively large changes in averages from the pre-treatment to the post-treatment surveys. The questions focused on how students felt about their ability to learn, understand, and explain science content.

The first question asked whether students felt they could understand science concepts more quickly than other students their age. Seventy percent of the students strongly agreed or agreed with this statement on the pre-treatment survey. That number declined to 56% on the post-treatment survey, with two students strongly disagreeing. One student who agreed with this statement commented in the follow-up interviews that participating in the project "makes me feel like I can do more than I originally thought."

Student answers for this question on the pre-survey and post-survey are shown in Figure 6.

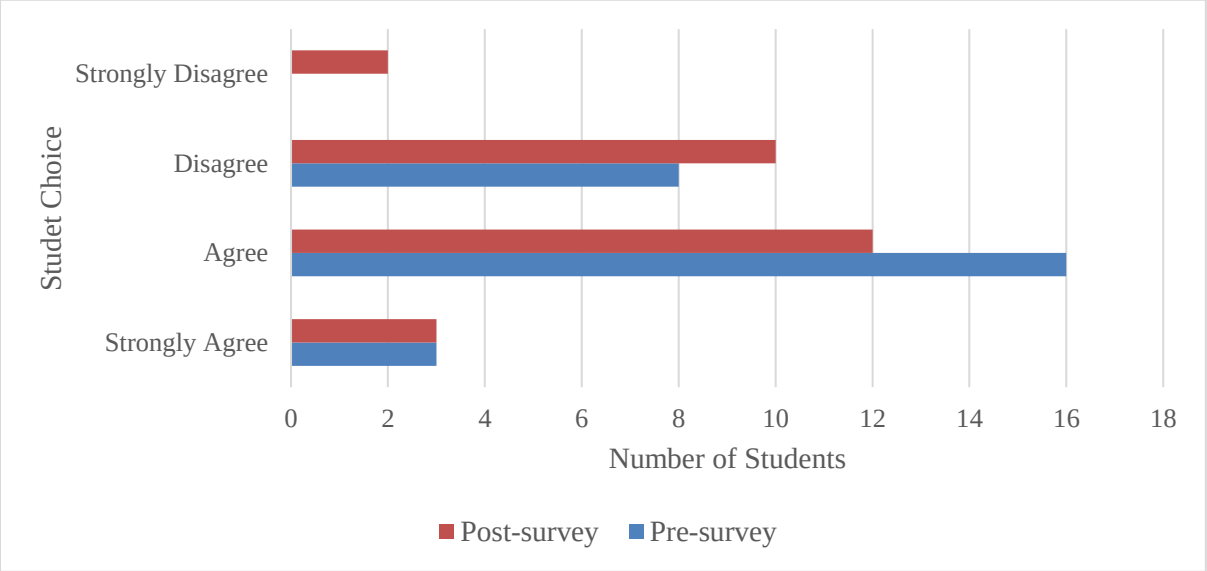


Figure 6. Student answers to question asking them how quickly they believe they learn new concepts compared to peers, (*N*= 27).

Another question showing a large difference between pre-survey and post-survey averages asked students how confident they were at explaining science concepts to others. In the pre-survey, 41% of students agreed or strongly agreed that they were confident of their ability to explain the science concepts to others, while 59% disagreed or strongly disagreed. For the post-survey those numbers were reversed, with 59% in the strongly agree or agree categories, and 41% in the disagree and strongly disagree categories, as shown below in Figure 7.

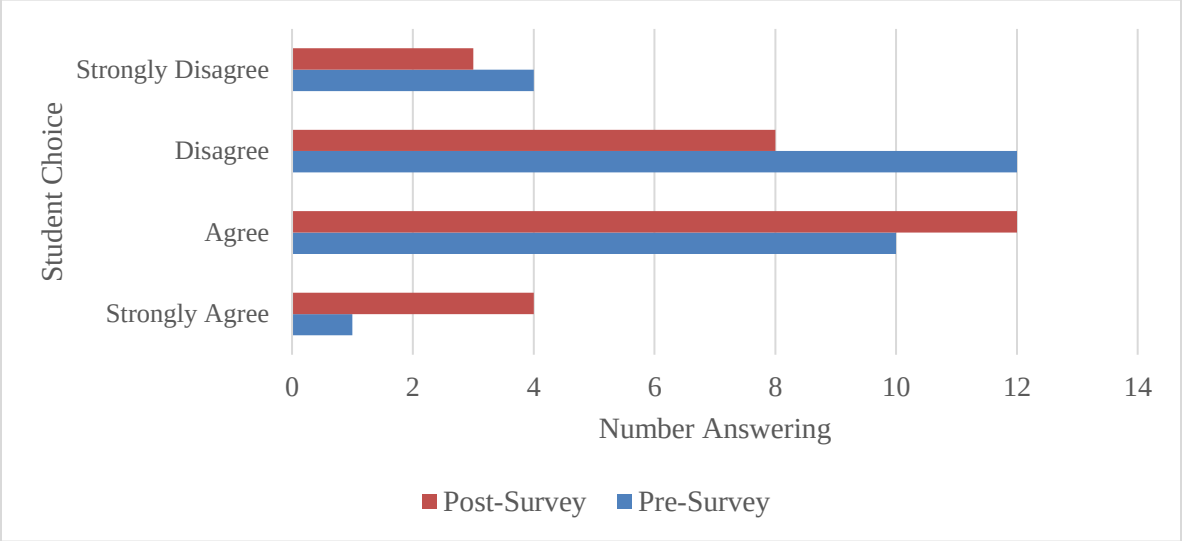


Figure 7. Student answers to question asking them how confident they are in their ability to explain science concepts, (*N*= 27).

Another question from this section of the survey asked students if they felt that it took them a long time to understand how to do citizen science activities. Fifty-two percent of the students disagreed or strongly disagreed with that statement on the pre-survey. On the post-survey the number disagreeing or strongly disagreeing climbed to 74%.

Additional data was collected through students answering weekly questions during the three-week treatment period. Questions were asked at a rate of three questions the first week, four the second week, and five the third and final week. The first week questions were mostly related to the pre-test, gauging knowledge and interests. Weeks two and three had similar questions to track student's participation, engagement and finally, future participation. The two follow-up questions gathered data on interest and ideas for future class projects.

Topics and questions for week one matched up with the pre-test. Students were again asked to define what citizen science is, and to describe the kinds of projects they

were interested in. The third question related to the process of scientific research. When asked what types of projects they were interested in, most students chose projects involving animals or biology, although one student expressed interest primarily in medical projects. One student's definition of citizen science was when "…the public helps carry out research." Another student stated, "the public pretty much works together so that research can be done more efficiently." Students were provided one in-class day per week of the treatment period to work on the citizen science projects. During the day chosen for week one of the first treatment period there were only seven students present. Five of the seven students worked on their chosen projects for the full period.

Review of the questions for the second week of the treatment period showed that some students tried one or two projects, while others tried up to six. The average number of projects tried this week was four. Students kept track and journaled about their time spent on the project outside of school as well. The time spent varied from zero up to two hours this week. During the days that students could work on the projects in class, my own observations and record showed that 71% of the students, combined from both treatment groups, were on task for more than half of the 50-minute class period.

For the third week's questions, students were again asked about how many projects they tried, and whether they had enjoyed working on the projects. One student reported that he/she enjoyed working on the projects because "some were like a game." The student also indicated that he/she was "getting to help other people and researchers with their research." Another student stated that he/she liked working on the projects because he/she "liked helping people." Only one of the two treatment groups was able to

work on the projects in class during the third week. On that day, I observed all fifteen students to be on task within 10 minutes of starting. On the second observation, I recorded fourteen students on task. By the third observation in a 30-minute timeframe, twelve of the fifteen were still working on their projects. A few, less than 5, students were observed discussing the various projects they had chosen.

Students reported on whether they would continue working on the projects once the assignment ended. One student stated “no, its boring”, while another student indicated that he/she probably would not due to homework and practice. Eleven of the students expressed similar feelings of likely not continuing. Out of the twenty-seven students, who participated in both treatments, six of the students indicated they might continue working on the projects on their own. In the follow-up interviews, two students indicated that continuing with citizen science was not interesting because the projects they worked on did not have any local connection.

INTERPRETATION AND CONCLUSION

Three questions were to be answered with this action research project. I wanted to evaluate the effect that adding citizen science projects would have on student achievement in my classroom. I was interested to see if student’s attitudes about science would change after participating in this study. Finally, I wanted to see if student’s perception that they were assisting with authentic science projects with real-world value changed because of participating in this study. These questions were chosen because finding real life science opportunities that are useful and interesting to my students has been a goal of mine for years. As a teacher, I hope to challenge students and give them

information that they can use in real life. I also wanted to use my questions, and the resulting data, as the basis for future projects.

To measure their achievement, I had the students complete the Basic Assessment of Student Knowledge as a pre and post-test. Their scores did show a small improvement. One student's scores were removed from the pre and post-tests. This student did not fully complete the pre-test and did not attempt the post-test, resulting in the only score of 0, skewing the data. The test results indicate that participation in the project did have a small positive benefit on student achievement. As I was evaluating the data gathered, I realized that I did not have as much data as I expected in order to evaluate changes in student achievement. I could have included more assessments or weekly quizzes to better address this goal. While measuring student achievement was my primary question at the beginning of the project, by the end, I realized that my focus had shifted more to student attitudes and their perceptions of the value of the citizen science projects.

Students had a better idea of what citizen science was and why it is a useful part of scientific research, as the treatment period ended. This is indicated through student responses to the question asking how completing the activities helped them understand what is involved in authentic scientific research. One student commented in his/her post-treatment interview that "It showed me how important it is to conduct real research, not just relying on an educated guess." Two other students commented in the post-interviews that they had not realized how important data analysis was in scientific research.

My second goal, to determine if student's attitudes about science would change after participating in this study, was met as evidenced by a series of student comments, observations and discussions. Information was gathered from weekly questions, discussions with students throughout the treatment period, and comments made by students during the follow-up interviews. Classroom observations were made throughout the project. Many of my students did see the value in participating in citizen science projects. For example, one student commented that he "enjoyed the fact that he was contributing to something."

The results from the Cornell Lab of Ornithology Motivation and Self-efficacy Survey (CLOMSS) also contributed towards my second goal. On the two questions asking the students if they chose to learn about and engage in science activities because they were fun, about two thirds of the students agreed to some extent. Results for the post-treatment part of the survey also showed that the students showed a small shift from primarily extrinsic motivations for engaging in science to a slightly more intrinsic view. I am curious how much more their attitudes, perceptions, and motivations might shift if they participated in a longer or more in-depth project.

The second section of the CLOMSS focused on students' self-efficacy, regarding understanding and explaining science topics in general, and the citizen science projects they assisted with. Responses on this section showed that seven of the eight questions had no significant change from pre to post-treatment. This suggests that the students did not perceive an increase in their abilities to understand, explain, and carry out scientific research after participating in the treatment. However, student perceptions did not match

data from the post test. Student scores improved, for the most part. This suggests that participating in the citizen science projects did slightly improve their achievement in my science classes, even if they didn't perceive that themselves. Also, student comments and writing suggested that everyone understood citizen science and how it is important. Although comfort and knowledge of tasks was increasing, many students had not yet acknowledged a boost in self-efficacy. Increasing the length of the study may have allowed students time to gain awareness and adding more in class work time would have improved confidence.

My final goal was to determine whether participating in the citizen science activities helped the students perceive they were participating in authentic science research, as opposed to just going through pre-made book labs. Students comments during the follow-up interviews and on the weekly questions did show awareness from many students that they were assisting with real science research that could lead to valuable discoveries. Many of the students also made comments indicating they enjoyed taking part in the citizen science activities. A couple of the students expressed interest in continuing to assist with the projects after the research ended.

Several challenges during the treatment periods affected my results. My initial plan had been to allow the students at least one in-class day for work and discussion each week of the treatment period. However, the computer lab we were using was booked during one of the weeks for the second treatment group, thus, there were only two in-class work days. As reflected in the teacher journal, the internet was running unusually slow on two of the days when the treatment groups did get to use the computer lab. The

internet issues caused frustration from the students and may have led to some of the off-task behavior recorded on those days.

In addition, this project was only carried out with two small sections of students for three-week treatment periods. The small sample size, and the relatively short data-collection periods also had an impact. Ideally, I would like to carry this out with more students over a longer period to see how my results are affected.

The results of my research project match with previously-conducted studies on the value of incorporating citizen science projects into science classrooms. Many students did indicate that they enjoyed participating in the activities. Observations and comments from interviews and student writing reflect their engagement. Students also agreed that they were able to learn about and participate in more authentic science research compared to current class work. Some of the students agreed that they felt more confident at explaining and undertaking citizen science activities after participating in this study as well.

The online citizen science projects that students participated in were not local. One, that many students helped with, was based in western Montana. Some students did express interest in developing future citizen science projects specific to the community. Local projects, that are developed by and relevant to students, could yield a stronger connection and broader understanding of the local area, as described in several previous studies examining the benefits of citizen science projects. This is another area I am interested in following up on with a future study. It is a long-term goal of mine to

incorporate more authentic, and possibly local, research opportunities into my classes in place of pre-made lab activities with pre-determined outcomes.

VALUE

The purpose of this study was to examine the impacts of incorporating citizen science projects into my high school classroom. I was interested in the impacts of the projects on student achievement, on their attitudes about science, and on their perception that the citizen science projects were allowing them to take part in authentic scientific research. While my results were not as clear and unambiguous as I hoped, I do feel that this project met many of my goals. The student comments from their weekly questions and from the follow-up interviews do show that many of the students did enjoy the projects and did feel that they were taking part in real science, instead of just working through pre-made labs and activities.

The citizen science projects and the accompanying questions and discussions provided a good introduction to this type of research for my students, and it allowed me to expand the types of activities I can use in my classroom in the future. This action research project is intended to be the first step in a multi-year process with the goal of developing a project with my students that is relevant to the local community. One of the final questions I asked the students was for them to come up with ideas for projects that they would want to carry out in the future. The top five ideas that students submitted related to weather, local wildlife, plant diversity, water quality issues around town, and the impact of agricultural chemicals on the organisms living around the farms.

Prior to undertaking this project, I had been using citizen science projects as supplementary activities, or as occasional replacement labs when computers were available. I had not undertaken any rigorous study of the impacts, nor had I developed any long-term plans to develop and implement a citizen science project with local relevance. Participating in this action research project helped me experience a new and useful way of making changes in my classroom and then evaluating the results in a scientific way. Another consequence of this action research project is that I feel much more confident and capable at developing, undertaking, and evaluating potential changes in my teaching and in my classroom.

Engaging in this research progress and the associated classes also helped me professionally in another significant way. Prior to this program, much of the professional development I participated in focused more on content that on tools and techniques I could use to improve my teaching and assessment methods. I feel that participation in this project expanded my repertoire of techniques for working with students in the classroom, and for assessing them at various stages in their learning.

I am already considering what steps I want to take going forward. A follow-up citizen science project that I want to implement locally involves using a cell phone ap that can track litter. I hope to have students gather data about the amount and types of litter found on school grounds. This would be a short-term project with local relevance that could allow the students another opportunity to participate in authentic scientific research. I have also begun planning a similar follow-up project related to citizen science to be potentially used in my classroom over future school years.

REFERENCES CITED

Council, S. E., & Horvath, J. E. (2016). Tools for Citizen-Science Recruitment and Student Engagement in Your Research and in Your Classroom. *Journal of Microbiology & Biology Education,17*(1), 38-40. doi:10.1128/jmbe.v17i1.1018

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64-74.

Hiller, S. E., & Kitsantas, A. (2016). The Validation of the Citizen Science Self-Efficacy Scale (CSSES). *The International Journal of Environmental and Science Education,11*(5), 543-558. doi:10.12973/ijese.2016.405a

Kobori, H., Dickinson, J. L., Washitani, I., Sakurai, R., Amano, T., Komatsu, N., Miller-Rushing, A. (2016). Citizen Science: a new approach to advance ecology, education, and conservation. *Ecological Research,31*(1), 1-19. doi:10.1007/s11284-015-1314-y

Meyer, N. J., Scott, S., Strauss, A. L., Nippolt, P. L., Oberhauser, K. S., & Blair, R. B. (2014). Citizen Science as a REAL Environment for Authentic Scientific Inquiry. *Journal of Extension,52*(4), 1-7. Retrieved January 31, 2018.

Miller-Rushing, A. J., Primack, R., & Bonney, R. (2012). The history of public participation in ecological research. *Frontiers in Ecology and the Environment,10*(6), 285-290. doi:10.1890/110278

Miller-Rushing, A. J. (2017). Reflections on the Strong Growth of Citizen Science: An Interview with Abe Miller-Rushing. *Maine Policy Review,26*(2), 92-93. Retrieved January 31, 2018.

Mitchell, N., Triska, M., Liberatore, A., Ashcroft, L., Weatherill, R., & Longnecker, N. (2017). Benefits and challenges of incorporating citizen science into university education. *Plos One,12*(11), 1-15. doi:10.1371/journal.pone.0186285

Montana Office of Public Instruction. (2017). GEMS. Retrieved March 27, 2018, from https://gems.opi.mt.gov/SitePages/DistrictInfo.aspx?legalid=0061https://gems.opi.mt.gov/SitePages/DistrictInfo.aspx?legalid=0061

Montana Hometown Locator. (2018) Retrieved March 27, 2018 from https://montana.hometownlocator.com/mt/carbon/joliet.cfm

Nugent, J., Smith, W., Cook, L., & Bell, M. (2015). 21st-Century Citizen Science. *The Science Teacher,82*(8), 34-38. Retrieved February 7, 2018.

Ruiz-Mallen, I., Riboli-Sasco, L., Ribrault, C., Heras, M., Laguna, D., & Perie, L. (2016).

Citizen Science: Towards Transformative Learning. *Science Communication,38*(4), 523-534. Retrieved February 7, 2018.

Shah, H. R., & Martinez, L. R. (2016). Current Approaches in Implementing Citizen Science in the Classroom. *Journal of Microbiology & Biology Education,17*(1), 17-22. doi:10.1128/jmbe.v17i1.1032

Silva, C. G., Monteiro, A., Manahl, C., Lostal, E., Holocher-Ertl, T., Andrade, N., Brito, R. M. (2015). Cell Spotting: educational and motivational outcomes of cell biology citizen science project in the classroom. *Journal of Science Communication,15*(1), 1-20. Retrieved from https://jcom.sissa.it/archive/15/01/JCOM_1501_2016_A02.

Yoho, R. A., & Vanmali, B. H. (2016). Controversy in Biology Classrooms—Citizen Science Approaches to Evolution and Applications to Climate Change Discussions. *Journal of Microbiology & Biology Education,17*(1), 110-114. doi:10.1128/jmbe.v17i1.1026

The White House-Office of Science and Technology Policy. (2015). Fact Sheet: Empowering Students and others through Citizen Science and Crowdsourcing. Retrieved from https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/citizen_science_backgrounder_03-23-15.pdf

APPENDICES

APPENDIX A

IRB APPROVAL FORM

MONTANA
STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

2155 Analysis Drive
c/o Microbiology & Immunology
Montana State University
Bozeman, MT 59718
Telephone: 406-994-6783
FAX: 406-994-4303
E-mail: cherylj@montana.edu

Chair: Mark Quinn
406-994-4707
mquinn@montana.edu
Administrator:
Cheryl Johnson
406-994-4706
cherylj@montana.edu

MEMORANDUM

TO: Sean McAndrews and John Graves

FROM: Mark Quinn, Chair Mark Quinn CJ

DATE: November 18, 2018

RE: *"Impact of Incorporating Citizen Science into High School Science Classrooms" [SM111818-EX]*

The above research, described in your submission of November 10, 2018, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

__X__ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

__X__ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

_____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

BASIC ASSESSMENT OF RESEARCH KNOWLEDGE

Please complete this short assessment to the best of your ability. Answer each of the first five questions in complete sentences. Answer true or false for the next five questions, and then write at least one sentence explaining your answer. Answer all questions on a separate piece of paper.

Participation in this research is voluntary and participation or non-participation will not affect your grades or class standing in any way.

Short Answer questions:

1. What is citizen science?

2. Can ordinary people take part in scientific research?

3. Do scientists carry out experiments only to develop new technologies?

4. What are the steps in the scientific method?

5. Do all scientists follow the scientific method when conducting experiments?

   Explain your answer:

True or False questions:

Choose true or false, and then write at least one sentence explaining your answer

6. True or false; real science can only be done in the lab.

7. True or false; it takes special equipment to carry out scientific research.

8. True or false; scientific data is always in the form of numbers and measurements.

9. True or false; the results of scientific data are facts that are accepted and never change.

10. True or false; analyzing data is complicated and should be left to experts

APPENDIX C

CORNELL LAB OF ORNITHOLOGY MOTIVATION AND SELF-EFFICACY SURVEYS

Please indicate how much you **DISAGREE** or **AGREE** with each of the following statements by circling the number in the appropriate column. Please respond as you really feel, rather than how you think "most people" feel.

Participation in this research is voluntary and participation or non-participation will not affect your grades or class standing in any way.

In general, why do you choose to learn and understand science topics?	Strongly Disagree	Disagree	Agree	Strongly Agree
1. Because I like learning about science topics	1	2	3	4
2. For the recognition or respect I'll get from others	1	2	3	4
3. Because I am required to understand science topics	1	2	3	4
4. Because people I look up to think it's good to learn about science topics	1	2	3	4
5. Because understanding science will help me achieve things that are important to me	1	2	3	4
6. Because it's fun to learn about science topics	1	2	3	4
7. Because I want others to think I'm good at understanding science topics	1	2	3	4
8. Because I believe that understanding science topics will help me in some way	1	2	3	4
In general, why do you engage in scientific activities?	Strongly Disagree	Disagree	Agree	Strongly Agree
9. Because scientific activities are fun to do	1	2	3	4
10. For the recognition or respect I'll get from others	1	2	3	4
11. Because I am required to do scientific activities	1	2	3	4
12. Because people I look up to think it's good to engage in scientific activities	1	2	3	4

13. Because doing scientific activities will help me achieve things that are important to me	1	2	3	4
14. Because I enjoy doing scientific activities	1	2	3	4
15. Because I want others to think I'm good at doing scientific activities	1	2	3	4
16. Because I believe that doing scientific activities will help me in some way	1	2	3	4

© Cornell Lab of Ornithology 2018

Please indicate how much you **DISAGREE** or **AGREE** with each of the following statements by circling the number in the appropriate column. Please respond as you really feel, rather than how you think "most people" feel. Please respond regardless of whether you've previously participated in citizen science.

	Strongly Disagree	Disagree	Agree	Strongly Agree
These statements are about how you feel about learning and understanding science content (e.g.,				
1. I think I'm pretty good at understanding science topics.	1	2	3	4
2. Compared to other people my age, I think I can quickly understand new science topics.	1	2	3	4
3. It takes me a long time to understand new science topics.	1	2	3	4
4. I feel confident in my ability to explain science topics to others.	1	2	3	4
These statements are about how you feel about doing citizen science activities (e.g.,				
5. I think I'm pretty good at following instructions for citizen science activities.	1	2	3	4
6. Compared to other people my age, I think I can do citizen science activities pretty well.	1	2	3	4

7. It takes me a long time to understand how to do citizen science activities.	1	2	3	4
8. I feel confident about my ability to explain how to do citizen science activities to others.	1	2	3	4

© Cornell Lab of Ornithology 2018

APPENDIX D

STUDENT FOCUS QUESTIONS

Answer these questions in your weekly journal in as much detail as you need to in order to explain your thoughts.

Participation in this research is voluntary and participation or non-participation will not affect your grades or class standing in any way.

Week one focus questions:

1. Explain in your own words what citizen science is.
2. Tell me what you think happens when a scientist carries out scientific research?
3. What types of projects are you interested in?

Week two focus questions:

1. What new projects have you tried over the past week?
2. How many projects have you tried overall?
3. Which one(s) did you find to be the most interesting? Why did you say that?
4. Did you enjoy working on the Citizen Science projects? Why or why not?

Week three focus questions:

1. What new projects have you tried over the past week?
2. How many projects have you tried overall?
3. Which one(s) did you find to be the most interesting? Why did you say that?
4. Did you enjoy participating in citizen science projects? Why or why not?
5. Will you continue to work on any of the projects after this assignment ends? Why or why not?

Follow-up questions:

1. If you could be a researcher and design your own citizen science project, what would you want to study?

2. Can you think of anything around our school or in the local community that you would want to research?

APPENDIX E

SAMPLE TEACHER/OBSERVER JOURNAL ENTRY

Day 2 of in-class work time on January 24th during 8th period--13 students present

1st check- 12 students working on projects, 1 off task

2nd check- all 13 working. I walked around and interacted with students

3rd check- 4 students off task

APPENDIX F

EXIT INTERVIEW QUESTIONS

Students will be read this statement prior to participating in the interviews:

Participation in this research is voluntary and participation or non-participation will not affect your grades or class standing in any way.

1. How did completing this project help you understand what scientists do when they are conducting research?
2. What is the most important thing you learned from participating in this project?
3. How has participating in this citizen science project changed your attitude towards science?
4. If you could participate in some type of project like the ones you assisted with online, except with a more local impact what would you want to study?
5. Do you think you will ever go back onto any of the projects your participated in and continue on your own? (Why or why not?)
6. Is there anything you would change about this citizen science project?