

CITIZEN SCIENCE PROJECT IMPACT ON STUDENTS' MOTIVATION, ATTITUDE, AND
SELF EFFICACY IN THEIR CHOSEN CAREER

by

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NOMENCLATURE

Citizen Science – Where professional scientists create a research project and ask volunteers to help aid the project by either collecting data, analyzing data, conducting experiments, discovering something new, and solving real world problems.

Impostor Syndrome – “behavioral health phenomenon described as self-doubt of intellect, skills, or accomplishments among high-achieving individuals” (Huecker, 2023).

Self-efficacy – individual's belief in their capacity to act in the ways necessary to reach specific goals.

STEAM – Acronym standing for Science, Technology, Engineering, Arts, Mathematics.

Supercomputer – A computer designed to handle large computational workloads and able to perform calculations faster than general use computers.

Wisdom of the crowds – An idea that large groups of people are collectively smarter than individual experts when it comes to problem-solving, decision making, innovating, and predicting.

ABSTRACT

As a graduate teaching assistant for a calculus based physics two, my students in the past have expressed to me that they don't feel they belong in their major and that they wish they could start research sooner. I designed this study that aimed to increase student motivation, attitude, and self-efficacy in their chosen career, to do so I gauged the impact of student participation in an active citizen science project of their choice. Citizen science is where professional scientists create a research project and volunteers then aid scientists by collecting data, analyzing data, conducting experiments, discovering something new, and helping solve real world problems. To determine this impact a pre and post project survey was administered in a three-week time frame, students also filled out a project report and participated in an optional interview. I used a mean, median, and mode analysis of the Likert data, a Chi-Square test of independence to determine statistical significance of that Likert data, and emerging thematic analysis of the qualitative data. The results show that there is a slight positive impact for the mean of the data there is a 12.5% increase in motivation, an 8.8% increase in attitude, and a 7.5% increase in self-efficacy, but based on the Chi-Square test these impacts are not statistically significant. Based on emerging thematic analysis of the qualitative data the evidence shows no impact in student motivation, attitude, and self-efficacy emphasizing the Chi-Square test showing no statistical significance. Two major themes from the data emerged, that there were no significant changes towards their major, and that the project was interesting and fun, but not completely relevant to their major. Overall based on the three analysis forms I believe there is no significant impact on the students, but there was still an overall positive experience and open students' eyes to different types of research and the citizen science community.

CHAPTER ONE

INTRODUCTION & BACKGROUND

Context of the Study

I was a graduate teaching assistant at Montana State University (MSU) in Bozeman, Montana with an undergraduate enrollment of 14,648 students and a graduate enrollment of 2,140 students (U.S. News & World report, n.d). Bozeman is nestled in the Gallatin River Valley with the Bridger Mountain range located just north of the city, Yellowstone National Park about an hour and a half drive to the South, and a major highway I-90 running west and east through the city. Bozeman is also home to the Bridger Bowl Ski area just 16 miles north from downtown with recreational skiing of all skill levels. Bozeman has a lot of opportunities for outdoor activities to do in the summer and winter time, and MSU take advantage of the outdoor spaces available by creating student/community events. One popular event with students is Rockin' the M which is a 100+ year old tradition where student help refurbish the M on Baldy Mountain, a large rock feature in the shape of an M, with new white paint at the beginning of each fall semester. To see the rock feature, it's a one to three mile moderate hike with 850 feet elevation gain that has views of the city and surrounding foothills (Figure 1) (England (Ed.), 2023). Hiking is a popular activity for students and faculty alike in the temperate months as MSU is close to the Hyalite Canyon and Gallatin National Forest. In the wintertime MSU hosts its annual holiday celebration the lighting of Montana hall, during this event students count down and the holiday lights on Montana Hall get turned on, the festivities include music and singers. Also, in the

wintertime the Bridger Bowl Ski area is a popular place to go skiing and snowboarding just 16 miles away, famously, from our downtown.

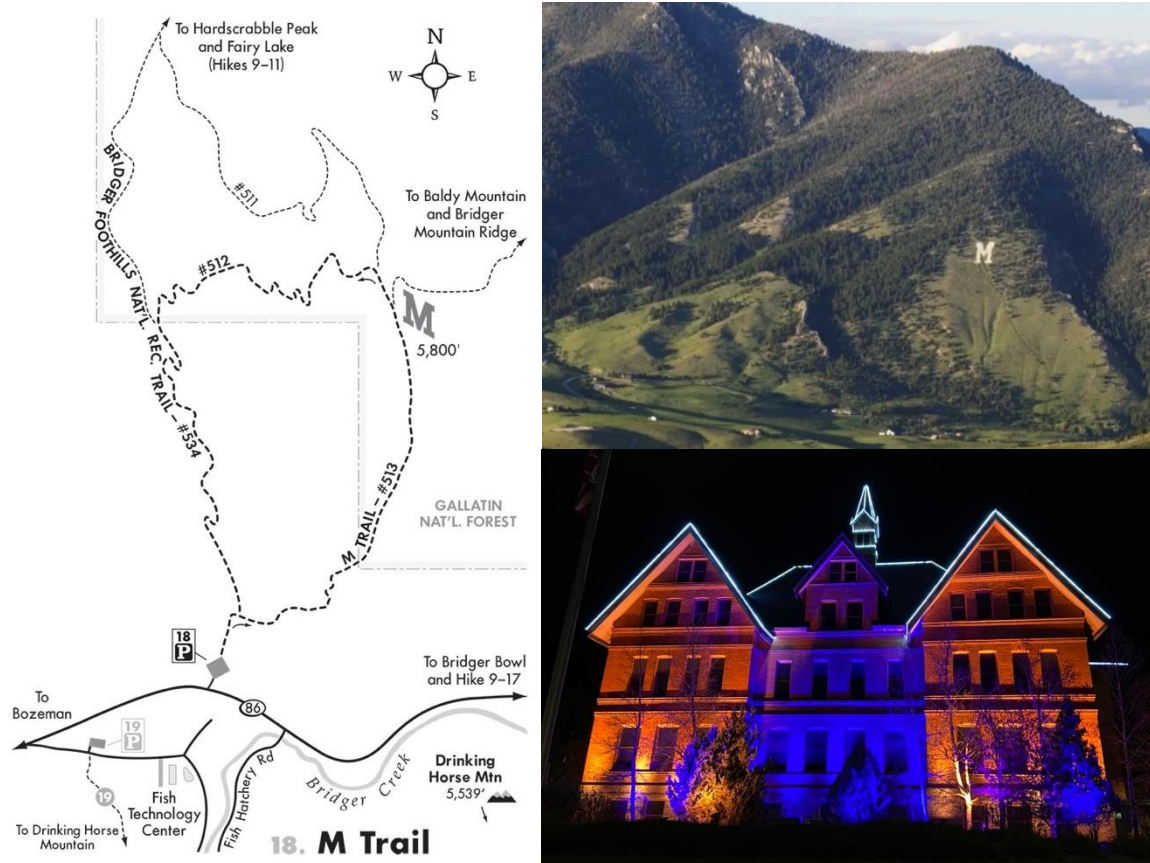


Figure 1. The image on the left depicts the M trail hiking path and other recreational paths in the same area (England (Ed.), 2023). The image on the top right shows the M on Baldy Mountain as seen from the city of Bozeman, MT (Gorham, 2023). The image on the bottom right shows what the lights on Montana Hall looks like after being lit up taken by Jessica Myron December 6, 2023.

The class taught was the lab portion of PHSX 222 Physics II with Calculus (PHSX – Physics Course Catalog, n.d). The lab reinforces topics learned in lecture through a hands-on approach where students work in teams of two to three going through the assigned procedure. Although, I had access to students present in PHSX 242, the honors version to PHSX 222, and PHSX 220 Physics I with Calculus (PHSX – Physics Course Catalog, n.d). In the spring 2024

semester there were 63 students I saw weekly from PHSX 222 and PHSX 242 separated into four separate labs. Most of the students in the course are engineers with only a few science majors, and at the freshman or sophomore level. This physics course uses calculus with the understanding that students have taken calculus one and are taking calculus two concurrently. The gender distribution in my classroom is 84% male and 16% female, however at the university level the gender distribution is 53% male and 47% female showing a lack of gender diversity in my classroom (U.S. News & World report, n.d). The ethnicity distribution in my classroom is 95% white and 5% minority which is reflected similarly at the university level with the ethnicity distribution is 84% white and 12% minority enrollment (U.S. News & World report, n.d).

I have been teaching the lab portion to this class for eight semesters now and what I have noticed is there are smaller number of female identifying students in my lab. Through office hours and weekly lab interactions with these students some have expressed to me their struggles with feeling that they are a part of a male dominated community. Many of those students referencing impostor syndrome, “behavioral health phenomenon described as self-doubt of intellect, skills, or accomplishments among high-achieving individuals” (Huecker, 2023). This phenomenon is commonly seen in ethnic and gender minority groups in academia, most relevantly in the female STEAM students in my classroom. Also, my students in the past have expressed to me that they wished they could start research early but didn’t have enough upper-level classes yet in their major or asked me how to become active in research at MSU at their current level. This research project I wanted to address these two issues feeling part of your career community and introducing research connections students can do at any level, this leads to my focus question.

Focus Question

My focus question was, How does student participation in an active citizen science project of their choice impact their motivation, attitudes, and self-efficacy in their chosen career?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Citizen Science

Citizen science, also known as community science, is a way for the general public to contribute to the scientific field as a volunteer. Professional scientists create a research project and volunteers then aid scientists by collecting data, analyzing data, conducting experiments, discovering something new, and helping solve real world problems (About Citizencience.gov, n.d). With the age of computers scientists have found ways to collect and analyze data more effectively than ever before, but sometimes a computer can't analyze or classify pieces of data as well as a human can (Zooniverse, n.d). Human pattern recognition and our ability to be surprised is superior to computer technology in many research fields (Zooniverse, n.d). When professionals want to utilize citizen science and connect to volunteers there are a few popular website resources where they can post their projects to. Some examples of these websites are Zooniverse, citizencience.org, iNaturalist, and SciStarter (McAndrews, 2019; Zooniverse, n.d).

To determine credibility of the research, especially since the volunteers don't have to be specialized in the discipline, Zooniverse uses the idea of 'wisdom of the crowds' (Zooniverse, n.d). Wisdom of the crowds is the idea that "large groups of people are collectively smarter than individual experts when it comes to problem-solving, decision making, innovating, and predicting" (Halton, n.d). This idea is usually utilized to show how financial markets can work and was popularized by James Surowiecki in his 2004 book, The Wisdom of Crowds (Halton,

n.d). In order for this idea to work the volunteers need to be of a diverse background and opinions so that bias can be averaged out (Halton, n.d).

With large sets of data collected, such as thousands of astronomical images, professionals would need to take lots of time to go through their data one by one, potentially one's entire career. In those cases where the data set is too large for an individual researcher or research team to go through in a reasonable time frame, such as a PhD thesis, they will need something more than just a regular computer, a supercomputer.

Computation/Supercomputers

Computers have their advantages but running large data sets would take up most of the computer's computational power, leaving minimal memory space for other tasks to run at the same time. There would be a need for researchers to have another computer separate from their daily/personal computers for the sole purpose of running computations for their data. This however would cost more money for the research group and need to be budgeted in when writing grant proposals (High performance computing, n.d).

With extremely large data sets, commercial computers won't have enough computational power to make the calculations necessary for professionals, therefore a supercomputer is required. A supercomputer, also known as high performance computing, is a computer designed to handle large computational workloads and perform calculations in a shorter amount of time compared to general use computers (High performance computing, n.d). To build and maintain a supercomputer is very expensive and at the university level it is often a limited resource as there are multiple other professionals using the supercomputer at the same time. Across the United

States universities allow different kinds of access to supercomputers for their researchers, normally to use this resource it costs additional money to be set aside from a researchers grant.

At MSU there are several supercomputing systems available to the research community with degrees of availability. These resources are Tempest, Snowcrest, Hyalite, Nautilus, and XSEDE (High performance computing, n.d). Tempest is a high-performance computing research cluster that is the largest supercomputer in Montana (Tempest Research Cluster, n.d). Usage of Tempest has a free tier access with the agreement that the research group will pursue funding opportunities for a buy-in when able, and a buy-in tier system with differing levels of CPU, GPU, and memory absolute priority access (Tempest Research Cluster, n.d). The minimum buy-in option for Tempest is \$5000 which allows priority access to 85 CPUs, one GPU, and 340 Gb of memory, in comparison a \$30000 buy-in gets 510 CPUs, 6 GPUs, and 2040 Gb of memory (Tempest Research Cluster, n.d). Snowcrest is a research server and workstation hosting environment, similar to a cloud hosting server, and the pay for the fully managed system is currently at \$495.00 per service (Snowcrest Research Hosting, n.d). Hyalite was MSU's first supercomputer, and it has been since decommissioned and replaced by the next-generation supercomputer Tempest, but it currently available for free under the basis that the use be for a session of basic training (Hyalite high-performance computing cluster, n.d). Nautilus is available for a free trial for MSU research and is a super computing resource created by the United States Navy Department of Defense (High performance computing, n.d). Lastly, XSEDE is a national supercomputing resource and available to MSU research communities as a proposal only model (High performance computing, n.d). At MSU the use of a supercomputer has minimal free opportunities, but the main usage requires money to buy-in.

Professionals utilizing citizen science instead of supercomputers is a more cost-effective way to help them go through their data and complete projects in a more reasonable time frame. This combined with the idea that human pattern recognition in many fields is superior to computer calculations, and ‘wisdom of the crowds’ makes citizen science a practical tool for professionals.

Zooniverse

Zooniverse.org is a website dedicated to citizen science research, where volunteers and professionals work together to make scientific discoveries. Professional scientists create a research project, post it to the site with tutorial instructions, and ask for volunteers to help them mainly analyze data. These volunteers don’t have to be specialized or trained in the field that they are doing this research in; anyone can participate at any age level or educational experience. The fields/disciplines that Zooniverse provides are arts, biology, climate, history, language, literature, medicine, nature, physics, social science, and space (Zooniverse, n.d).

Zooniverse is the “world’s largest and most popular platform for people powered research” (Zooniverse, n.d). On the website, under the projects tab, you can choose between active, paused, and finished citizen science projects. The first four projects shown are the ones that the website has determined needs the most help and the user can scroll down to see the different projects separated by the disciplines. When the user hovers over a project icon a brief, approximately one sentence, summary pops up, and when a project is selected a page of information show up. After reading the page of information and going to the ‘About’ section the user will go into the ‘Classify’ section and a tutorial pops up. This tutorial steps the user through what kind of analysis they are looking for and has available a field guide, to reference at any

time, that can help if a distinction is difficult to determine. Zooniverse also has a feature where users can discuss with each other or professionals about classifying the current item in the 'Talk' section. Users can help with as many classifications as they want and click out at any time. In the profile for the user it shows statistics for number of classifications separated by project and items you favorited as well as other useful information about your time on the website.

Citizen Science Project Summaries

The project summaries below are all projects my students have participated in on the Zooniverse website, in no particular order. The summaries are in the biology, nature, physics, space, history, climate, language, and social science categories. My students didn't choose projects in the arts, literature, and medicine categories.

Name that Neutrino! is an active citizen science project on the Zooniverse website in the nature, physics, and space categories. The IceCube Neutrino Observatory located at the South Pole detects neutrinos which are weakly interacting particles and over 100 trillion pass through our bodies without us noticing. This project aims to determine astronomical origins for neutrinos detected and help answer the questions where cosmic rays come from, what is dark matter, and what is the nature of neutrino oscillations. The tutorial asks for the user to watch a seven second film and determine based on the color dots and placement of those dots if the detection is a through-going track, starting track, stopping track, skimming track, or cascade. This classification will help organize the data for the scientists and assist in their artificial intelligence training to correctly classify the neutrino detections (Zooniverse, n.d).

Where's Walleye? is an active citizen science project on the Zooniverse website in the biology and nature categories. This project wants to understand how changing water levels can

affect fish populations in the Georgina Bay, located in Ontario, as well as determine if this method of fish surveying is optimal for research and utilize less invasive techniques for the health of the fish. The tutorial asks for users to watch a 10 second clip of an underwater habitat and then categorize the different fish seen by species, number of fish, and if they are juvenal or adult. The field guide has examples of each species and how to identify them as well as a tool bar to help you narrow down what you have seen from the fish's anatomy (Zooniverse, n.d).

Seadbirdwatch is an active citizen science project on the Zooniverse website in the biology and nature categories. This project looks at sea bird populations in multiple sites across the North Atlantic to determine changes in the marine ecosystem and hopefully pinpoint larger or local impacts for better conservation of sea birds. The tutorial asks for users to look at a photo and identify if the birds on the ground are Kittiwakes, Guillemots, Kittiwake chicks, Guillemot chicks, or another animal/human. The field guide has references to what each type of bird looks like and how to identify them and their chick counterparts. This classification will help researchers determine chick survival/breeding success, causes for chick mortality, indicate if there are different timing for breeding and environmental conditions connected therein (Zooniverse, n.d).

WWII Army Separation Notices is an active citizen science project on the Zooniverse website in the history category. A separation notice is a form filled out when an individual leaves the U.S. military and indicates that they have separated from their branch. The physical copies of these more than 250,000 separation notices from WWII are housed at the National Personnel Records Center, St. Louis, MO and have been scanned in for this project. This project wants to make a digital record of WWII army separation notices that is accurate, searchable, and made

available at the Library of Virginia. The tutorial explains that there are 11 different separation notice forms that the army used at that time and researchers want to be able to distinguish between the different types. When an image of a form pops up, they ask for you to identify if the form looks like the Army Qualification 1945 page 1, Army Qualification 1945 page 2, Army Qualification 1944, other, or back of form. When people participate in this project, they are helping many people gain awareness and access to these records such as “researchers, genealogists, historians, educators, family members, and the broader public.” (Zooniverse, n.d).

Redshift Wrangler is an active citizen science project on the Zooniverse website in the physics and space categories. This project will eventually determine redshifts for distant galaxies and be able to make estimates for star formation rate, chemical abundance, and the nature of the supermassive black hole at the center of each galaxy. To determine these astronomical prosperities astronomers use spectroscopy, the study of light from a source, in this case an astronomical source, and graphing that intensity at many different wavelengths. The spectrum of a source can tell you chemical abundance information via emission lines or absorption lines, the length and width of these spikes or dips in the graph can tell you how much of certain elements are present. If these elemental lines are shifted from what we know to be true in the Earth laboratory, then the cosmological redshift can be measured and determine distances therein. The tutorial gives you the spectrum of a galaxy and has you identifying if there is a real emission or absorption line indicating by a computer, and if the computer had accurately fit that data (Zooniverse, n.d).

Whale Chat is an active citizen science project on the Zooniverse website in the biology and nature categories. This project investigates humpback whale songs and classify the different

calls/units so that the scientists can train deep learning models to better automate the classification process and find patterns human might not be able to detect. By having these classifications scientists can learn more about health of humpback whale populations. The tutorial has users listen to publicly available audios from many different years and from different regions. Then users categorize the sounds by whale calls/sounds, human noise such as boats, snapping shrimp clicking sounds, and other (Zooniverse, n.d).

Gravity Wave Zoo is an active citizen science project on the Zooniverse website in the climate, physics, and space categories. Gravity waves are waves in the Earth's atmosphere triggered by an event such as air being forced upward into stable air such as hitting a mountain range. Gravity waves can be detected by cloud formations, the clouds condense in the colder regions of the waves and cause a rippling like effect similar to a rock being dropped in a pond. This project's goal is to recognize gravity waves, the instabilities of those waves, when the waves break, atmospheric conditions for each event, and identify seasonal variations. The tutorial asks users to watch a 10 second clip of a 180-degree view of the Alaskan sky and identify if there are gravity waves in the video, if there are instabilities which are smaller and perpendicular to the gravity waves, and/or if there is an aurora present. Once the users have combed through the data the scientists will cross reference with radar data measuring wind velocities and sodium LIDAR data measuring temperature and altitude differences. This information will help scientists determine atmospheric conditions that caused these cloud formations or aurora. This research will help scientists improve weather forecasting that can directly help pilots identify rough air and assist scientists in tracking climate change (Zooniverse, n.d).

Radio Meteor Zoo is an active citizen science project on the Zooniverse website in the physics and space categories. This project aims to detect meteoroids plummeting into the Earth's atmosphere by using radio receivers in the BRAMS (Belgian RAdio Meteor Stations) network utilizing the forward scattering technique. Forward scattering is when the transmitter and the receiver are not in the same location, when a radio signal hits a meteor in the Earth's atmosphere it can cause a fraction of a second delay in signal called a meteor echo. The tutorial gives you a spectrogram which is a graph of frequency over time color coded in a spectrum as red with a lot of power to blue low power. On each spectrogram the tutorial asks you to draw a rectangle around potential meteor echoes which are vertical features seen with more power than the background. This research can help scientists because there are more than 8000 individual spectrograms created daily and there isn't enough manpower to go through all the data. Computer automation for this type of detection isn't good making the human eye the best detection method for the meteor echoes, that's why they need help from citizen scientists to help them go through all that data (Zooniverse, n.d).

Maturity of Baby Sounds is an active citizen science project on the Zooniverse website in the biology, language, and social science categories. This project studies children speech development from all different languages and cultures around the globe. Children aged three months to five years wear audio recorders for about 10 to 16 hours and once this data is collected it goes into a computer algorithm to find the sounds and breaks them up into smaller clips. The tutorial asks users to listen to very short audio clips, lasting seconds to protect privacy, and categorize them by baby, child, adolescent, adult, or junk. After one of those categorize are chosen then it asks to specify was that sound canonical, non-canonical, laughing, or crying. This

project helps researchers by comparing data from less developed countries to more developed countries as most of data collected has been from the United States. Also, determine how or when children start mimicking adult sounds around them, other sounds from other children influencing others, and how language plays a part in this development (Zooniverse, n.d).

WildCam Gorongosa is an active citizen science project on the Zooniverse website in the biology and nature categories. This project studies a large-scale international conservation effort for the Gorongosa National Park located in Mozambique, southeastern Africa. Civil war in Mozambique caused devastating decline in the Gorongosa National Park wildlife population by 90%. Apart of this conservation plan is to document what animals are left monitoring them for a long time, document in surrounding wildlife areas to understand its connectivity to Gorongosa, and studying in more detail species of preservation concern such as elephants, lions, and baboons. In order to document wildlife this project utilizes camera traps, devices powered by batteries attached to trees that take a photo when its motion sensor is activated. The tutorial asks users to identify if in the photo(s) there is an animal, person, vehicle, fire, or flooding. That information is then sent to a different workflow to identify specific animal species and researchers will look at images in each category for more thorough dissection and analysis. This project helps researchers because there are hundreds of thousands of images to go through and they need help from citizen scientists to go through all that data (Zooniverse, n.d).

Citizen Science Projects Used in Education

Sean McAndrews's capstone paper in the MSSE program from July 2019 is a good example of a citizen science project used in education. This study looked at an Earth and physical sciences high school classroom and the impact that adding citizen science projects to the

classroom had. The focus of the study was to analyze student feedback, via a pre and post survey, about how citizen science had impacted student achievement in class, attitudes about science, and perceptions of their own capability in science. Twenty-seven students participated in this study and were directed to the website Zooniverse which housed many different citizen science projects they could choose from containing a variety of difficulty. The conclusion of this study showed that there was a small improvement in student achievement, a small shift in attitude towards science from an extrinsic view to intrinsic view, and lastly no significant shift in student perceptions of their own science capabilities (McAndrews 2019).

Lüsse's study does a deep dive into the literature surrounding citizen science's impact in an educational setting and compiled positive learning outcomes. Important note from this study is that "implementing citizen science projects show great potential for pupils' learning...as well as their personal development as responsible and active citizens." This study found various papers showing that when students get involved in a citizen science project there are positive impacts on self-efficacy, on student motivation as students feel they are helping and contributing to science, in interest in scientific subject matter and/or particular project topic, increased scientific inquiry and skill, influences positive behavior and stewardship, and increased understanding of scientific concepts. This study also notes that citizen science project participation, "support[s] [student] development of career choice goals" (Lüsse, 2022, p. 1127).

CHAPTER THREE

METHODOLOGY

Demographics

Being the lab instructor allows me to have a different dynamic with my students as I communicate with them often which gives more opportunities to see how they can communicate scientific principles. This interaction also allows me to see how my students work together in groups. The group members don't tend to change throughout the semester and by the end students are more comfortable and I have found it easier for them to create a scientific dialogue with each other and with me.

Something I was keeping in mind while creating the citizen science project was that my students are in college with limited time. I wanted to choose a project length that wasn't too much effort on the students' part while being meaningful and able to answer my focus question.

At the end of the study the following demographic information was collected. In the Pre/Post Citizen Science Project Survey, Gender reported indicated that 81.2% of students were male, 18.8% of student were female, 0% non-binary, 0% transgender, 0% prefer not to say, and 0% for write in category. When asked about year students were in school 62.5% indicated sophomore, 25.0% freshman, 6.2% junior, and 6.2% Senior. Ninety-three and eight tenths' percent of students were in PHSX 222, 6.2% were in PHSX 242, and 0% were in PHSX 220. The majors present are 84.2% engineering with 36.8% of students being mechanical engineers, and 15.8% in physical sciences or math. When asked about student career goals or jobs they'd be interested in 87.5% of student reported something specific

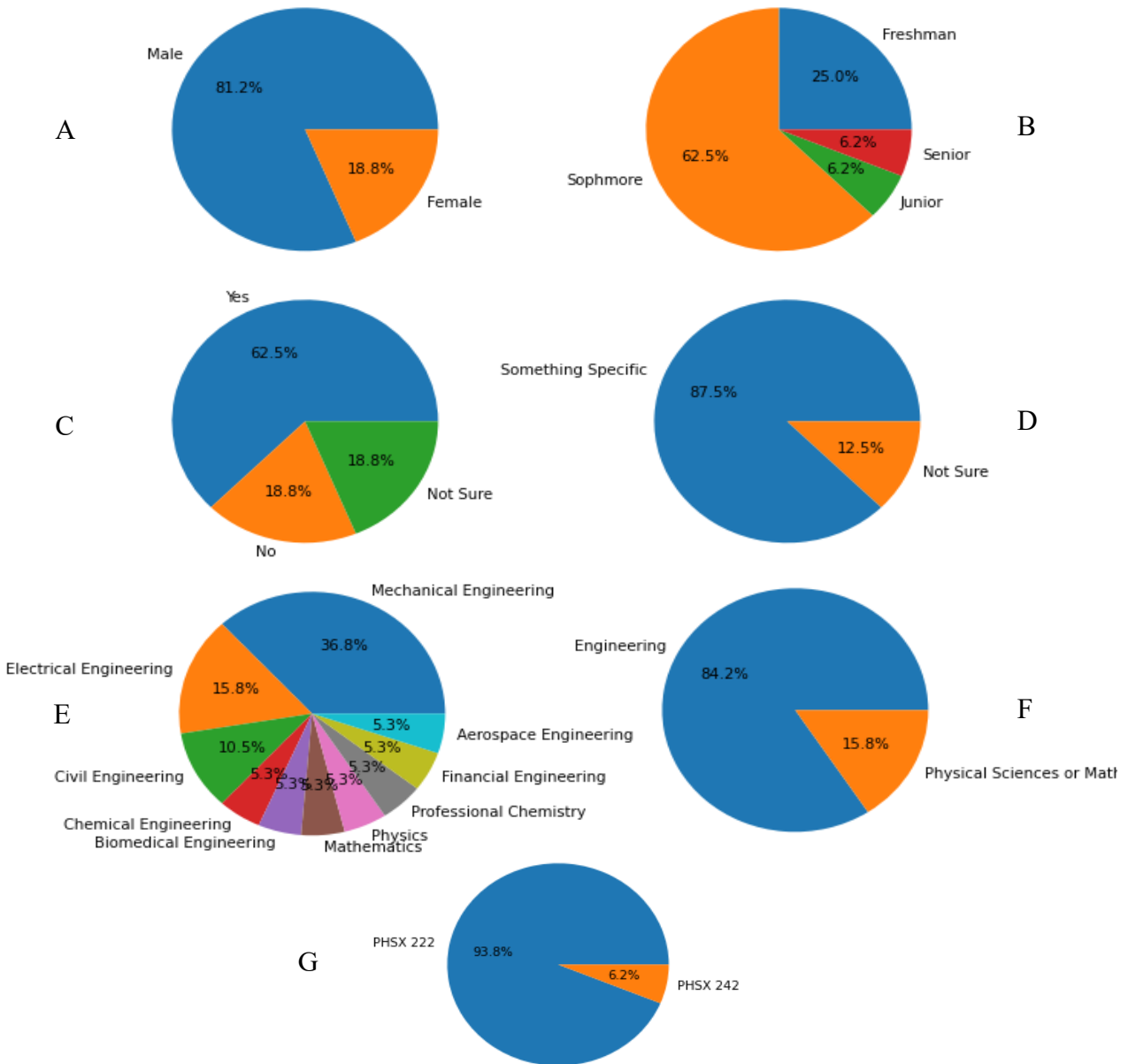


Figure 2. A: Pie chart indicating percentage of gender students identify. B: Pie chart indicating percentage of students in each year of college. C: Pie chart indicating percentage of students interested in doing research in their field. D: Pie chart indicating percentage of students when asked about what career or job students would be interested in. E: Pie chart indicating percentage of students in each major reported. F: Pie chart indicating percentage of students in two categories of student majors. G: Pie chart indicating percentage of students in each physics course. ($N=20$).

to their major, and 12.5% of student indicated that they were not sure. Lastly, when asked if students were interested in research in their field 62.5% said yes, 18.8% said no, and 18.8% were not sure (Figure 2).

Treatment

Students participated in active citizen science project/s that they find interesting or useful for three weeks in addition to the regular physics curricula. Students find these projects posted on the website Zooniverse. Through the Zooniverse interface students will create an account, choose from a variety of STEAM categories, and assist in active research projects directly through the website. The goal is to gauge the impact of student's motivation, attitude, and self-efficacy in their chosen field by participating in an active citizen science project. Students who participated were chosen from both PHSX 220 and PHSX 222 to maximize student participation as it was fully voluntary, and I didn't offer any incentive to participate.

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

Data Collection and Analysis Strategies

Pre/Post Citizen Science Project Survey

At the beginning and end of the three-week citizen science project, students filled out the Pre and Post Citizen Science Project Survey (Appendix B). These surveys are identical to show the change, if any, in motivation, attitude, and self-efficacy in students' chosen STEAM field. Questions in this survey are in the form of quantitative and qualitative questions and adapted

from the Test of Science-Related Attitudes (TOSRA) handbook to meet the needs of the focus question (Fraser, 1982). The quantitative question was in the form of a five-point Likert survey Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly Agree (SA). Following these Likert questions there was a corresponding text box for student to elaborate why they chose what they chose. Questions were grouped into three categories motivation, attitude, and self-efficacy. The motivation category contains questions one through three from the Pre/Post Citizen Science Project Survey, the attitude category contains questions four and eight, and the self-efficacy category contains questions five through seven. Student participation was voluntary, and completion of the Pre/Post Citizen Science Project Survey didn't affect their grade in the course.

To analyze this data, I collected responses in the form of a Google form and exported the data to Google sheets and compared using mean, median, and mode analysis and emerging thematic analysis. Emerging thematic analysis is taking qualitative data and looking for themes or patterns from those responses. To determine statistical significance of quantitative data a Chi-Square test of independence was performed.

Citizen Science Project Report

The Citizen Science Project Report is a written formative assessment report to collect data on students' motivation, attitude, and self-efficacy in their chosen STEAM field (Appendix C). This report includes information about time spent in total and time spent on each individual project they worked on, a brief summary of one project assisted, career interests, motivation/attitude on chosen project(s), and self-efficacy towards their chosen career.

The Citizen Science Project Report Rubric is a way to separate the Citizen Science Project Reports into four major categories consisting of a D level, C level, B level, and A level

(Appendix D). The three elements of the rubric include time spent, number of projects assisted, and writing expectation, with each categorized by the four levels and the final category is determined by the average of each element. D level is indicative of spending less than an hour in total, assisted in one to two projects, and writing at least one question did not follow instructions by writing something that didn't answer the question asked at least once. C level is indicative of spending one to five hours in total, assisted in three to four projects, and majority of questions answered used one or few words and didn't have complete sentences. B level is indicative of spending five to 10 hours in total, assisted in five to six projects, and majority of questions had complete sentences at a satisfactory undergraduate writing level. A level is indicative of spending more than 10 hours in total, assisted in seven or more projects, and writing beyond satisfactory undergraduate writing level or wrote multiple sentences. Student participation was voluntary, and completion of the Citizen Science Project Report didn't affect their grade in the course.

To analyze the data, I collected responses in the form of a Google form and exported the data to Google sheets. Histograms and pie charts were used to analyze the quantitative data, and emerging thematic analysis for the qualitative data and further group the corresponding data into three subcategories motivation, attitude, and self-efficacy.

Citizen Science Project Interview

The Citizen Science Project Interview is a face-to-face interview with students who have completed the Citizen Science Project Report after the three-week project period (Appendix E). During each interview students were asked questions at the end of their project gaining more details about their major's environment. The Citizen Science Project Interview is designed to

obtain more details about motivation, attitudes, and self-efficacy in their chosen field than the Pre/Post Citizen Science Project Survey and the Citizen Science Project Report. The Citizen Science Project Interview took three quantitative questions from the Citizen Science Project Survey and instead of using the five-point Likert Survey it uses a 10-point Likert Survey which doesn't include a neutral option. The 10-point Likert survey includes a range of response from one to 10 from Strongly Disagree (one) to Strongly Agree (10). There were three students that volunteered to participate in the interview process. Each of these three students were asked the same questions and met with me in my office. Student participation is voluntary, and completion of the Citizen Science Project Interview didn't affect their grade in the course.

To analyze this data, all written notes taken during the interview were collected in a journal categorized by date of interview. All quantitative data was typed and organized in a Microsoft Word document and compared to the Pre/Post Citizen Science Project Survey using mean, median, and mode analysis method. To determine statistical significance a Chi-Square test of independence was performed. The qualitative data was organized into three categories motivations, attitudes, and self-efficacy and in those categories emerging thematic analysis was performed.

Statistical Significance: Chi-Square Test of Independence

A Chi-Square test of independence determines whether two variables are independent of each other. In order for the two variables to have a statistical significance and therefore are dependent of each other the p-value must be below a defined significance level, anything above that value would mean you couldn't reject the null hypothesis. The null hypothesis states that the two variables you are looking at are not related or there is no relationship between the two. For

this project my two variables were the Pre/Post Citizen Science Project Survey and I decided to use a significance level of 0.05 indicating a 95% confidence rate. In the Pre/Post Citizen Science Project Surveys for each of the eight Likert questions I separated them into three categories motivation, attitude, and self-efficacy. When calculating the Chi-Squared test each category added together two or three Likert questions and combined the frequency of each five-point response (strongly disagree, disagree, neutral, agree, and strongly agree). Then determined the expected value for each five-point response by taking the total number of responses multiplying it by the total number of responses for that points pre and post and dividing it by the total number of responses for pre and post combined. To determine the Chi-Square value or test statistic I plugged in the observed and expected values into this equation $\chi^2 = \frac{(Observed - Expected)^2}{Expected}$. After obtaining the test statistic to find the p-value utilized the Chi-Square distribution function on google sheets where the test statistic and degrees of freedom were inputted. Since the Likert survey was a five-point survey the degree of freedom was n-1, meaning for this data was a degree of freedom of four. After obtaining the p-value to determine statistical significance if that value is above the significance level of 0.05 then the data is not statistically significant, if the p-value is below the 0.05 level then the data is statistically significant.

Data Triangulation Matrix

There were three different sources of data collection which consisted of the Pre/Post Citizen Science Project Survey, a written formative assessment Citizen Science Project Report, and Citizen Science Project Interview. A mixed-method data collection approach was used in the form of quantitative and qualitative data collection. The quantitative shows how student

participation in an active citizen science project of their choice impacts their motivation, attitudes, and self-efficacy in their chosen STEAM career. The corresponding qualitative data is used to back up claims seen in the analysis of the quantitative data. In order to show impact of a citizen science project on the students the pre and post surveys contained the same questions in order to compare directly (Table 1).

Table 1. Data Triangulation matrix.

Focus Question	Data Collection Instruments		
	Source 1	Source 2	Source 3
How does student participation in an active citizen science project of their choice impact their motivation, attitudes, and self-efficacy in their chosen STEAM career?	Pre/Post Citizen Science Project Survey	Citizen Science Project Report and Rubric	Citizen Science Project Interview

CHAPTER FOUR

DATA ANALYSIS

Results

The results of comparing the Pre/Post Citizen Science Project Survey, analyzing Citizen Science Project Report, and Citizen Science Project Interview showed that there are no impacts on students' motivation, attitude, and self-efficacy in their chosen career by participating in an active citizen science project of their choice ($N=16$). Between two large lecture classes for PHSX 220 and PHSX 222 I had 583 students that could have participated, 56 students participated in the Pre Citizen Science Project Survey, 20 participated in the Citizen Science Project Report, 16 participated in both the Pre/Post Citizen Science Project Survey, and three participated in the Citizen Science Project Interview. The students that participated in both surveys and the interviews were from PHSX 222 with one student from the honors version PHSX 242 and most of them were my lab students.

Pre/Post Citizen Science Project Survey Results

The results of the Pre/Post Citizen Science Project Survey specific to the motivation category indicated that the average response improved by 0.63 points on a five-point scale. This was a 12.5% increase in motivation, in addition the median and mode did not change (Figure 3). Speaking to motivation, a shift I saw was from one student who said initially "I'm always

looking to learn new things and grow” to then after participation the same student said,
 “[r]esearch is important to my major”.

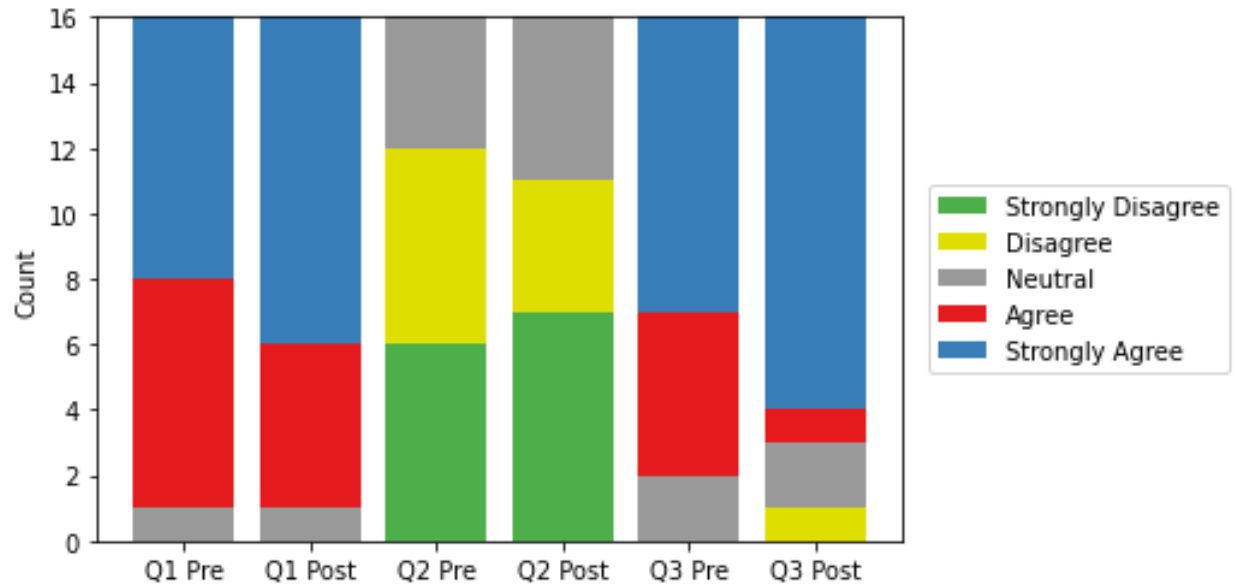


Figure 3. Stacked bar chart of student responses to motivation Likert questions in the Pre/Post Citizen Science Project Survey with question one left two columns, question two middle two columns, and question three right two columns. For all three questions the mean response improved by 0.06 points on a five point scale on average, the median and mode response didn't change. *Note:* Q1: When I leave school, I would like to work with people who make discoveries in [my major]; Q2: Talking to friends about [topics in my major] after school would be boring; Q3: [My major] can help to make the world a better place in the future, ($N=16$).

The results of the Pre/Post Citizen Science Project Survey specific to the attitude category indicated that the average response improved by 0.44 points on a five-point scale. This was an 8.8% increase in attitude, in addition the median increased by 15% and the mode increased by 30% (Figure 4). After student participation in a citizen science project one student said regarding attitude that, “[a]nswering questions in the world seems beneficial and [citizen science] is an efficient way to have work be completed.”

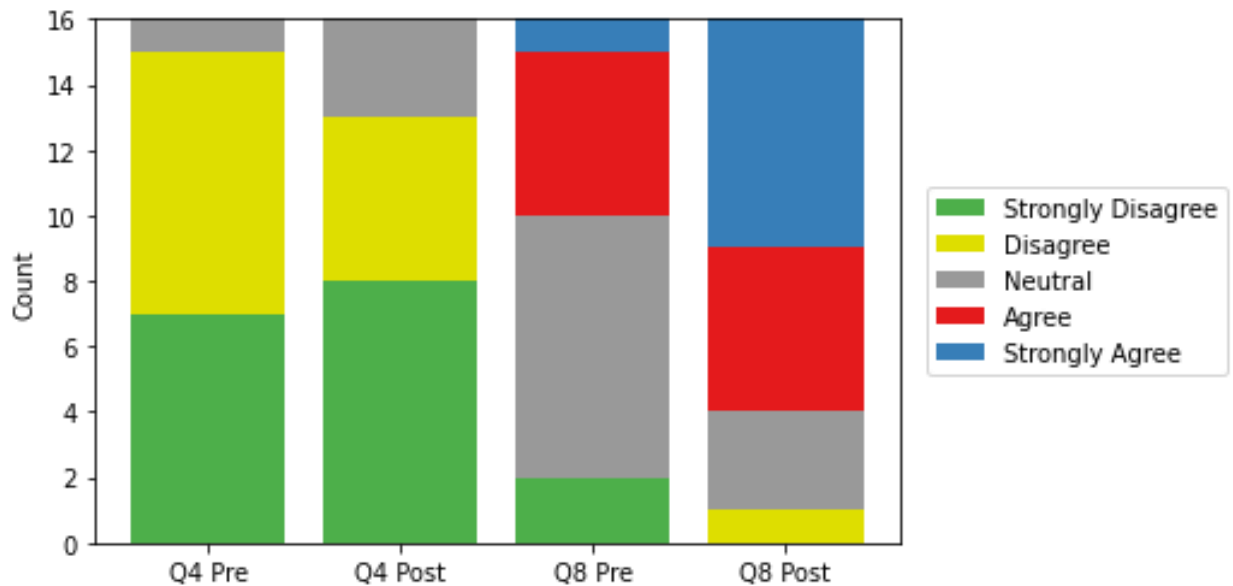


Figure 4. Stacked bar chart of student responses to attitude questions in the Pre/Post Citizen Science Project Survey, question four left two columns and question eight right two columns. For all questions the mean response improved by 0.44 points on a five scale on average, the median improved by 0.75 points on a five-point scale, and the mode improved by 1.5 points on a five point scale. *Note:* Q4: I dislike listening to other people's opinions; Q8: Would you recommend participating in citizen science projects to a friend, ($N=16$).

The results of the Pre/Post Citizen Science Project Survey specific to the self-efficacy category indicated that the average response improved by 0.38 points on a five point scale. This was a 7.5% increase in self-efficacy, in addition the median and mode increased by 6.6% (Figure 5). One student's small shift in self-efficacy is seen from their initial thought about confidence in their scientific/career ability saying, "I am smart but not the smartest person out there" to then after participation saying, "I'm getting there."

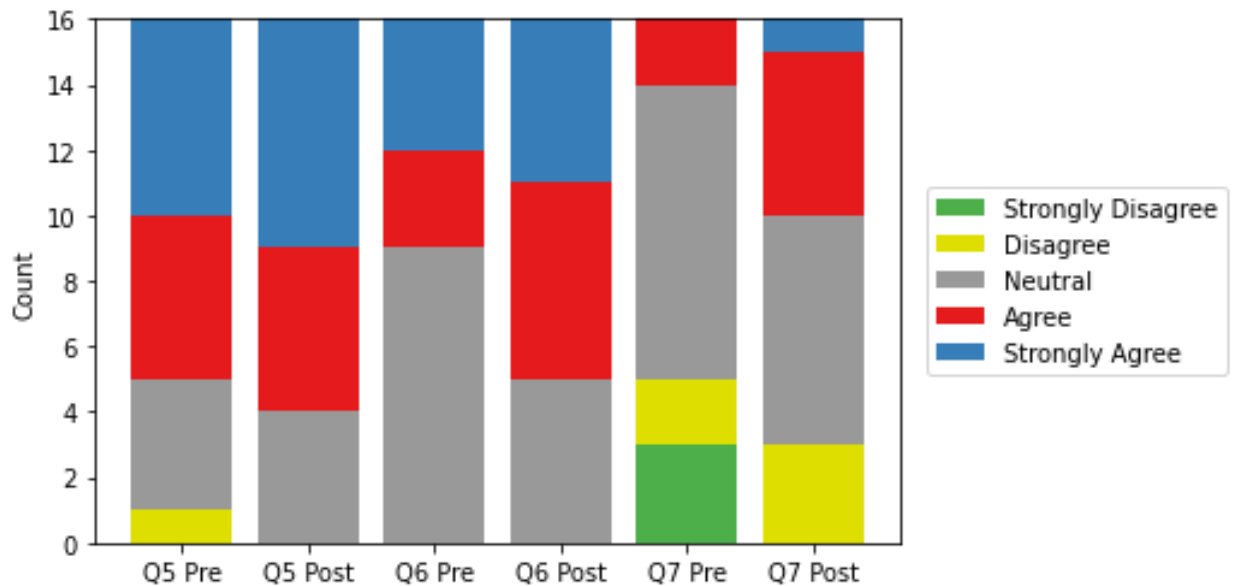


Figure 5. Stacked bar chart of student responses to self-efficacy questions in the Pre/Post Citizen Science Project Survey, question five left two columns, question six middle two columns, and question seven right two columns. For all questions the mean response improved by 0.38 points on a five point scale on average, the median improved by 0.33 points on a five point scale, and the mode improved by 0.33 points on a five point scale. *Note:* Q5: Do you feel you belong to your major/career?; Q6: Are you confident in your scientific [and/or career] ability?; Q7: Do you feel a part of the citizen science community, ($N=16$).

The Chi Square test of independence showed that there was no statistical significance in any of the three categories. In the motivation category the p-value was 0.23 which is above the 95% significance level of 0.05 making the trend shown not statistically significant. In the attitude category the p-value was 0.08 which is above the 0.05 significance level making the trend shown not statistically significant. Lastly, in the self-efficacy category the p-value was 0.22 which is above the significance level of 0.05 making the trend shown not statistically significant. Once I broke down the questions independently the only question that had a p-value below the 0.05 significance level was question eight with a p-value of 0.04. Question eight asked if participants would recommend participating in citizen science projects to a friend.

Using emerging thematic analysis on the qualitative questions, questions 1 through 8, in the Pre/Post Citizen Science Project Survey, the results show no impact on students' motivation, attitude, or self-efficacy in their chosen career. Most notably, for every question in the Post Citizen Science Project Survey, one student said that "[The] [a]nswer is the same as first participation". The results for question one, that asked if students would like to work with people who make discoveries in their major, showed that a major theme was 50% of students initially referenced that it interests them and after treatment a new major theme emerged where 56% of students indicated it would help them grow professionally. The results for question two, that asked if talking to friends about their major would be boring, showed that in the pre and post survey had similar themes but there was a significant shift from 56% of students indicated yes because they enjoyed their major being the most common choice to 31% of students specifying that yes it would be but only if their friends were also in their major. From the Citizen Science Project Interview one student said that, "system stuff can get lost as a freshman, but when they understand the concepts, it is more fun." The results for question three, that asked if their major would make the world a better place, showed that there was little to no change in the pre survey 87% indicated yes and in the post survey 75% indicated yes with the two students moved to the other category. The results for question four, that asked if students disliked listening to other's opinions, showed little to no change as initially 87% indicated that it was important for them to be open minded, and after treatment 81% indicated the same. The results for question five, that asked if students felt they belonged to their major, showed little to no change as initially 75% of students indicated yes as they like their major, and after treatment 68% also indicated yes. The results for question six, that asked if students are confident in their scientific/career ability,

showed that there was a small change in perspective from 31% of students initially indicating that they were good at their major to 50% indicating the same. The results for question seven, that asked if students feel a part of the citizen science community, showed that initially most of the students (56%) didn't know what citizen science was to 50% indicating yes. From the Citizen Science Project Interview one student clarified "[y]es, I feel a part of the citizen science community but specifically for bird conservation, not the whole community." The results for question eight, that asked if they would recommend citizen science projects to a friend, showed that most of the students (56%) didn't know what citizen science was initially to 75% indicating yes, they would.

Citizen Science Project Report Results

The results from the Citizen Science Project Report showed that 90% of students chose one project to participate in, 5% of students chose three projects to participate in, and 5% of students chose five projects to participate in (Figure 6) (N=20). Also reported was 62.5% of

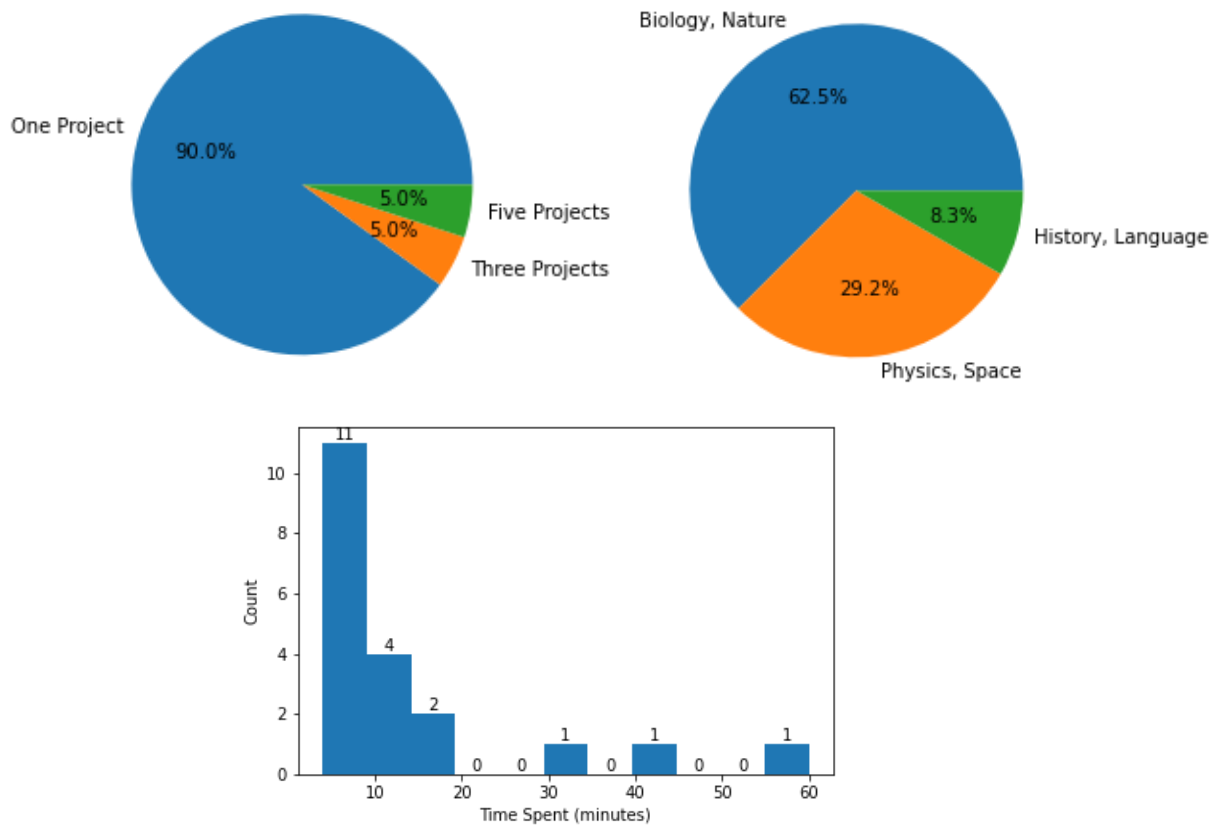


Figure 6. Top left pie chart shows total number of citizen science projects each student participated in. Top right pie chart shows frequency of each citizen science subject picked by students. Bottom histogram shows time each student spent in total on citizen science projects, (N=20).

students chose projects in the biology and nature categories, 29.2% of students chose projects in the physics and space categories, and 8.3% of students chose projects in the history and language categories. Lastly, 11 students reported time spent to be from four to eight minutes, four students

said 10 minutes, two said 15 minutes, one said 30 minutes, one said 43 minutes, and one said 60 minutes. Figure 6 represents pie charts in percentage form for number of citizen science projects participated in, which citizen science project subject chosen, and a histogram indicating frequency of time each student spent in total on citizen science projects.

The Citizen Science Project Rubric was designed to indicate the level of work students put into their projects based on three categories time spent, number of projects participated in, and level of writing. The levels are indicative of an A grading level, B, C, and D as if the assignment would be taken for a grade, which it was not. The results of the Citizen Science Project Rubric show that majority of the students received an overall D level in time spent and number of projects participated in categories, and majority received an overall B level in writing ($N=20$). The D level in time spent and number of projects participated shows that students didn't spend enough time working on this project and didn't participate in many projects. The B level in the writing category indicated that students have above average writing skills but did not go above and beyond. In the time spent category 95% of students were in the D level, 5% of students were in the C level, and 0% in the B and A level. In the number of projects assisted category 90% of students were in the D level, 5% in the C level, 5% in the B level, and 0% in the A level. In the writing category 10% of students were in the D level, 30% in the C level, 55% in the B level, and 5% in the A level.

Using emerging thematic analysis on the qualitative questions, questions 5 through 10, in the Citizen Science Project Report the results show no impact on students' motivation, attitude, or self-efficacy in their chosen career. The results for question five, that asked to summarize one project they participated in, showed that 18 students correctly summarized the project where two

didn't correctly summarize a project or didn't follow instructions. The results for question six, that asked what students learned, liked, or didn't like about their favorite project, showed that seven students reference things specific to their topic, six found the topic fun/interesting, four found it easy/boring, two didn't follow directions, and one student "...thought it was cool to help the researchers conduct their study."

The results for question seven, that asked if any of the research participated in interest them in a career, indicating attitude, showed that 80% of students used the phrase "it's not relevant to my career" or similar verbiage with one student saying, "Not really, this has a lot of identifying animals which is far off from my major." Of those students' half mentioned something similar to "it's not relevant but fun/interesting" one example is someone saying, "not really but [I] find it interesting non[e] the less". From the Citizen Science Project Interview when asked the same question student elaborated more saying it was "[m]ore for fun and as a hobby, dream life [she] would be able to do it all with research, but not feasible in [her] current career dreams." Fifteen percent of students mentioned that it was relevant to their career and 5% of students were unsure. The results for question eight, that asked their motivation/attitude on why they chose the projects to participate in, showed that 45% of students indicated it was because they "liked nature, fishing, wildlife, or space" or something similar. Forty percent of students said because it "looked fun/interesting" or similar verbiage, and 15% students said because it was "random", "First one [they] saw", and that "[i]t looked easy to do and like it wouldn't take much time".

The results for question nine, that asked self-efficacy in their chosen career after participation, showed that 60% of students reported no change, 25% indicated an increase, 0%

showed a decrease, and 15% didn't follow instructions. With one student saying, "[he] do[esn]'t feel much different towards mechanical engineering after this project." Lastly, question 10 asked if there was anything else they wanted to include and of those that responded a common theme was that the project was fun, neat, and that "[they] will probably do it again", and although they all had positive experiences it wasn't completely relevant to them in their career.

CHAPTER FIVE

CLAIM, EVIDENCE, AND REASONING

Claims From the Study

This study looked at how student participation in an active citizen science project of their choice impacted their motivation, attitudes, and self-efficacy in their chosen STEAM career.

Based on analysis, I can make the following claims:

1. There was no impact on student motivation, attitude, or self-efficacy in their chosen STEAM career by participating in an active citizen science project of their choice.
2. When given the choice many students didn't choose a citizen science project relevant to their career, they chose ones mostly because it was fun/interesting.
3. Students participating in a citizen science project had a positive experience.

There was no impact on student motivation, attitude, or self-efficacy in their chosen STEAM career by participating in an active citizen science project of their choice. Comparing the before and after Likert questions in the Pre/Post Citizen Science Project Surveys indicated a 12.5% average increase in motivation, 8.8% average increase in attitude, and 7.5% average increase in self-efficacy. This data was determined to be not statistically significant from the Chi square significance test indicating no impact from the citizen science project on student careers. This claim is also backed up by student responses in all three data collection methods. One quote from the Post Citizen Science Project Survey that sums up this claim is "Answer is the same as first participation" indicating no change.

When given the choice many students did not choose a citizen science project relevant to their career. In the Citizen Science Project Report 80% of students indicated that the project they chose to participate in was not relevant to their career. When asked about motivation/attitude for picking the topic 45% mentioned that they “liked nature, fishing, wildlife, or space” or something similar, and 40% because it “looked fun/interesting” or similar verbiage. With one student saying, “I do enjoy nature and animals but my career will be more focused on medical devices”. Over half of the students, 62.5%, chose citizen science projects in the nature/biology category, I believe the location of the school impacted this choice. The state of Montana and Bozeman specifically, where MSU is located, has a large outdoor recreation culture year-round, this is why students tended to gravitate towards projects relating to nature/biology. If students weren’t picking projects based on career and more for fun or topic of interest it makes sense that they would choose nature/biology. Potential bias in student choice here is there was not an explicit engineering category for students to choose as 84.2% of students are engineering majors, self-reported from the Pre/Post Citizen Science Project Survey. From the Citizen Science Project Interview one student stated “[citizen science] is more for fun... than directly related to [his] career research interest. If there was more of a direct engineering project to participate, I’m sure it would be”. Confirming that this bias is most likely present in this study. The topic students chose change depending on where the study is taking place, major students have, and availability/direct access of citizen science projects in student major.

Lastly, students participating in the citizen science projects had positive experiences. One student response from the Post Citizen Science Project Survey said, “This was a fun activity, I will look more into the projects later!” In the Citizen Science Project Interview, when asked if

there was anything else to add, one student said, “Cool program! More people should know about it, especially children this feel more like a K-12 school project than college level.” Another student mentioned that it was a “[m]ostly positive experience...” Other evidence is that the overall tone of the interviews was positive, as well as throughout the three-week treatment period students expressed to me how cool and fun it was. One quote from the Citizen Science Project Interview that sums of this claim is citizen science “...is really neat. I can see the benefit to collecting large amounts of data all around the world and I will probably do it again.”

Value of the Study and Consideration for Future Research

Citizen science is a useful tool for professional researchers as it can help them process data in a more efficient, accurate, and cost-effective way. Being able to give back to the scientific community is an important part of my career and a value I would like to instill in my students. Previous studies suggest that citizen science implemented in a high school classroom has small but positive effects on students’ achievement and attitude (McAndrews 2019). This research I completed adds to previous studies in this field by showing impacts at a university level with little structure on time and project choice, with an emphasis on student career.

If I was going to do this project over again, there would need to be more structure for my students. I would give my students a strict rubric for amount of time participated in to be at least 45 minutes because the students that spent more than that had a large increase compared to the others. I would also require the number of projects participated in to be at least three, shorten the time frame from three weeks to one week, and cultivate a list of career specific project categories. I would also give students more of an incentive to participate in project such as offering extra credit including a different but equal value extra credit assignment to keep to IRB

standards and reduce bias. Despite these changes I predict that the outcome would be the same because of the lack of direct engineering projects available but I couldn't say for sure and would be interested to see what the official conclusion would be in a future study.

A potential bias to this study is that in the Pre/Post Citizen Science Project Survey question eight was put into the attitude category but I think it has more to do with students' attitude with citizen science than it does with their career. That question was the only one determined to be statistically significant with a 18.75% improvement in the average responses. Another potential bias to this study is that of the 583 students that could have participated in this study only 16 participated in the Pre/Post Citizen Science Project Survey, and of those students most of them were in my lab class. I think those students participated because they knew who I was and saw who the information was directly benefiting. These students also had the most reminders each week on due dates for the surveys, reports, and interviews.

I have learned that citizen science at the university level of education, unless specialized to each student's major, doesn't have a significant impact on their motivation, attitude, and self-efficacy in their field. Future research on impact to motivation, attitude, and self-efficacy in student career would include a larger professional development angle. For example, practicing science communication via groups, student presentations, and/or leadership and confidence building workshops. This type of research would put more of an emphasis on improving confidence and self-efficacy that could benefit the students in the course the most suffering from impostor syndrome.

Other future research would be to utilize citizen science in the classroom but specialize it to the class, in this case, a physics project that directly relates to the material being taught. This

also could include asking the MSU department of physics if their researchers have projects that can be benefitted by citizen science analysis and working with them to include an educational component for my students. I would also be interested to see if having an online citizen science platform like Zooniverse or a more hands on physical project would have a larger impact if any. The classes that I think would benefit the most from having a specialized project to participate in is astronomy and physics courses as there are many relevant space/physics projects available.

Another impactful research effort would be to try this again with a K-12 age group. Students in a younger age group might not have chosen what career they want, but by participating in a citizen science project of their choice, students would have the opportunity be able to view different areas and determine what STEAM field would be interesting to them. The students surveyed are at the university level and have already chosen their major and while only a few indicated that they are interested in changing their major this could have biased the results.

Impact of Action Research on the Author

My background and training in physics and astrophysics has prepared me to be a scientist. Going into this research I was confident in my abilities to crunch the numbers, but I was less confident in analyzing qualitative data and how to put findings into action. Funny enough, as a GTA, I have been doing action research this whole time and did not even know it. My students would bring up issues to me, such as “exam one was very difficult I did not feel prepared” and I would ask if others felt the same way. Based on their responses, I set up a review lecture before the next exam. The needs of my students have always been on my mind and through this action research I now have the tools to design a project, accurately gauge its impact for the benefit of my students and quantify if my suggestions are working.

At the beginning of this research journey my motivation in designing a project was centered around the idea that students wanted to start research earlier but didn't have the necessary skills yet in their major, and specifically in my female students I wanted to address feeling apart of your career community. I was inspired to do a more career-based project instead of physics based because most of my students are engineering majors and this physics course, although useful, is not directly related to their major. Once I had the focus question, the next step was to determine data collection instruments needed to accurately answer the focus question. I decided a survey would be the best method to answer my question. Building a survey was difficult at first until I found a resource called TORSA which had questions asking about the motivation and attitudes in science (Fraser, 1982). I was then able to adapt this resource to ask about motivation and attitudes for students' individual careers. The initial draft of the survey consisted of only Likert questions, but then developed to include a box for students to write why they chose the answer they chose. Having both quantitative and qualitative data strengthened my claims because I could identify multiple sources that reach the same conclusion.

The most difficult part of this project was trying to get students to participate. Between two large lecture classes I advertised my research to, 583 students could have participated, but only 16 participated in both the Pre/Post Citizen Science Project Survey. The students that participated in both surveys were from PHSX 222 and most of them were my lab students. I think they participated because they knew who I was and saw who the information was directly benefiting. During the three-week project period I became increasingly nervous I wouldn't have enough data, towards the end of the three weeks I gave frequent reminders and almost begged students to participate in the optional interview of which only three participated. I do think that I

obtained enough data to make my claims, but any less and the claims would not have been as strong. Expressing my concerns to a peer, they had mentioned something they were doing to incentivize students to participate. Offering my project as an extra credit assignment would encourage student participation, but for fairness and meeting IRB standards I could create another extra credit assignment different from mine as another option then students don't feel forced to participate. Another thing I would do differently is change the three-week total time frame to a one week time frame, this way everything is fresh in the students mind and less likely to forget.

After the stress of collecting data, then the fun part of analyzing began. I learned how to perform quantitative statistical significance tests and learned about qualitative emerging thematic analysis, both of which I had never done before. While the data was being collected, I looked briefly at what the results were so when I did the deep dive into the numbers and written responses the conclusion was comparable to what I had seen. After the data analysis the data showed little to no impact on students' motivation, attitude, and self-efficacy in their chosen career and that surprised me. I initially thought that the impact would be positive as students had mentioned in the past that they wished they could start research earlier and were less confident in themselves. Even though the outcome wasn't what I had expected I learned a lot about what not to do, and what I would change. Something else I would do differently is give more structure and less freedom in choosing citizen science projects. For example, the time spent I would like student to spend at least an hour, participate in multiple projects, and having the instructor pick projects that relate to the course or their career. This study shows there is not an impact in student

careers, but there could be impacts in other areas as students have an overall positive experience and I intend to explore the other potential areas in my new classroom.

A quote that stood out to me in the data analysis stage was from a female student in response to the Pre Citizen Science Project Survey asking if students feel they belong in their major/career, “Sometimes the classes are so confusing, I feel like I will not be able to do anything significant or become homeless because I don't understand anything.” This stood out to me because of the severity and extremeness this student related to being homeless and not doing well in school. This quote demonstrates the amount of pressure this student is putting on herself, and sadly consistent to what I have heard in previous semesters. Another quote that stood out to me from the same question asked was “There are times when my imposter syndrome is really bad. Although there are a decent amount of girls, certain classes like physics make me contemplate if I am smart enough.” This quote resonated with me because of my experience as an undergrad physics major, I had worried if I was smart enough to stay in the major and struggled with my own feelings of impostor syndrome. What helped me the most was relating to other female peers going through the same thing I was and two female professors/mentors that boosted my confidence in my physics knowledge. Especially if students only have to take physics for two semesters, I can see the potential for students to have lower self-esteem as I have in my personal experience. In this research, I saw a lot of female students and some male students having negative self-talk with regards to their confidence in their major and mentioning impostor syndrome. I do think that the lack of confidence is still an issue with mostly female STEAM students, at least here at MSU, and I will consider its impacts on education moving forward with my career as an educator and try my best to improve student confidence.

Even though my research was shown to not be statistically significant, all the time spent was not wasted because I learned so much about how to conduct educational research and what kind of educator I want to be. I aspire to be an educator that thinks of student learning in a holistic way, be an inquiry based educator, be an inclusive educator, and keep up to date on latest research in my field. To improve the education of my students holistically I need to account for negative and positive influences that could affect their education. With my new skills and lessons learned I plan to perform more action research projects to further my student's success, education, and confidence in themselves. Ultimately, I hope to inspire and empower the next generation of STEAM students.

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APPENDICES

APPENDIX A

IRB EXEMPTION STATEMENT

2/16/24, 9:58 AM

Mail - Myron, Jessica - Outlook

IRB Protocol #2024-1269-EXEMPT APPROVED

NoReply@TOPAZTI.com <NoReply@TOPAZTI.com>

Mon 1/29/2024 4:02 PM

To: Graves, John <graves@montana.edu>; Myron, Jessica <jessicamyron1@montana.edu>; Beiswanger, Kelly <kelly.beiswanger@montana.edu>; Szott, Brenna <brenna.szott@montana.edu>

External Sender

Hello Myron, Jessica,

Your protocol was reviewed by the IRB and has been approved.

PI: Myron, Jessica

Approval Date: 1/29/2024

Title: CITIZEN SCIENCE PROJECT IMPACT ON STUDENTS' MOTIVATION, ATTITUDE, AND SELF EFFICACY IN THEIR CHOSEN CAREER

Protocol #: 2024-1269-EXEMPT

Review Type: Exemption

Expiration Date: 1/29/2029

Work described under this protocol may now commence. The PI is responsible for ensuring that the protocol accurately describes research practices being conducted.

- > Review Category designation determined by the IRB can be found in the final section of your protocol.
- > IRB-stamped active Consent Forms are attached within your protocol where applicable.
- > Any changes must be submitted via Amendment prior to implementation.
- > Per the Common Rule, research only requires Interim (annual) Review by the IRB if 1) it was reviewed via Full Committee or 2) is regulated by the FDA.
- > All research is subject to post approval monitoring.
- > All protocol types must be renewed 5 years after approval.
- > Inform the IRB once your research is complete so that the protocol may be inactivated.

Please contact your IRB Program Manager with any questions or if you are in need of assistance. Thank you for your diligence in the care of human subjects research participants.

Institutional Review Board for the Protection of Human Subjects | Office of Research Compliance | Montana State University

Access your protocol anytime at <https://nam10.safelinks.protection.outlook.com/?url=https%3A%2F%2Fmontanaprod.topazti.net%2F%2FElements%3FemailLink%3D11%252c102%252c10905&data=05%7C02%7Cjessicamyron1%40montana.edu%7Cea71ee050cad49e394d008dc211e4ec5%7C324aa97a03a644fc91e43846fbced113%7C0%7C0%7C638421661270483378%7CUnknown%7CTWFEpbGZsb3d8eyJWljojMC4wLjAwMDAiLCJQljojV2luMzliLCJBTil6lk1haWwiLCJXVCi6Mn0%3D%7C0%7C%7C%7C&sdata=yuPcMWBnrkBVNwtogdQBmQBmNskbR0zTqCioTheJoKo%3D&reserved=0>.

APPENDIX B

PRE/POST CITIZEN SCIENCE PROJECT SURVEY

Student participation is voluntary, and completion of the Pre/Post Citizen Science Project Survey won't affect your grade in the course.

Demographic information

- Full Name
- Current Major
- Current Minor
- Year in school
- Gender
- What are your career goals or jobs you'd be interested in?
- Are you interested in doing research in your field? If so what kind of research interests, you?

Motivation, Attitude, and Self-Efficacy

1. When I leave school, I would like to work with people who make discoveries in [my major]. (Strongly Disagree 1 -> Strongly Agree 5) Why?
2. Talking to friends about [topics in my major] after school would be boring. (Strongly Disagree 1 -> Strongly Agree 5) Why?
3. [My major] can help to make the world a better place in the future. (TORSAs) (Strongly Disagree 1 -> Strongly Agree 5) Why?
4. I dislike listening to other people's opinions. (TORSAs) (Strongly Disagree 1 -> Strongly Agree 5) Why?

5. Do you feel you belong to your major career? (Strongly Disagree 1 -> Strongly Agree 5) Why?
6. Are you confident in your scientific [and/or career] ability? (Strongly Disagree 1 -> Strongly Agree 5) Why?
7. Do you feel a part of the citizen science community? (Strongly Disagree 1 -> Strongly Agree 5) Why?
8. Would you recommend participating in citizen science projects to a friend? (Strongly Disagree 1 -> Strongly Agree 5) Why?

Is there anything else you would like me to know?

APPENDIX C

CITIZEN SCIENCE PROJECT REPORT

Citizen Science Project Report

Howdy my name is Jessica Myron I am a graduate student in the MSSE (Master of Science in Science Education) Program. The purpose of my research is to understand how student participation in an active citizen science project of their choice impact their motivation, attitudes, and self-efficacy in their chosen career. The feedback collected will be used in a professional paper as a part of my MSSE capstone requirements, and any personal contact information collected is used to connect your pre/post surveys to your project.

Student participation is voluntary, and completion of the Citizen Science Project Report won't affect your grade in the course or class standing in anyway. You can choose to not answer any questions you do not want to answer and/or you can stop at any time. Proceeding with the survey indicates your consent to participate.

If you have any questions, please reach out to me Jessica Myron (jessicamyron1@montana.edu) or the MSU IRB (irb@montana.edu). This research is conducted by Montana State University.

* Indicates required question

1. Full name *

2. Time spent in total *

3. Time spend on each project *

6/21/24, 6:32 PM

Citizen Science Project Report

4. Number of project participated *

5. Name of each project participated in *

6. Briefly summarize one project and reference it by name *

7. Pick your favorite project (reference it by name) what did you learn from it, what did you like, what didn't you like? *

6/21/24, 6:32 PM

Citizen Science Project Report

8. Does any of the research you participated in interest you for a career? If so, why? *

9. Motivation/attitude on why you chose the projects you chose. *

10. Self-Efficacy (or confidence) towards your chosen career after participation. *

11. Include any additional notes, fun facts, or details about your participation. *

APPENDIX D

CITIZEN SCIENCE PROJECT REPORT RUBRIC

Citizen Science Project Report Rubric

	A Level	B Level	C Level	D Level
Time Spent	Greater than 10 hours	5-10 hours	1-5 hours	Less than 1 hour
Number of Projects Assisted	7+	5-6	3-4	1-2
Writing relating to questions 7, 8, and 9 of the Citizen Science Project Report	Writing is beyond satisfactory undergraduate writing level and/or wrote multiple complete sentences.	Majority of the questions, students wrote a complete sentence at an undergraduate writing level.	Majority of the questions answered used one word, few words, or not complete sentences.	At least one of the questions students did not follow instructions or wrote something that didn't answer the question asked.

Student participation is voluntary, and use of the Citizen Science Project Rubric didn't affect students' grade in the course.

APPENDIX E

CITIZEN SCIENCE PROJECT INTERVIEW

Student participation is voluntary, and completion of the Citizen Science Project Interview won't affect your grade in the course.

Interview Questions

1. Describe to me your major/career's environment.
2. Why did you choose your current major and or minor?
3. Do you think you share the same attitudes towards your major as people in your same major?
4. Does the course you are in, PHSX 222, 242, or 220, prepare you for your chosen career? Why/Why not?
5. Do you think your major is actively preparing you for your chosen career? Why/why not?

Questions adapted from Pre/Post Citizen Science Project Survey

1. When I leave school, I would like to work with people who make discoveries in [my career]. Why? (10-point Likert; Strongly Disagree 1 -> Strongly Agree 10)
2. Talking to friends about [topics in my major] after school would be boring. Why? (10-point Likert; Strongly Disagree 1 -> Strongly Agree 10)
3. Do you feel you belong to your major/STEAM career? Why? (10-point Likert; Strongly Disagree 1 -> Strongly Agree 10)
4. Do you feel a part of the citizen science community? Why? (10-point Likert; Strongly Disagree 1 -> Strongly Agree 10)

Conclusion Questions

5. What is a major take away from participating in citizen science projects.
6. After participating in a citizen science project would that research interest you in your career? Any research connections to citizen science?
7. Is there anything else you would like to share with me?