Analyzing perceptions of citizen science as part of an international learning experience

Katelyn Marie Miner
University of Northern Iowa

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ANALYZING PERCEPTIONS OF CITIZEN SCIENCE AS PART OF AN
INTERNATIONAL LEARNING EXPERIENCE

An Abstract of a Thesis
Submitted
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Katelyn Marie Miner
University of Northern Iowa
May 2021
ABSTRACT

This study focused on a perceptions-based citizen science project that emphasizes meaning over measurement. Specifically, student perceptions of citizen science in a unique location, rather than the specific data outcomes of the water quality citizen science activity were analyzed. Many researchers have used citizen science participants to collect samples from water sources around them, increasing the use of mass data collection for scientific purposes. This study was a mixed-methods design, using triangulation of the pre-survey, modified focus group, and post-survey. The goal was to gauge the perceptions of participants in perceived benefits and gains before and after participating in a water quality citizen science activity in an international setting. While citizen science is widely used to increase data collection and knowledge about science, this study achieves a fuller understanding of the motivations and benefits of participants and how location plays a role in their decision to volunteer. This study demonstrates the importance of geography and the geographic threads of citizen science that determines the role that location plays on participants, and how it impacts the use of future citizen science studies.
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This Study by: Katelyn M Miner

Entitled: Analyzing Perceptions of Citizen Science as Part of an International Learning Experience

has been approved as meeting the thesis requirement for the Degree of Master of Arts

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DEDICATION

This thesis is dedicated to my family for their endless love and support in everything I do. And to my wonderful professor and friend, Lisa Tabor, for pushing me toward greatness, always.
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I would like to thank my participants for their wonderful input, my professors for their encouragement and knowledge, and McDonalds for always tasting the same around the world.
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CHAPTER I
INTRODUCTION

Citizen science is defined as non-science, public volunteers collecting scientific data for research or public use (Bonney et al., 2014; Bonney et al., 2009). Citizen science dates back before the early 20th century (Silvertown, 2009). Initially, scientists collected data about their own interests during their own personal time, but through gradual changes, they were able to begin training non-scientists to voluntarily participate in the data collection process as well (Silvertown, 2009). Since this transition, citizen science has been implemented and utilized regularly in hundreds of studies including, but not limited to, monitoring biodiversity and collecting ocean plastics (Dohrenwend, n.d.; van der Velde et al., 2017).

Many researchers have used citizen science participants to collect samples from water sources around them, teaching the participants about the importance of water resources and the quality of those water resources locally (Alender, 2016; Shupe, 2017; Thornhill et al., 2017). As a necessity of life, water – and water quality – is extremely important. While there have been several studies that use citizen science in water quality testing and monitoring (Church et al., 2018; Lévesque et al., 2017), there are still many gaps within this topic and field of study. Currently, there are global initiatives that are engaging people of all ages to participate in citizen science locally by testing water resources around their local communities and having these results shared online. An example is World Water Monitoring Day that is a worldwide initiative to gather water quality data and map those findings online (Chandler et al., 2012).
Even though there are numerous citizen science water resource focused projects, there are limited studies on perceptions of citizen science; and the ones that exist, focus mainly on monitoring scientific knowledge and attitude change, understanding motivations with the importance of water quality monitoring, and gauging perceived impacts of citizen science (Alender, 2016; Brossard et al., 2005; Den Broeder et al., 2017). These studies, however, omit an international learning experience component and a specific inquiry as to whether or not location matters to the participants. Because of this, citizen science is not understood as well as it could be.

This study focused on perception-based citizen science to further understand locational influence on participant motivation and personal impact. In this study, a small group of local Iowan undergraduate students participated in a water testing citizen science activity in Costa Rica, as part of their international learning experience. The students completed pre- and post-surveys and engaged in a modified focus group to share their perceptions about participating in a citizen science activity, how their perceptions did or did not change before and after participating, and if location, in this case international, mattered.

While citizen science is widely used to increase data collection and knowledge about science, this study achieves a fuller understanding of the motivations and benefits of participants and how location plays a role in their decision to volunteer. This study demonstrates the importance of geography and the geographic threads of citizen science that determines the role that location plays on participants, and how it impacts the use of future citizen science studies. The citizen science literature is also expanded upon to add
in the undergraduate international learning experience component. Overall, this study leads to new and exciting results through perspectives based on student perceptions of citizen science that could help shape how citizen science and water quality monitoring is used and explored globally.

**Research Questions**

1. What are student perceptions of citizen science, before and after participating in an international citizen science activity?
2. What do students gain from participating in an international citizen science activity?
3. Does location matter in an international citizen science learning experience?

**Overview of the Methods**

This study was a mixed-methods design, using triangulation of the pre-survey, modified focus group, and post-survey. The goal was to gauge the perceptions of participants in perceived benefits and gains before and after participating in a citizen science activity in an international setting. Prior to departing the U.S. for Costa Rica, the undergraduate students performed three tasks during a pre-departure meeting accordingly: 1) completed the pre-survey, 2) engaged in an interactive presentation on citizen science, water quality, and their role in participating in this study, and 3) practiced using the water quality test kits they would use while abroad. Once in Costa Rica, the undergraduate students physically completed the citizen science process of water quality testing from multiple water sources. The modified focus group immediately followed the testing. When the undergraduate students returned to the U.S., the post-survey was distributed to them. The perception data was qualitatively analyzed (Figure 1).
This research was part of a formal education course in an international learning experience. This study focuses on perceptions of those who take part in citizen science and the importance of location, where the citizen science activities take place. Thus, it is important to specifically note that water quality testing and Costa Rica were not main components of this study, meaning that other forms of citizen science data collection (i.e. butterfly counting, ocean plastic monitoring, etc.) could be substituted as equally important citizen science projects. Moreover, other international locations may comparably be utilized during a short-term study abroad program to gather data and participate in citizen science. Water quality and Costa Rica were chosen for this study because of the importance of water quality issues globally, the convenience and timing of the short-term study abroad program in Costa Rica, and the expertise of the researcher.
Figure 1. Research Design

Citizen Science

Water Quality
- Water quality testing using citizen science
- Importance of water quality monitoring

International
- Engaging students in citizen science during an international learning experience
- Importance of location in citizen science

Perceptions
- Motivations, benefits, absorption of information
- Importance of location in citizen science
- Level of agreement with reason for volunteering

Integration of the public in scientific studies
Pre-survey and post-survey
Modified focus group
Qualitative analysis
Definitions of Terms

Citizen Science – Volunteer participants from the general public collecting data for a scientific study (Bonney et al., 2014; Bonney et al., 2009).

International Learning Experience – Also known as a short-term study abroad program where students are in an international location for a short period of time (Green et al., 2011).

Perceptions – A way of regarding, understanding, or interpreting something (Jiang et al., 2018).

Water Quality Testing – The physical collection and analysis of water samples for specific components at certain levels (Burt et al., 2014).
CHAPTER II

LITERATURE REVIEW

The literature review explains necessary background knowledge of the key components in this research. These components are geographic perspectives, qualitative methods in geography, citizen science, water quality, perception-based studies, and international learning experiences with undergraduate students. It concludes with a discussion of the role that water quality, perceptions, international learning experiences, and Costa Rica play within citizen science for this study.

Geographic Perspectives

The evolution of geography, geographic thought, and the questions we ask as geographers plays a significant role in the understanding of our world (Hanson, 2004). From studying who we are and the questions we ask, Hanson makes the case for the geographic advantage. The geographic advantage is the idea that as geographers, we must have an understanding of: relationships between people and the environment; the importance of spatial variability (the place-dependence of processes); processes operating at multiple and interlocking geographical scales; and the integration of spatial and temporal analysis, as well as sustaining our diversity and identity (Hanson, 2004). In essence, within geography, place matters and the geographic advantage is important to informing this research by directly studying and implementing the role that location plays within citizen science perceptions. This research also promotes the questions we ask based on who we are – from Hanson’s argument – by taking a qualitative methods and
analysis approach that allows for a more holistic understanding of the research questions in this study and how they are answered.

**Qualitative Methods in Geography**

Qualitative methods is an approach to scholarly inquiry that relies on human-environment experiences and theoretical frameworks that inform qualitative research through observations and interpretations (Creswell, 2009, 2013). Qualitative methods require many aspects that very much consider it a well-rounded process to use in geographic research. Such aspects included in this study were extensive time and commitment, rigorous data collection, and complex data analysis (Creswell, 2013). Qualitative methods also dive deeper into the human-environment perspective that is grounded in geographic research (Hay, 2010) and as Creswell states:

> “a qualitative approach is appropriate to use to study a research problem when the problem needs to be explored; when a complex, detailed understanding is needed; when the researcher wants to write in a literary, flexible style; and when the researcher seeks to understand the context or settings of participants” (Creswell, 2013, p. 65).

This research uses a qualitative methods perspective because of the need to explore perceptions of citizen science through undergraduate participants in a complex manner.

**What is Citizen Science?**

Citizen science is the integration of public participation (non-experts) in science-based learning projects, activities, or studies (Bonney et al., 2014; Bonney et al., 2009; Parrish et al., 2019; Phillips et al., 2018). Citizen science is used in different types of studies such as monitoring biodiversity (Branchini et al., 2015; Chandler et al., 2017; Toogood, 2013; Williams et al., 2015), ocean reflectance (Yang et al., 2018), ocean
plastics (Dohrenwend, n.d.; van der Velde et al., 2017), butterfly counts (Ries & Oberhauser, 2015), plant identification (Fuccillo et al., 2015), insect monitoring (Clary et al., 2012), and even management of pet cats (Roetman et al., 2018). The key component of this kind of work is the integration of the public in these studies to increase data collection as well as scientific knowledge within the community (Brossard et al., 2005). There has been large growth in citizen science activities in recent years as a means to achieve mass data collection and increase public awareness and knowledge on certain issues (Parrish et al., 2019). This growth has led to widespread use of citizen science in most fields and is now viewed as a useful tool in science and scientific studies (Bonney et al., 2009).

What is Water Quality?

Water is a basic necessity of life. It covers 71 percent of the earth’s surface, only 0.02 percent of which is freshwater (Jolly, 1973). Because water is a major part of life and the natural environment, water quality monitoring is important in determining the status of water resources as well as detecting any unwanted changes that may be occurring (Burt et al., 2014). Burt et al. (2014) reported that with the continually changing environment, it is crucial to begin long-term monitoring of water resources for the health and safety of all life on this planet. The potential additions of citizen science water quality studies to literature is a helpful step for continued understanding of changes taking place within our local and global water resources.
Why Study Perceptions?

Perception-based studies are ideal for investigating what and why people think and behave as they do (Hay, 2010). Investigating people’s thoughts in this way leads to diving deeper into how perceptions can change over time, such as before and after partaking in an activity (Brossard et al., 2005). Perceptions are a challenging topic in research as the information gathered can be costly, time consuming, and in some cases, open to personal bias (Soriano-Redondo et al., 2017). Jiang et al. (2018) defined perceptions as a phenomena that is regarded, understood, and interpreted in their study based on environmental data collection. Perceptions data can be exceptionally useful in citizen science studies, and they are being used to influence the development of environmental technology and the applications of the data produced (Jiang et al., 2018).

International Learning Experiences with Undergraduates

This study worked with undergraduate students in an international learning experience in Costa Rica to gather and analyze their perceptions of citizen science based in an international location. It is widely stated and accepted in academia that international learning experiences (i.e. short-term study abroad programs) are beneficial to undergraduate students in developing intercultural competence and global perspectives (Andenoro & Bletscher, 2012; Green et al., 2011). Previous research has focused on the self-motivations and benefits reported by undergraduate students from being involved in international learning experiences and study abroad programs (Bretag & van der Veen, 2017; Singh & Jack, 2018). Bretag and van der Veen (2017) found through conducting pre-departure and post-return surveys during a study abroad program, undergraduate
students felt an increase in confidence to go out of their comfort zones as well as an increase in competency and personal skills stemming from their study abroad experience.

Why Costa Rica?

Short-term study abroad programs are increasingly more popular, especially in Costa Rica (Study Abroad Data, 2017). According to “Study Abroad Data” (2017), over 8,000 students studied in Costa Rica during the 2016/2017 academic year, the highest number of study abroad students in Central America. Costa Rica is a more generalizable study abroad location, allowing this study to be replicated due to its normality in the study abroad field. This normality includes their high literacy rate, their commitment to sustainability, and their comfortable accommodations for U.S. and other foreign students (Aragon, 2015).

A Synthesis of the Literature

Synthesizing the main components of the research – citizen science, perceptions, water quality, and international learning experiences – demonstrates the need for this work through gaps in the research.

Citizen science is often used as a data collection tool for water quality testing at a global level. Many researchers have used citizen participants for collecting samples from water sources around them, teaching the participants about the importance of water resources, and the quality of those water resources locally (Alender, 2016; Shupe, 2017; Thornhill et al., 2017). While there have been several studies that use citizen science in water quality testing and monitoring (Church et al., 2018; Lévesque et al., 2017), there are still gaps within this topic and field of study. Specifically, no work focuses on citizen
science water quality testing as part of a formal education course for undergraduate students in an international setting.

Many perception-based citizen science studies have focused on the perceived benefits that participants receive, analyzing perceptions through theory or quantifying perceptions based on specific instrumentation, such as the Attitude Toward Organized Science Scale (ATOSS) (Brossard et al., 2005; Den Broeder et al., 2017; Parrish et al., 2019; Phillips et al., 2018). Using ATOSS, Brossard et al. (2005) examined scientific knowledge and attitude change within citizen science projects and found that there was no significant change in participants’ attitudes towards science and the scientific process, suggesting that researchers need to clarify the issues that participants are engaging in. Therefore, in this study, the methods based on that of ATOSS were prepared and utilized for this research and the pre-departure preparation.

Other perception-based research on water quality or policy looked to understand the motivations and benefits behind participating in water quality data collecting (Alender, 2016; Carlson & Cohen, 2018; Church et al., 2018; Jollymore et al., 2017). Alender (2016) found that the strongest motivation to participate in citizen science water quality monitoring was engaging in work that helped the community, environment, and advanced scientific knowledge, suggesting that this is a useful tool to be used in other studies. Focusing more on government and how community-based water quality monitoring contributes to bigger government decision-making, Carlson and Cohen (2018) found that government decision-making and data collection should not completely rely on community-based water quality testing, meaning that participants should be better
trained to do water quality testing. Jollymore et al. (2017) incorporated citizen science within their water quality monitoring to analyze the data implications of citizen perspectives, finding that meaningful engagement with participants represents a substantial and under-utilized opportunity.

Prior to this study, there was no current literature on citizen science being conducted in an international setting by undergraduate students. Most citizen science activities pertain to “in your own backyard” activities, conducting research within local communities nearby (Clary et al., 2012). Local citizen science is a very useful and convenient way for engaging the public in fun and interactive science projects. “In your own backyard” citizen science also teaches public participants the importance of data collection as well as the importance of a growing issue or problem that the data collection is helping to solve (Clary et al., 2012). While local citizen science is deemed useful, studying the perceptions of citizen science and using water quality testing in international learning experiences poses a new way to further understand the impact of citizen science on participants (Andenoro & Bletscher, 2012; Green et al., 2011).
CHAPTER III

METHODLOGY

The methods outline the demographics of the participants in this study, the location of where the research took place, the instrumentation in detail, and the procedure in full. A description of the analysis ends this chapter to lead into the data findings of the following chapter.

Participants

The participants in this study were all undergraduate juniors and seniors from the University of Northern Iowa with 17 identifying as female and three as male. Their college majors were 90% business related with three in finance, seven in marketing, one in economics, three in accounting, two in management, and one in supply chain. Two individuals were not in a business related major: one in biology and one in education. These students were between the ages of 19 and 22, with one individual at the age of 19, five at 20, seven at 21, and seven at 22 years of age. All students reported Iowa as their home state. The participants in this study were part of a business capstone class that took the students to Costa Rica to study eco-tourism.

Research Location

This research took place in San José, Costa Rica, located in central Costa Rica and is the capital of the country (Figure 2). The students visited multiple locations throughout the city and countryside of Costa Rica. The citizen science activity as part of this research was completed in the study abroad hotel location within the city of San José during the students’ class hours.
Figure 2. Satellite Image of Costa Rica
Instrumentation

The instrumentation used for this research were a pre-survey, modified focus group, and post-survey. The surveys and modified focus group protocol were all researcher-created, incorporating some parts of existing successful instruments. The following describes the instruments and how they were implemented in the procedure using a mixed methods research design.

Pre-Survey

The goal of the pre-survey was to comprehend the participants’ initial understandings and perceptions of citizen science and water quality. The pre-survey was administered through Survey123 – an online survey tool, with a total of 18 questions and took the students less than 10 minutes to complete (Appendix A). There were seven demographic questions, three open-ended questions, two level of agreement question sections, five one-to-ten scale questions, and one “comments for me” textbox.

The open-ended questions asked about the students’ previous experience with citizen science and water quality testing and about what they thought the term ‘citizen science’ was defined as. The first section of level of agreement questions were created and adjusted based on Alender (2016) surveys from her “Level of Agreement with Reason for Volunteering” section. These questions asked about the students’ willingness to volunteer, their level of wanting to help their communities and environment, their level of wanting to learn, gain knowledge, and contribute to science, and their inclination to participate in citizen science. The second section of level of agreement questions were about water quality and how important water quality is to the students locally and
internationally. The one-to-ten scale questions asked the students about the importance of
citizen science, the importance of participating locally and internationally, how
comfortable they are with participating, and how likely the students are to participate in
citizen science. The “comments for me” section provided an open-end textbox for the
students to give any thoughts, concerns, or feedback to the researcher at the end of the
survey.

Focus Group

The goal of the modified focus group was to discuss the data findings and the
students’ thoughts on the whole process of “doing” citizen science through water quality
data collection. The modified focus group took 48 minutes and consisted of 13 semi-
structured probing questions with sub-questions for the participants (Appendix B). Three
questions related to location and its potential impact on the participants’ perceptions, six
questions related to participants’ gains and benefits, and seven questions related to
participants’ perceptions before and after participating. The information gathered from
the discussion in the modified focus group was recorded in an audio format and
transcribed for analysis by the researcher. Not all questions from this modified focus
group are reported on in the results chapter because some questions were used solely for
facilitating discussion, while others were used to answer the research questions.

Post-Survey

The goal of the post-survey was to further analyze the students’ perceptions of
citizen science and water quality issues after engaging in the process. The post-survey
partially reflected the pre-survey questions for comparison with the intention of
demonstrating initial student perceptions and the impact of the experience itself. The post-survey was administered through Survey123 with a total of 11 questions and took the students less than 10 minutes to complete (Appendix C). There were three open-ended questions, two level of agreement question sections, one level of understanding question, four one-to-ten scale questions, and one “comments for me” question.

The open-ended questions asked about what participating in citizen science means and what benefits the students felt they gained. Relating to the pre-survey, the first section of level of agreement questions was the same and were created and adjusted based on Alender (2016) surveys from her “Level of Agreement with Reason for Volunteering” section. These questions asked the students if they felt that they helped their communities and environment, if they learned anything, gained new knowledge, and contributed to science, and if their inclination to participate in citizen science increased. Also aligned with the pre-survey, the second section of level of agreement questions were about water quality and how important water quality is to the students locally and internationally. The level of understanding question was included from a survey created by Brossard et al. (2005) from their “Understanding of the Scientific Process Items” section. This question asked the students what level of understanding they have of the term ‘citizen science’ after participating. The one-to-ten scale questions asked the students about the importance of citizen science, how comfortable they are with participating in more citizen science studies, and how likely the students are to participate in other citizen science studies.
Procedure

The procedure was completed in six parts: pilot study, pre-survey, water testing, modified focus group, post-survey, and analysis of the data.

Part I - Pilot Study

The following procedure was piloted in Cedar Falls, Iowa at the University of Northern Iowa on June 30, 2019 with a group of eight undergraduate student volunteers. The purpose of this pilot study was to mock the actual study in order to practice, implement, and revise the following instrumentations and methodological order of the procedure. Special attention was paid to understanding the timing of the instrumentation and identifying potential flaws in the planned methods.

To begin, the students were sent a link to a pre-survey via email. Water quality testing began after the pre-survey using the Hach Water Testing Kits and Hach Water Testing Strips. Hach was used because of their reputation as an accurate source of data collection and availability. The students were separated into two groups and given the water samples with instructions. Each group tested for ammonium nitrogen, nitrate, free & total chlorine, pH, temperature, alkalinity, and hardness on three different water sources: bottled, tap, and surface water (collected from Dry Run Creek in Cedar Falls, IA). To simulate an actual citizen science project, all results were recorded on provided sheets of paper. Students were thanked with a complimentary meal. Immediately following the water testing, the modified focus group was held. The results from the modified focus group were recorded in an audio recording format. The focus group took
about 15 minutes to complete. After the focus group, the students were sent a link to the post-survey via email, which was completed immediately.

Adjustments & preparation. After the pilot study, necessary adjustments, editing, and revisions were made to the instrumentation based on responses and feedback from students. Specifically, adjustments were made through adding questions, revising the surveys and the focus group questions, increasing the number of recording devices for the focus group, editing the water testing instructions for clarification, and creating a presentation to better explain the test kits and the chemicals used.

Part II - Pre-Survey & Debriefing in the U.S.

A pre-departure meeting was scheduled by the professor leading the study abroad program on December 3rd, 2019. During this meeting, the pre-survey was given to the undergraduate students via the Survey123 link in a private Facebook group created by the study abroad department on campus to communicate directly with all of the students. Out of 22 students, 20 responded to the pre-survey, giving it a 90.9% response rate. After completing the pre-survey, the researcher presented a PowerPoint presentation outlining the water quality and ecology of Costa Rica, the water quality test kits they would be using, and the same chemicals as in the pilot study that they would be testing for. This included practice using the test kits with a tap water sample during the meeting so that the students would be more familiar with the kits when conducting the citizen science in San José. It took the students approximately 30 minutes to finish testing the chemicals with the tap water sample.
Part III – On-site Citizen Science Water Quality Testing in Costa Rica

Once in San Jose, Costa Rica, the citizen science activity of water quality testing with the students was completed on January 3rd, 2020. The tap water source was collected from a bathroom sink in the hotel, the bottled water source was purchased in a nearby convenience store, and the surface water was collected from a nearby water fountain in downtown San Jose (Figure 3).

Figure 3. Downtown San Jose Water Fountain (Surface Water Source) – While collecting this water source, a citizen went out of their way to tell me that this water was contaminated and that I shouldn’t drink it.
The students tested for chemicals in the water samples; specifically, ammonia nitrogen, nitrate, pH level, chlorine, hardness, and alkalinity. The water samples results were recorded on sheets of paper provided for the students (Appendix D).

Figure 4. The Students Conducting Water Quality Tests.

Part IV - Focus Group

After testing water samples, students were gathered for the modified focus group. The modified focus group occurred in an available meeting room in the study abroad hotel location, where students sat in a circle of chairs. There was 100 percent participation; 22 out of 22 students partook in the water quality testing and modified focus group. This has been considered a modified focus group because of the high
quantity of participants that is not considered a traditionally sized focus group. This focus group was also considered modified because it was found best to pass around the recording device to answer the questions, thus leading to an ‘ask and answer’ format rather than a traditional focus group discussion. The focus group audio recording was later transcribed by the researcher for analysis.

Part V - Post-Survey

One week after returning to the U.S. from Costa Rica, the post-survey was shared to the students through the same private Facebook group as the pre-survey via another Survey123 link. There were 20 out 22 students who responded to the post-survey, which also gave the post-survey a 90.9% response rate, consistent with the response rate to the pre-survey. With that said, student identifiers were not used in either survey, and thus the compared pre-survey and post-survey data is not paired data.

Part VI - Analysis

The pre-survey, modified focus group, and post-survey, collected through Survey123 and/or recorded and then transcribed, were analyzed for comparison and examined for patterns. Using Excel to export, organize, and analyze the survey data from Survey123, the quantitative survey information was analyzed using measure of central tendency and the qualitative data was analyzed for expected and emergent themes using a content analysis. For example, from the pre-survey data, 75% of students rated themselves above a five out of ten on their level of comfortability with participating in citizen science. Another example from the open-ended question of defining citizen science is that the expected themes included Citizens, Public, and Research, while the
emergent themes were found to be Citizens, Environment, and Community. The transcribing took approximately five hours intermittently and was done by listening to the recording and hand-typing each word that was said by the participants. The transcription was exported to Excel to better organize each individual question and the answers associated with them for coding of themes using a content analysis. Word cloud data was used as comparison to the manual codes for confirmation. The qualitative and quantitative data was triangulated for greater confirmation and reliability of the data. This occurred using methodological triangulation, meaning that there was more than one method used to gather data (i.e. focus group and surveys). The triangulated data was used to answer the research questions on perceptions of citizen science in an international setting.

**Analysis of the research questions.** The research questions were answered based on the content analysis of qualitative data. The following specific data was examined and triangulated to answer each question. Research question 1, *what are student perceptions of citizen science, before and after participating in an international citizen science activity*, uses the instrumentation to determine the students’ preconceived knowledge prior to participating, their perceived knowledge change on citizen science after participating, and lastly, their potential change in awareness on water quality testing and issues. Research question 2, *what do students gain from participating in an international citizen science activity*, investigates the students’ overall perceived gains regarding the importance of citizen science to students, the comfort level of the students with participating in citizen science, and their perceived benefits in participating. Research
question 3, *does location matter in an international citizen science learning experience*,
explores the importance of place to the students and is determined from the
instrumentation by examining the students’ perceived benefits in volunteering, their
motivation behind participating, and their inclination to participate based on geography.
CHAPTER IV

RESULTS

The results chapter details the findings from the three instruments in the order they were administered. The findings are analyzed and discussed in Chapter 5 to answer the research questions.

Pre-Survey

In this section of detailing the pre-survey results, participants’ self-characterizations are described as how the students define themselves in terms of their enjoyment with science, their personal scientific literacy, and their reasons for volunteering in citizen science. Following their self-characterizations are the students’ previous experiences as well as their comfortability with citizen science and water quality. The pre-survey sample size was 20 students (represented at N=20 during calculations).

Participants’ Self-Characterizations

Starting with the pre-survey questions, when asked if they enjoyed science classes in school, 11 out of 20 participants (55%) answered ‘no’, six (30%) answered ‘yes’, and three (15%) answered ‘somewhat’. Along with this, the students were asked if they considered themselves scientifically literate: nine out of 20 (45%) participants answered ‘no’, two (10%) answered ‘yes’, and nine (45%) answered ‘somewhat’.

Level of agreement questions. There were 11 questions in the Level of Agreement with Reason for Volunteering section on a scale of ‘strongly agree’, ‘agree’, ‘neutral/undecided’, ‘disagree’, and ‘strongly disagree’ that were based on percentage in the
following list and displayed graphically in Figure 5. 20 Participants were asked the questions listed below and the responses’ percentages were as follows:

- I want to help or enhance the environment.
  - Eight (40%) answered ‘strongly agree’.
  - 11 (55%) answered ‘agree’.
  - One (5%) answered ‘neutral/un-decided’.
  - Zero (0%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- I want to help the community.
  - 10 out of 20 participants (50%) answered ‘strongly agree’.
  - 10 (50%) answered ‘agree’.
  - Zero (0%) answered ‘neutral/un-decided’.
  - Zero (0%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- I want to get outside or connect with nature.
  - Nine (45%) answered ‘strongly agree’.
  - Nine (45%) answered ‘agree’.
  - Zero (0%) answered ‘neutral/un-decided’.
  - Two (10%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- I want to contribute to scientific knowledge.
  - One (5%) answered ‘strongly agree’.
  - 10 (50%) answered ‘agree’.
  - Six (30%) answered ‘neutral/un-decided’.
  - Three (15%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- I want to learn more about water quality.
  - Three (15%) answered ‘strongly agree’.
  - Eight (40%) answered ‘agree’.
  - Six (30%) answered ‘neutral/un-decided’.
  - Two (10%) answered ‘disagree’.
  - One (5%) answered ‘strongly disagree’.

- I want to learn skills or new knowledge while volunteering.
  - Seven (35%) answered ‘strongly agree’.
  - 10 (50%) answered ‘agree’.
  - Three (15%) answered ‘neutral/un-decided’.
  - Zero (0%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- I want to have fun while volunteering.
  - 12 (60%) answered ‘strongly agree’.
  - Eight (40%) answered ‘agree’.
- Zero (0%) answered ‘neutral/un-decided’.
- Zero (0%) answered ‘disagree’.
- Zero (0%) answered ‘strongly disagree’.

- I want to engage with other people while volunteering.
  - 10 (50%) answered ‘strongly agree’.
  - Nine (45%) answered ‘agree’.
  - One (5%) answered ‘neutral/un-decided’.
  - Zero (0%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- I would be more inclined to participate in citizen science if it was in a place I had never been before.
  - One (5%) answered ‘strongly agree’.
  - Six (30%) answered ‘agree’.
  - 12 (60%) answered ‘neutral/un-decided’.
  - One (5%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- I would be more inclined to participate in citizen science if it was in an international location.
  - One (5%) answered ‘strongly agree’.
  - Six (30%) answered ‘agree’.
  - Nine (45%) answered ‘neutral/un-decided’.
  - Four (20%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- I would be more inclined to participate in citizen science if it was close to where I live.
  - Three (15%) answered ‘strongly agree’.
  - Seven (35%) answered ‘agree’.
  - Seven (35%) answered ‘neutral/un-decided’.
  - Two (10%) answered ‘disagree’.
  - One (5%) answered ‘strongly disagree’.
**LEVEL OF AGREEMENT WITH REASON FOR VOLUNTEERING**

<table>
<thead>
<tr>
<th>Reason</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral/Undecided</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I WOULD BE MORE INCLINED TO PARTICIPATE IN CITIZEN SCIENCE IF IT WAS IN A PLACE I HAD NEVER BEEN BEFORE.</td>
<td>1</td>
<td>6</td>
<td>12</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>I WOULD BE MORE INCLINED TO PARTICIPATE IN CITIZEN SCIENCE IF IT WAS IN AN INTERNATIONAL LOCATION.</td>
<td>1</td>
<td>6</td>
<td>9</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>I WOULD BE MORE INCLINED TO PARTICIPATE IN CITIZEN SCIENCE IF IT WAS CLOSE TO WHERE I LIVE.</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>I WANT TO HELP OR ENHANCE THE ENVIRONMENT.</td>
<td>8</td>
<td>11</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I WANT TO HELP THE COMMUNITY.</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I WANT TO GET OUTSIDE OR CONNECT WITH NATURE.</td>
<td>9</td>
<td>9</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I WANT TO CONTRIBUTE TO SCIENTIFIC KNOWLEDGE.</td>
<td>1</td>
<td>10</td>
<td>6</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>I WANT TO LEARN MORE ABOUT WATER QUALITY.</td>
<td>3</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>I WANT TO LEARN SKILLS OR NEW KNOWLEDGE WHILE VOLUNTEERING.</td>
<td>7</td>
<td>10</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I WANT TO HAVE FUN WHILE VOLUNTEERING.</td>
<td>12</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I WANT TO ENGAGE WITH OTHER PEOPLE WHILE VOLUNTEERING.</td>
<td>10</td>
<td>9</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 5.** Level of Agreement with Reason for Volunteering Pre-Survey Questions – *This figure shows the rankings for each question, visualizing how much students agree or disagree with each statement.*
Participants’ Previous Experience with Citizen Science and Water Quality Testing

When asked if they have had any previous experience with citizen science, 17 out of 20 participants (85%) answered ‘no’, one (5%) answered ‘yes’, and two (10%) answered ‘maybe’. The participant who answered ‘yes’ said that they had done water quality testing with citizen science before. When asked if they have had any previous experience with water quality testing, 15 out of 20 participants (75%) answered ‘no’, five (25%) answered ‘yes’, zero (0%) answered ‘maybe’. The participants who answered ‘yes’ said that they had either tested in 8th grade science class, high school, or their hometown and tested bottled water, tap water, and surface water for pH levels and hardness.

The students were also asked, in your own words, what do you think the term ‘citizen science’ means?. For this open-ended question, three examples were pulled out of the 20 responses to show a spectrum of negative, neutral, and positive responses. The negative response was defined as a participant who was not sure what the term ‘citizen science’ meant. The neutral response was defined as a participant who somewhat knew what the term meant. The positive response was a participant who was close to the actual definition. The three responses are as follows, respectively:

<table>
<thead>
<tr>
<th>Negative</th>
<th>“I honestly don’t have the first idea. Maybe social science in how a citizen interacts with their culture and society?”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>“People that do not study science or do not have an extensive knowledge of science”</td>
</tr>
<tr>
<td>Positive</td>
<td>“Regular people helping with scientific research”</td>
</tr>
</tbody>
</table>
For the open-ended questions, the participants’ answers were qualitatively analyzed by the researcher, looking for descriptors to create codes that more specifically defined and exemplified the codes; see Table 1 for an example of the descriptor-code relationship. According to the researcher, the main descriptors were ‘Science’, ‘Citizens’, ‘Environment’, and ‘Participating’ (Table 1). The codes for ‘Science’ were scientific, collecting, testing, analyzing, observations, studying, research, and results (Table 1). The codes for ‘Citizens’ were people, community, non-science, no knowledge, not certified, individual or group, ordinary, normal, and regular (Table 1). The codes for ‘Environment’ were world, natural, doing good [for it], observing, human interactions [with it], and quality of life (Table 1). The codes for ‘Participating’ were working together and helping (Table 1). A Word Cloud was created using the responses given by the students to compare to the hand-coded descriptors and codes (Figure 6). A Word Cloud is a visual representation of text data that emphasizes keywords and trending terms based on the frequency of use and prominence.

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>Scientific, Collecting, Testing, Analyzing, Observations, Studying, Research, Results</td>
</tr>
<tr>
<td>Citizens</td>
<td>People, Non-science, No Knowledge, Not Certified, Individual or Group, Ordinary, Normal, Regular</td>
</tr>
<tr>
<td>Environment</td>
<td>World, Natural, Doing Good [for it], Observing, Human Interactions [with it], Quality of life</td>
</tr>
<tr>
<td>Participating</td>
<td>Working together, Helping</td>
</tr>
</tbody>
</table>

Table 1 Defining the Term ‘Citizen Science’ Codes
Citizen science. Students were asked a series of questions to respond using a scale of 1-10, these questions were about citizen science (Figures 7-10). When asked, how important do you think participating in citizen science is?, zero out of 20 participants (0%) answered ‘1’, zero (0%) answered ‘2’, zero (0%) answered ‘3’, zero (0%) answered ‘4’, four (20%) answered ‘5’, four (20%) answered ‘6’, six (30%) answered ‘7’, five (25%) answered ‘8’, zero (0%) answered ‘9’, and one (5%) answered ‘10’ (Figure 7).

The average rating of importance was 6.8 out of 10.
Figure 7. ‘Level of Importance in Participating in Citizen Science’ – This figure displays student response ratings based on how important they think it is to participate in citizen science.

When asked, how comfortable do you feel participating in citizen science?, one out of 20 participants (5%) answered ‘1’, one (5%) answered ‘2’, one (5%) answered ‘3’, two (10%) answered ‘4’, zero (0%) answered ‘5’, four (20%) answered ‘6’, two (10%) answered ‘7’, five (25%) answered ‘8’, two (10%) answered ‘9’, and two (10%) answered ‘10’ (Figure 8). The average rating of comfortability was 6.5 out of 10.
When asked, *how likely are you to participate in citizen science locally?*, one out of 20 participants (5%) answered ‘1’, one (5%) answered ‘2’, one (5%) answered ‘3’, two (10%) answered ‘4’, three (15%) answered ‘5’, four (20%) answered ‘6’, five (25%) answered ‘7’, zero (0%) answered ‘8’, one (5%) answered ‘9’, and two (10%) answered ‘10’ (Figure 9). The average rating of likeliness was 5.85 out of 10.
When asked, *how likely are you to participate in citizen science internationally?*, zero out of 20 participants (0%) answered ‘1’, one (5%) answered ‘2’, three (15%) answered ‘3’, four (20%) answered ‘4’, three (15%) answered ‘5’, four (20%) answered ‘6’, two (10%) answered ‘7’, three (15%) answered ‘8’, zero (0%) answered ‘9’, and zero (0%) answered ‘10’ (Figure 10). The average rating of likeliness was 5.05 out of 10.
Figure 10. ‘How Likely Students are to Participate in a Foreign Location’ – *This figure displays student response ratings based on their likeliness to participate in citizen science in a foreign location.*

**Water quality.** The students were asked three Level of Agreement with Water Quality Importance questions on a scale of ‘strongly agree’, ‘agree’, ‘neutral/un-decided’, ‘disagree’, and ‘strongly disagree’ (Figure 11):

- The quality of water where I live is important to me.
  - 17 (85%) answered ‘strongly agree’.
  - Three (15%) answered ‘agree’.
  - Zero (0%) answered ‘neutral/un-decided’.
  - Zero (0%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.
- The quality of water in Costa Rica is important to me.
  - Nine (45%) answered ‘strongly agree’.
Nine (45%) answered ‘agree’.
Two (10%) answered ‘neutral/un-decided’.
Zero (0%) answered ‘disagree’.
Zero (0%) answered ‘strongly disagree’.

- The quality of water everywhere is important to me.
  - 11 (55%) answered ‘strongly agree’.
  - Six (30%) answered ‘agree’.
  - Three (15%) answered ‘neutral/un-decided’.
  - Zero (0%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

Figure 11. Level of Agreement with Water Quality Importance Pre-Survey Questions – This chart shows the students’ level of importance of water quality to them based on location. No student disagreed or strongly disagreed with any of the statements.

When asked, how comfortable do you feel doing water quality testing?, one out of 20 participants (5%) answered ‘1’, one (5%) answered ‘2’, two (10%) answered ‘3’, two (10%) answered ‘4’, three (15%) answered ‘5’, four (20%) answered ‘6’, two (10%) answered ‘7’, three (15%) answered ‘8’, one (5%) answered ‘9’, and one (5%) answered ‘10’. The average rating of comfortability was 5.65 out of 10.
Focus Group

The students went through a 13 question – with sub-questions – modified focus group protocol. Some questions were filler questions (i.e. opening questions to facilitate discussion) and others being pertinent to this study. Thus, not all questions were reported on as mentioned in the previous chapter, since they are not essential in answering the research questions. The modified focus group results detail the students’ perceptions of citizen science and participating in citizen science, immediately following the citizen science activity of water quality testing. These results are separated into pre and post perceptions of this citizen science activity, personal gains and benefits that the students felt they received, and the role that location plays to the students. The modified focus group was analyzed differently than the pre- and post-surveys because the responses given were all open verbal responses and thus not as definitive, and not all 22 students responded, or felt the need to answer, each focus group question as they did in the surveys.

Pre and Post Citizen Science Activity Perceptions

Citizen science. Students were asked the following questions about their perception of citizen science:

- What are your immediate thoughts and reactions to partaking in citizen science?
- How do you think this citizen science study went? What are your thoughts and feelings about citizen science now that you’ve participated in it?

The transcribed responses to these questions were studied for main descriptors and codes. The main descriptors for the question, *what are your immediate thoughts and reactions to partaking in citizen science?*, were ‘Could Be Fun’, ‘Not Interested’, and ‘Impacts’
(Table 2). The codes for ‘Could Be Fun’ were depending on interests and relevance, depends on people, digital tool would be fun, access to easier tools, and directly affects me (Table 2). The codes for ‘Not Interested’ were not going to care, inaccurate, and tedious process (Table 2). The codes for ‘Impacts’ were who it impacts, who it's for, how it impacts people, the market for citizen science, effects on people, motivation behind it, helpful, and reason for it (Table 2). A Word Cloud was not always used in the analysis because there was significant data in the students’ oral responses.

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Could Be Fun</td>
<td>depending on interests and relevance, depends on people, digital tool would be fun, access to easier tools, directly affects me</td>
</tr>
<tr>
<td>Not Interested</td>
<td>not going to care, inaccurate, tedious process</td>
</tr>
<tr>
<td>Impacts</td>
<td>who it impacts, who it's for, how it impacts people, the market for citizen science, effects on people, motivation behind it, helpful, reason for it</td>
</tr>
</tbody>
</table>

Table 2 ‘Immediate Thoughts and Reactions to Citizen Science’ Codes

To further understand these codes, three responses are listed to provide better details on the main descriptors and associated codes. The main descriptors are found in each of these example responses throughout.

“I think unless it really personally affects me, I don’t feel I’d get that involved. Obviously, there’s certain circumstances like Flint and stuff. I feel like that would be kind of something I would want to get involved in or help with those kind of projects”

“I think, you talked about how having the digital one that your professor bought for you or whatever, that would be more fun than this tedious process. So if we had access to easier tools, I would be more interested in doing that.”
“I think depending on what the test is and if it’s something that’s relevant to you or interesting to you, it could be fun and depending on the people you’re with, but if it’s something that you have zero interest in, it’s not going to be anything that you really cared to do accurately or well.”

The descriptors for the question, *how do you think this citizen science study went?* *What are your thoughts and feelings about citizen science now that you’ve participated in it?*, were broken down into ‘Positive Answers’ and ‘Negative Answers’ (Table 3). The codes for ‘Positive Answers’ were easy to get involved, helping others, already doing something interested in, doing something that affects others, beneficial to someone, if paid motivation changes, and the class is incentive (Table 3). The codes for ‘Negative Answers’ were had to do this, don't know what's happening with data, confusing, more interesting elsewhere, stressful, need clear order of operations, need ease of access, don't know what's happening, and need incentive (Table 3).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Answers</td>
<td>easy to get involved, helping others, already doing something interested in, doing something that affects others, beneficial to someone, if paid motivation changes, the class is incentive</td>
</tr>
<tr>
<td>Negative Answers</td>
<td>had to do this, don't know what's happening with data, confusing, more interesting elsewhere, stressful, need clear order of operations, need ease of access, don't know what's happening, need incentive</td>
</tr>
</tbody>
</table>

Table 3 ‘How This Citizen Science Study Went’ Codes
To understand these codes, two examples were pulled from the responses to show a positive and negative response. The positive response was a participant who had a good reaction to how this citizen science study went. The negative response was defined as a participant who had a poor reaction to how this citizen science study went.

**Positive** - “I think ease of access to do it too is really nice, like I go fishing a lot and it’s really easy for them to collect records of fish populations because they add drop boxes of you know, “what did you catch that day?” Add like length measurements, number of fish, like there’s ways you can do that. People can easily get involved in and then you’re helping the DNR, or whoever it is, [and] help with something you’re really interested in or a passion you have. So, you know, getting involved in what interests you, I think, is really easy and actually kind of cool.”

**Negative** - “I think we did it because we were told and we don’t know what’s happening with the data, if it’s helping anyone, if it’s going out to the public. So I feel like that’s where it gets confusing for me.”

**Water quality testing.** Students were asked the following questions about their perception of water quality testing:

- How do you think the testing went? What are your thoughts and feelings about water quality testing now that you have done it?
- Was it fun or boring to you to be using these test kits? Would you use them again?

The responses to these questions were examined, looking for main descriptors and codes. The main descriptors for the question, *how do you think the testing went? What are your thoughts and feelings about water quality testing now that you have done it?*, were broken down into ‘Positive Answers’ and ‘Negative Answers’ (Table 4). The codes for ‘Positive Answers’ were easy, test strips easy, easier when equipped, beneficial to keep up, pretty easy to do, and interesting when someone else does it (Table 4). The codes for ‘Negative Answers’ were not cost effective, carrying it around, more compact, costly.
time consuming, questionable accuracy, different results, concerning, need large numbers of people, don't believe I can do it, and hard to change view (Table 4).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive Answers</strong></td>
<td>easy, test strips easy, easier when equipped, beneficial to keep up, pretty easy to do, interesting when someone else does it</td>
</tr>
<tr>
<td><strong>Negative Answers</strong></td>
<td>not cost effective, carrying it around, more compact, costly, time consuming, questionable accuracy, different results, concerning, need large numbers of people, don't believe I can do it, hard to change view</td>
</tr>
</tbody>
</table>

Table 4 ‘How the Testing Went’ and ‘Immediate Thoughts and Reactions to Water Quality Testing’ Codes

To understand these codes, two examples were pulled from the responses to show a positive and negative response. The positive response was a participant who had a good reaction to how the water quality testing went. The negative response was defined as a participant who had a poor reaction to how the water quality testing went.

**Positive** - “I think it’s pretty easy. Well, I guess I didn’t do the spinner wheel, but the strips are easy. If it was more cost effective of carrying it around with you when you traveled, I think it would be beneficial for us to keep up with it.”

**Negative** - “I’m a big answer person. I want there to be answers, so it’s really hard for me to not know if we did it right at all and so it’s hard for me to change my view on it because I don’t believe I can do water testing. So it’s hard to change my view that I should be doing it.”

The main descriptors for the question, *was it fun or boring to you to be using these test kits? Would you use them again?*, were broken down into ‘Fun’ and ‘Boring’ (Table 5). The codes for ‘Fun’ were knew each other, made it fun, only couple minutes,
to a certain point, people with, made it exciting, joked around, science is fun, and good group of people (Table 5). The codes for ‘Boring’ were time consuming, frustrating, waiting, more tubes, tedious, wasting materials, not fun, actual testing, and wouldn't do by myself or with strangers (Table 5).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fun</td>
<td>knew each other, made it fun, only couple minutes, to a certain point, people with, made it exciting, joked around, science is fun, good group of people</td>
</tr>
<tr>
<td>Boring</td>
<td>time consuming, frustrating, waiting, more tubes, tedious, wasting materials, not fun, actual testing, wouldn't do by myself or with strangers</td>
</tr>
</tbody>
</table>

Table 5 ‘Using the Test Kits is Fun or Boring’ Codes

Two responses were selected to provide better details on how the main descriptors were found. The responses are as follows:

“I would say it was fun for the first couple of minutes and then it just got tedious. Doing the three different tests over the same thing over and over again, that’s just the tedious part, and I think if I was with complete strangers, I’d hate my life.”

“So, I would never say it was necessarily fun to do the actual testing, but we made it fun. So, the people I was with made it exciting and fun and we joked around. So, I think science is fun as long as you’re with a good group of people, but like [she] said, if I was by myself or with strangers, no way.”

Overall perceptions. The students were asked the following questions about their overall perceptions of this study:

- Do you feel like you understand what you’re doing and why you’re doing it?
- What were you expecting before participating in this study?
- How are your thoughts, feelings, and expectations of water quality testing and citizen science different after participating?
• Did you feel like any part of this process was too difficult or not engaging? Which part and why?
• What is one question this water testing and citizen science study makes you want to ask? What do you want to know?
• What was your favorite part of the whole process today? And why?
• Is this something you can see yourself doing again?

The responses to these questions were studied for main descriptors and codes. The main descriptors for the question, *do you feel like you understand what you’re doing and why you’re doing it?*, were ‘Not Understanding’, ‘Do Not Care’, ‘Not Convenient’, ‘Understanding’, and ‘Suggestions’ (Table 6). The codes for ‘Not Understanding’ were absolutely not, still don't, do not know what it means, vocabulary, hard to follow, can't remember presentation, and low motivation to understand (Table 6). The codes for ‘Do Not Care’ were difficult, not going to care, peaked curiosity, and doesn't pertain to me (Table 6). The codes for ‘Not Convenient’ were would learn more if was convenient and would do more if was convenient (Table 6). The codes for ‘Understanding’ were recite some stuff, familiar with numbers, consistently work with data, presentation, and learned a little more (Table 6). The codes for ‘Suggestions’ were having other people and cheat sheet with definitions (Table 6).
Main Descriptor | Codes
--- | ---
Not Understanding | absolutely not, still don't, do not know what it means, vocabulary, hard to follow, can't remember presentation, low motivation to understand
Do Not Care | difficult, not going to care, peaked curiosity, doesn't pertain to me
Not Convenient | would learn more if was convenient, would do more if was convenient
Understanding | recite some stuff, familiar with numbers, consistently work with data, presentation, learned a little more
Suggestions | having other people, cheat sheet with definitions

Table 6 ‘Understanding What They’re Doing and Why’ Codes

Three examples are listed below to display the variety of responses corresponding with the main descriptors and codes.

| “Absolutely not. I still don’t understand. I sat through the presentation, I could recite some of the stuff other people were reciting, but I still do not know what any of it means.” |
| “Going off that, I don’t really understand the vocabulary of alkalinity, and I still don’t understand completely what that is, and if I don’t understand it, it’s just hard to follow so.” |
| “I would do and learn – going off of your point – learn more about it if it was convenient, but if it was not convenient, I’m not going to look it up and I’m not going to care about what it is or what it means.” |

The main descriptors for the question, *what were you expecting before participating in this study?*, were broken down into ‘Expectations’ and ‘Reality’ (Table 7). The codes for ‘Expectations’ were one and done, rainforest, community involvement,
and outside (Table 7). The codes for ‘Reality’ were not what happened and hotel (Table 7).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expectations</td>
<td>one and done, rainforest, community involvement, outside</td>
</tr>
<tr>
<td>Reality</td>
<td>not what happened, hotel</td>
</tr>
</tbody>
</table>

Table 7 ‘Expectations Before Participating’ Codes

To understand these codes, two responses were selected to show the difference between expectations and reality. The responses are as follows:

“I was expecting one and done and we were out and that’s not what happened.”

“I thought we were going to be in the rainforest for this for some reason, versus actually inside in the hotel.”

The main descriptors for the question, How are your thoughts, feelings, and expectations of water quality testing and citizen science different after participating?, were ‘Concerned’, ‘Awareness’, and ‘Involvement’ (Table 8). The codes for ‘Concerned’ were no change, wary about results, and big differences (Table 8). The codes for ‘Awareness’ were citizen science, advertising, marketed more, and put in front of people (Table 8). The codes for ‘Involvement’ were passionate people involved, doing something you love, and help others (Table 8).
Main Descriptors | Codes
--- | ---
Concerned | no change, wary about results, big differences
Awareness | citizen science, advertising, marketed more, put in front of people
Involvement | passionate people involved, doing something you love, help others

Table 8 ‘Thoughts, Feelings, Expectations Different After Participating’ Codes

All three responses were shared below as a means to explain how and why the main descriptors and codes were chosen.

“My only thing is [that] nothing really changed other than I just kind of, after seeing the discrepancies between the two groups testing, I’m just now more I guess wary about the results from citizens testing because I don’t know about you guys, but there was some pretty big differences.”

“From a marketing perspective, now that I have the awareness of citizen science, it needs to be advertised and marketed a lot more so people who are passionate about their industries or whatever the citizen science is pertaining to, they can be involved in it versus just happening to run into it like we are right now.”

“Yeah like how [he] was talking earlier, he helps the DNR by doing something he’s passionate for, so he’s already fishing. So, awareness of putting it in front of people’s face while you’re doing something you love to also help someone else.”

The main descriptors for the question, **did you feel like any part of this process was too difficult or not engaging? Which part and why?**, were ‘Time’, ‘Organization’, ‘People’, and ‘Perspective’ (Table 9). The codes for ‘Time’ were too long and could be shorter (Table 9). The codes for ‘Organization’ were lack of and not enough tubes (Table 9). The codes for ‘People’ were too many and not enough tasks (Table 9). The code for ‘Perspective’ was different if scientist (Table 9).
### Main Descriptor | Codes
--- | ---
Time | too long, could be shorter
Organization | lack of, not enough tubes
People | too many, not enough tasks
Perspective | different if scientist

Table 9 ‘Too Difficult or Not Engaging Parts of the Process’ Codes

All three responses are listed below to further show the connection between the responses and the codes.

| “I kind of [want to] reiterate on the lack of organization. We were just kind of given tubes and not enough, so we had to reuse a lot of them. So, it extended the time that it took. It could have been a lot shorter, which would’ve been nice.” |
| “There were also a lot of people in each group, so a lot of people didn’t have specific jobs or tasks to do, which kind of then limited attention.” |
| “I also think if we – the majority of us are business majors – so, I think if we were in the science field, I think we would’ve had a different perspective on this whole thing.” |

When asked, *what was your favorite part of the whole process today? And why?*, the main descriptors were found to be ‘Results’, ‘Teamwork’, and ‘Finishing’ (Table 10).

The code for ‘Results’ was comparing Costa Rica to Iowa (Table 10). The code for ‘Teamwork’ was hearing others’ thoughts (Table 10). The codes for ‘Finishing’ was being honest (Table 10).

### Main Descriptor | Codes
--- | ---
Results | Comparing Costa Rica to Iowa
Teamwork | Hearing others’ thoughts
Finishing | Being honest

Table 10 ‘Favorite Part of the Whole Process’ Codes
The main descriptors for the question, *what is one question this water testing and citizen science study makes you want to ask? What do you want to know?*, were broken down into three categories based on the questions that the participants asked; ‘Involvement’, ‘Benefits’, and ‘Impact’.

- The questions asked that were pertaining to ‘Involvement’ were:
  - Why don’t more people do it?
  - How many people actually participate in citizen science?
  - How can I get involved and where do I go to get involved?

- The questions asked that were pertaining to ‘Benefits’ were:
  - What are the benefits of having citizens do the science, instead of people that are trained?
  - What are the benefits of our experiments that we did?
  - Where do the results end up? Who do they benefit directly?

- The question asked/statement made pertaining to ‘Impact’ was:
  - It would be cool to see a correlation between how many studies are done and how many of those studies are actually impactful.

Lastly, to understand the students’ perceptions before and after participating, I asked them, *is this something you can see yourself doing again?* (Figure 12). 12 out of 22 participants (54.5%) answered ‘Yes’, three (13.6%) answered ‘No’, and seven (31.8%) answered ‘Maybe/Possibly’ (Figure 12). The seven participants who answered with ‘Maybe/Possibly’ stated that they would need an incentive or would need to be interested in the subject.
Figure 12. ‘Asking the Students if This is Something They Would Do Again’

The students were asked if citizen science is something that they would participate in again, with the majority answering ‘Yes’ or ‘Maybe’.

Personal Gains and Benefits from Participating

The students were asked a series of questions focused on their personal gains and benefits from participating in this study. The questions asked relating to this were:

- How do you feel being acquainted with everyone? Does being acquainted increase your motivation to do citizen science? Does being acquainted determine your level of motivation and knowledge growth?
- How do you feel your expectations were met, not met, or exceeded?
- What have you gained from this experience?
- What is one takeaway from today that you will remember forever?
- How do you think that this information is important to take with you?

The main descriptors for the question, how do you feel being acquainted with everyone? Does being acquainted increase your motivation to do citizen science? Does being acquainted determine your level of motivation and knowledge growth?, were ‘Stake’, ‘Continue’, and ‘People You Know’ (Table 11). The codes for ‘Stake’ were not about being acquainted and recognizing our stake in society (Table 11). The codes for ‘Continue’ were doing citizen science and keep it in mind (Table 11). The codes for
‘People You Know’ were a lot easier, get to know each other, testing with same group, and flow better (Table 11).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stake</td>
<td>not about being acquainted, recognizing our stake in society</td>
</tr>
<tr>
<td>Continue</td>
<td>time, doing citizen science, keep it in mind</td>
</tr>
<tr>
<td>People You Know</td>
<td>a lot easier, get to know each other, testing with same group, flow better</td>
</tr>
</tbody>
</table>

Table 11 ‘Motivation and Knowledge Growth Based on Being Acquainted’ Codes

To understand these codes, three responses were pulled provide greater understanding of the students’ motivations and knowledge growth with being acquainted. The responses are as follows:

“I feel in this case it’s not so much of being acquainted that brings us to this, it’s more of we have a stake. Seeing that we’re from America, it’s an individualistic society. I think it’s more of us having a stake in the water and us recognizing that stake, which makes us – would make us – prompted to continue doing citizen science and not so much just doing it for the benefit as we see everyone, if it’s not just for ourselves. I guess I’m trying to say is pretty much how we view ourselves versus how other people view – like back to [his] original point of individualism in America [and] family here, it’s that type of thing. We just have to recognize that we have a stake in it to continue it.”

“I think that seeing how much you have put your time into this has really affected my look on it and how going forth I’ll continue to keep it in mind.”

“I think that being acquainted makes it a lot easier. We definitely had all the pre-meetings to get to know each other and we’ve even done the experiment before, so we have done the testing with the same group of people, and I think that that made it flow a lot better this time around and it’s just nice to work with people that you know.”
For the question, *how do you feel your expectations were met, not met, or exceeded?*, no participants answered ‘Exceeded’, so the main descriptors were broken down into ‘Met’ and ‘Not Met’ with the three responses given (Table 12). The code for ‘Met’ was comparing data (Table 12). The codes for ‘Not Met’ were confusing, don't know, didn't understand, too long, and different (Table 12).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Met</td>
<td>comparing data</td>
</tr>
<tr>
<td>Not Met</td>
<td>confusing, don't know, didn't understand, too long, different</td>
</tr>
</tbody>
</table>

Table 12 ‘How Expectations Were Met or Not Met’ Codes

All three responses are shared below to explain the codes and main descriptors corresponding to the responses.

“I feel like my expectations were met because we got to compare data from Iowa to Costa Rica, but I also feel like they were not met because I was kind of confused on what I was testing for some of them because I didn’t remember what they meant. And then also not having a comparison factor, like knowing what’s good and bad made it – yeah I forget what I was saying but okay.”

“I felt like for me it was hard to have any expectations because I didn’t know what was going on and I didn’t understand why we were coming here to do water testing if the water was already safe to drink. And I also didn’t – when we signed up for this class, I don’t know about you guys, but I didn’t know water testing was a part of it at all. So, I didn’t have any expectations to be doing that, so it was hard to form any personal expectations. I just thought it was something we had to do.”

“I just felt like mine weren’t met because of how our professor kind of talked about it. He said, “Yeah she’ll be coming and we’re doing water testing and this is how it’s going to go”, and that’s why I thought it would be a lot shorter. And had I known that right away from the beginning, I would’ve been okay with it and I’m still okay with it, but [it’s] just a little different than what I thought.”
When asking students, *what have you gained from this experience?*, all 22 participants gave a response. From the responses, the main descriptors were ‘Citizen Science’, ‘Water Quality’, ‘People’, ‘Appreciation’, ‘Experience’, and ‘Awareness’ (Table 13). The codes for ‘Citizen Science’ were important, I can do it, exists, answers questions, and make impact (Table 13). The codes for ‘Water Quality’ were think about it, different, and learn differences between water (Table 13). The codes for ‘People’ were teamwork, what people can do, unique, trust, and regular (Table 13). The codes for ‘Appreciation’ were regained for science and everything science does (Table 13). The codes for ‘Experience’ were unique, different perspective, cool, new place, perspective of world, eye-opening, and interesting (Table 13). The codes for ‘Awareness’ were more well-know and what citizen science is (Table 13). A Word Cloud was created from the responses given by the students to compare to the hand-coded descriptors and codes (Figure 13).
<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citizen Science</td>
<td>important, I can do it, exists, answers questions, make impact</td>
</tr>
<tr>
<td>Water Quality</td>
<td>think about it, different, learn differences between water</td>
</tr>
<tr>
<td>People</td>
<td>teamwork, what people can do, unique, trust, regular</td>
</tr>
<tr>
<td>Appreciation</td>
<td>regained for science, everything science does</td>
</tr>
<tr>
<td>Experience</td>
<td>unique, different perspective, cool, new place, perspective of world, eye-opening, interesting</td>
</tr>
<tr>
<td>Awareness</td>
<td>more well-know, what citizen science is</td>
</tr>
</tbody>
</table>

Table 13 Defining ‘What Students Gained from This Experience’ Codes
The students were asked what they felt they gained from this experience in their own words. This is a Word Cloud of their answers. Similar to the researcher’s codes, the important words from this Word Cloud are Science, Citizen, People, Awareness, and Perspective.

When asked, what is one takeaway from today that you will remember forever?, three students responded, each with a different take on their experience:

<table>
<thead>
<tr>
<th>Takeaway</th>
</tr>
</thead>
<tbody>
<tr>
<td>“I helped you and your research project and that’s the most important thing.”</td>
</tr>
<tr>
<td>“That the tap water is actually safe in Costa Rica.”</td>
</tr>
<tr>
<td>“That it doesn’t actually take that much time out of your day and that anyone can do it.”</td>
</tr>
</tbody>
</table>
Similarly, when asked, *how do you think that this information is important to take with you?*, a single response given was:

“I think it’s important to give back to others and help others and I think this is a new way to do that a lot of us probably didn’t know about before this event.”

Importance of Location

The students were asked a series of questions focused on location and the impact of location on this study. The questions asked relating to this are as follows:

- Why do you think I had you do this study while in an international place?
- Do you feel as though this impacted how you did this study? Being in a foreign location? How?
- Is this something that you would do back home? Do you feel as though it is more beneficial to do this in a foreign location?
- How does location matter to you in this situation? Do you feel it affects your participation and motivation?
- Does participating in citizen science seem more fun or interesting to you because it is in a new-to-you location? Why or why not?
- How likely are you to participate in local citizen science studies back in the US, wherever your hometown is, now?
- What about international citizen science studies? How likely are you to participate in international citizen science studies, now that you’ve done one?
- Do you feel more inclined to participate locally or in a not-as-well-known location, or different location? Which one do you feel more inclined to do for citizen science?

The main descriptors for the question, *why do you think I had you do this study while in an international place?*, were ‘Comparison’, ‘Water’, ‘Cultures’, and ‘Beneficial’ (Table 14). The codes for ‘Comparison’ were U.S. to other countries and different country (Table 14). The codes for ‘Water’ were differences, how clean it is, and water quality studies (Table 14). The codes for ‘Cultures’ were high quality of living, individual focused, under the surface, social political, laid back, family focused, looks some way,
and different perspectives (Table 14). The code for ‘Beneficial’ was to connect (Table 14).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparison</td>
<td>U.S. to other countries, different country</td>
</tr>
<tr>
<td>Water</td>
<td>Differences, how clean it is, water quality studies</td>
</tr>
<tr>
<td>Cultures</td>
<td>High quality of living, individual focused, under the surface, social political, laid back, family focused, looks some way, different perspectives</td>
</tr>
<tr>
<td>Beneficial</td>
<td>To connect</td>
</tr>
</tbody>
</table>

Table 14 Defining ‘Why They are Doing this Study in an International Place’ Codes

The main descriptors for the question, *do you feel as though this impacted how you did this study? Being in a foreign location? How?*, were ‘Attention’, ‘Perspective’, and ‘Motivations’ (Table 15). The codes for ‘Attention’ were more, focused, and not as new (Table 15). The codes for ‘Perspective’ were living quality, expecting different numbers, perspective of water, not much different, and more interested here (Table 15). The codes for ‘Motivations’ were travelled all the way here, made the effort, and hectic time in semester (Table 15).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>more, focused, not as new</td>
</tr>
<tr>
<td>Perspective</td>
<td>living quality, expecting different numbers, perspective of water, not much different, more interested here</td>
</tr>
<tr>
<td>Motivations</td>
<td>travelled all the way here, made the effort, hectic time in semester</td>
</tr>
</tbody>
</table>

Table 15 ‘Foreign Location Impacts on How They Did This Study’ Codes
To better understand these codes, two responses were selected to provide detail on the main descriptors and codes that were found. The responses are as follows:

“I think the fact that you traveled all the way here kind of for this study made us pay a little more attention to it than maybe we did in class, since you made the effort to do that.”

“I feel like it has – it didn’t change a ton, like I agree with that factor that I was more focused on it this time maybe because it wasn’t as new and wasn’t such a hectic time in the semester.”

When asked, *is this something that you would do back home? Do you feel as though it is more beneficial to do this in a foreign location?*, the two responses given were one ‘Yes’ and one ‘No’, both with an explanation. The responses are as follows, respectively:

**Yes** - “I think it would be beneficial to do it anywhere just to see the differences between even cities in the state or the US, because Cedar Falls has really hard water, but Cedar Rapids has way better water and I feel comfortable drinking that water, but I don’t feel comfortable drinking the Cedar Falls water. So, I think it’d be interesting to see the differences between the two.”

**No** - “I think it’s interesting to see the differences, but am I actually going to do it? Probably not.”

Similarly, when asked, *how does location matter to you in this situation? Do you feel it affects your participation and motivation?*, two responses were given; one ‘Yes’ and one ‘No’.

**Yes** - “Yeah, I think so because Central America kind of gets a bad rep for not having good water quality, so I think bringing it here – even though we knew it was good – to actually test it and find out, [would] make our moms feel better about it.”

**No** - “I think one thing that was hard was with us not testing it and then doing it in a hotel room that looks very similar to America, it didn’t really feel like we left. So, I’m like ‘Ah man we’ve could’ve just done this back in the states’. Somebody could’ve shipped us water or something like that and it would’ve been the same thing, since we didn’t actually see the testing, so that would’ve kind of enhanced the motivation.”
The overall descriptor for the question, *does participating in citizen science seem more fun or interesting to you because it is in a new-to-you location? Why or why not?,* was ‘No’ (Table 16). The codes for this descriptor were in hotel, rather do in river, priority isn’t this, hard to get into citizen science mode, rather do in non-vacation location, want to relax, not do citizen science, location doesn’t matter, and just helping out fellow student (Table 16).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>in hotel, rather do in river, priority isn't this, hard to get into citizen science mode, rather do in non-vacation location, want to relax, not do citizen science, location doesn't matter, and just helping out fellow student</td>
</tr>
</tbody>
</table>

Table 16 ‘Whether Participating is More Fun in a Different Location’ Codes

The three responses to this question are listed below to show a variety of reasons for why participating in a different location is not more fun to the students.

“F*.*m me also, I wasn’t really here for – my main priority on this trip definitely isn’t school. So, for me it’s more of a vacation so it’s hard for me to get in the mode to do citizen science, even though we’re in a different country. But again, if I was going to Africa where I know it’s a third world country, where it’s not really be a vacation, it’s going to be more of helping people [and] I feel like I’d be more prone to do it. Whereas, Costa Rica I view it more as a beachy, ‘let’s hang out and relax’, not citizen science.”
“I think it helps that you come from UNI too and so even though I’m not super passionate about this, I want to help you as a fellow UNI student and you’re really nice, so that helps too. But somebody that I completely don’t know and I just came to Costa Rica and we were like, ‘oh, we’re going to go do this citizen science thing’, I think that might be also more difficult, even if it was outside and things like that.”

Similarly, there was a single overall descriptor of ‘Maybe’ for the question, how likely are you to participate in local citizen science studies back in the U.S., wherever your hometown is, now? (Table 17). The codes for ‘Maybe’ were if opportunity presented itself, needs to be an interest, need incentives, and wouldn't seek out (Table 17).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
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</thead>
<tbody>
<tr>
<td>Maybe</td>
<td>if opportunity presented itself, needs to be an interest, need incentives, wouldn't seek out</td>
</tr>
</tbody>
</table>

Table 17 ‘Likeliness to Participate Back Home’ Codes

To understand these codes, the two responses are as follows to provide detail on the students’ likeliness to participate in citizen science back home:

“I definitely don’t think I’d seek it out, but like I said, if the opportunity presented itself with incentives, I wouldn’t be opposed to it.”

“I second that. I think that I don’t know what the opportunities are for citizen science in my area, so if I did know and I saw something that I was interested in, I would be more apt to do it.”

The overall descriptor for the question, what about international citizen science studies? How likely are you to participate in international citizen science studies, now that you’ve done one?, was also ‘Maybe’ (Table 18). The codes for ‘Maybe’ were needs to be warm, motivating, thrill in different country, and if already there (Table 18).
<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maybe</td>
<td>needs to be warm, motivating, thrill in different country, if already there</td>
</tr>
</tbody>
</table>

Table 18 ‘Likeliness to Participate Internationally’ Codes

The responses for these codes are listed below to show how the main descriptors and codes correspond to the responses.

“I think it’s more motivating now that we’re in Costa Rica because it kind of gives us a – I don’t know, at least for me it’s a thrill to kind of be a in different country. So, I think if there’s an opportunity to do an international project, I think I’d maybe jump on the chance to do it. Preferably somewhere warm during the winter.”

“Well I mean, with this we’re assuming we’re travelling. Obviously to travel you probably need money, so if I was in a place at the time, I’d probably might be likely to do it.”

To put together these questions about location in citizen science, the students were asked, *do you feel more inclined to participate locally or in a not-as-well-known location, or different location? Which one do you feel more inclined to do for citizen science?*. The overall answer was ‘Locally’. The responses are as follows:

“I mean, I feel more inclined to do it locally because, I mean, that’s my home. Anything that happens there does really affect me directly as opposed to say we do it here in Costa Rica, yeah it’s cool that we checked the water, but ten days down the road does it really going to impact me that much? Probably not.”

“I would rather help people at home and be able to possibly see the results from a close point of view.”

**Post-Survey**

The post-survey results are focused on the students’ perceptions after participating, both on citizen science and water quality. The last section of these results
details the students’ overall understanding and benefits of participating. The post-survey sample size was 20 students (represented at N=20 during calculations).

**Perceptions after Participating**

The post-survey was purposefully designed to complement the pre-survey by asking similar questions as a comparison to see how their answers as a group may or may not have changed after participating in citizen science. After participating, the students were asked their understanding of what the term ‘citizen science’ means: two out of 20 participants (10%) answered ‘a clear understanding of what it means’, 14 (70%) answered ‘a basic understanding of what it means’, four (20%) answered ‘little understanding of what it means’, and zero answered ‘no understanding of what it means’ (Figure 14).

![Figure 14. Students’ Level of Understanding with the Term ‘Citizen Science’.](image)

This figure shows how the students feel they understand the term ‘citizen science’. No students responded with ‘No Understanding’, and most students responded with ‘A Basic Understanding’.
**Level of agreement questions.** Similar to the pre-survey, there were 11 questions in the Level of Agreement with Reason for Volunteering section on a scale of ‘strongly agree’, ‘agree’, ‘neutral/un-decided’, ‘disagree’, and ‘strongly disagree’ (Figure 15):

- **I feel like I have helped or enhanced the environment.**
  - Zero (0%) answered ‘strongly agree’.
  - Eight (40%) answered ‘agree’.
  - Four (20%) answered ‘neutral/un-decided’.
  - Eight (40%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- **I feel like I have helped the community.**
  - One (5%) answered ‘strongly agree’.
  - Eight (40%) answered ‘agree’.
  - Six (30%) answered ‘neutral/un-decided’.
  - Five (25%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- **I feel like I was able to get outside and connect with nature.**
  - Zero (0%) answered ‘strongly agree’.
  - Five (25%) answered ‘agree’.
  - Five (25%) answered ‘neutral/un-decided’.
  - Six (30%) answered ‘disagree’.
  - Four (20%) answered ‘strongly disagree’.

- **I feel like I contributed to scientific knowledge.**
  - Zero (0%) answered ‘strongly agree’.
  - Nine (45%) answered ‘agree’.
  - Five (25%) answered ‘neutral/un-decided’.
  - Six (30%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- **I feel like I learned more about water quality.**
  - Eight (40%) answered ‘strongly agree’.
  - 10 (50%) answered ‘agree’.
  - Two (10%) answered ‘neutral/un-decided’.
  - Zero (0%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- **I feel like I learned skills or new knowledge during this study.**
  - Six (30%) answered ‘strongly agree’.
  - 12 (60%) answered ‘agree’.
  - One (5%) answered ‘neutral/un-decided’.
  - One (5%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- **I felt like I had fun during this study.**
• I feel like I engaged with other people during this study.
  o Seven (35%) answered ‘strongly agree’.
  o 13 (65%) answered ‘agree’.
  o Zero (0%) answered ‘neutral/un-decided’.
  o Three (15%) answered ‘disagree’.
  o Zero (0%) answered ‘strongly disagree’.

• I feel more inclined to participate in citizen science that is close to where I live.
  o Zero (0%) answered ‘strongly agree’.
  o Seven (35%) answered ‘agree’.
  o 10 (50%) answered ‘neutral/un-decided’.
  o Three (15%) answered ‘disagree’.
  o Zero (0%) answered ‘strongly disagree’.

• I feel more inclined to participate in citizen science in an international location.
  o Zero (0%) answered ‘strongly agree’.
  o Two (10%) answered ‘agree’.
  o 13 (65%) answered ‘neutral/un-decided’.
  o Five (25%) answered ‘disagree’.
  o Zero (0%) answered ‘strongly disagree’.

• I feel more inclined to participate in citizen science in other places I haven’t been to before.
  o Zero (0%) answered ‘strongly agree’.
  o Five (25%) answered ‘agree’.
  o 10 (50%) answered ‘neutral/un-decided’.
  o Five (25%) answered ‘disagree’.
  o Zero (0%) answered ‘strongly disagree’.
Figure 15. Level of Agreement with Reason for Volunteering Post-Survey Questions

This figure shows the rankings for each question, visualizing how much students agree or disagree with each statement after participating in this study.

Participants’ Definitions of Participating in Citizen Science

In this section of the post-survey, the students were asked, *in your own words, please define what it means to participate in citizen science.* For this open-ended question, three examples were pulled out of the 20 responses to show a spectrum of
negative, neutral, and positive responses. A negative response was defined as a participant who was not sure what it meant to participate in citizen science. A neutral response was defined as a participant who somewhat knew what it meant to participate. A positive response was defined as a participant who was close to the actual meaning. The three responses are as follows:

| **Negative** | “To participate in citizen science means to do basic research or experiments to come to a conclusion.” |
| **Neutral**  | “Normal people participating in science and research.” |
| **Positive** | “It means to participate in something that helps researchers/scientists better understand the environment around them. In turn, helping the everyday citizen understand how to protect the environment around them.” |

The participants’ answers were qualitatively analyzed by the researcher, looking for descriptors and codes. The main descriptors were ‘Community’, ‘Contributing’, ‘Enhancing/Helping’, ‘Science/Scientific’ and ‘Participating’ (Table 19). The codes for ‘Community’ were other people, personal, non-professional, general public, together, regular citizen, for/help community, no prior knowledge, volunteer, member, common people, general citizen, without training, and normal people (Table 19). The codes for ‘Contributing’ were learn more, contributing knowledge, have more answers today better understanding environment, add to scientific knowledge, educating yourself, and important research (Table 19). The codes for ‘Enhancing/Helping’ were science, environment, way of life, research, scientists, do something, and benefit local environment (Table 19). The codes for ‘Science/Scientific’ were taking insight, applying to study, scientific project, getting data, analyze, work and test theory, lots of data, experiments, important, how to protect environment, gather information, data collecting,
come to conclusion, and particular study (Table 19). The codes for “Participating” were
assignment to work, profound impact, doing research, taking part in a study, and
participating in science and research (Table 19). A Word Cloud was created from the
actual answers given by the students to compare to the hand-coded descriptors and codes
(Figure 16).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community</td>
<td>other people, personal, non-professional, general public, together, regular citizen, for/help community, no prior knowledge, volunteer, member, common people, general citizen, without training, normal people</td>
</tr>
<tr>
<td>Contributing</td>
<td>learn more, contributing knowledge, have more answers today better understanding environment, add to scientific knowledge, educating yourself, important research</td>
</tr>
<tr>
<td>Enhancing/Helping</td>
<td>Science, environment, way of life, research, scientists, do something, benefit local environment</td>
</tr>
<tr>
<td>Science/Scientific</td>
<td>taking insight, applying to study, scientific project, getting data, analyze, work and test theory, lots of data, experiments, important, how to protect environment, gather information, data collecting, come to conclusion, particular study</td>
</tr>
<tr>
<td>Participating</td>
<td>assignment to work, profound impact, doing research, taking part in a study, participating in science and research</td>
</tr>
</tbody>
</table>

Table 19 Defining ‘what it means to participate in citizen science’ codes
Figure 16. Defining ‘What it Means to Participate in Citizen Science’ (via wordclouds.com) – The students were asked what it means to participate in citizen science in their own words. This is a Word Cloud of all of their answers. Similar to the researcher’s codes, the biggest words from this Word Cloud are Environment, Science, Citizen, and Participating, Help, Understand, and People.
**Citizen science.** On a scale of 1-10, the students were asked a series of questions about citizen science (Figures 17-20). When asked, *how important do you think participating in citizen science is*, zero out of 20 participants (0%) answered ‘1’, zero (0%) answered ‘2’, one (5%) answered ‘3’, four (20%) answered ‘4’, five (25%) answered ‘5’, four (20%) answered ‘6’, four (20%) answered ‘7’, two (10%) answered ‘8’, zero (0%) answered ‘9’, and zero (0%) answered ‘10’ (Figure 17). The average rating of importance was 5.6 out of 10.

![Figure 17. ‘Level of Importance in Participating in Citizen Science’](image)

*This figure shows how the students felt after participating in this study, specifically how important participating in citizen science is to them.*
When asked, *how comfortable do you feel participating in other citizen science studies*, zero out of 20 participants (0%) answered ‘1’, zero (0%) answered ‘2’, three (15%) answered ‘3’, one (5%) answered ‘4’, one (5%) answered ‘5’, five (25%) answered ‘6’, seven (10%) answered ‘7’, three (15%) answered ‘8’, zero (0%) answered ‘9’, and zero (0%) answered ‘10’ (Figure 18). The average rating of comfortability was 6.05 out of 10.

![Figure 18. ‘Comfortability in Participating in Other Citizen Science Studies’ – The students’ level of comfort in doing other citizen science studies or activities is displayed in this figure.](image-url)
When asked, *how likely are you to participate in more citizen science studies locally*, zero out of 20 participants (0%) answered ‘1’, four (20%) answered ‘2’, one (5%) answered ‘3’, six (30%) answered ‘4’, four (20%) answered ‘5’, three (15%) answered ‘6’, zero (0%) answered ‘7’, two (10%) answered ‘8’, zero (0%) answered ‘9’, and zero (0%) answered ‘10’ (Figure 19). The average rating of likeliness was 4.45 out of 10.

Figure 19. ‘Likeness to Participate Locally’ – *Displayed in this figure are the students’ likeliness to participate in more citizen science studies or activities at local level, meaning somewhere near their hometown or state.*
When asked, *how likely are you to participate in more citizen science studies internationally*, two out of 20 participants (10%) answered ‘1’, five (25%) answered ‘2’, three (15%) answered ‘3’, six (30%) answered ‘4’, two (10%) answered ‘5’, one (5%) answered ‘6’, one (5%) answered ‘7’, zero (0%) answered ‘8’, zero (0%) answered ‘9’, and zero (0%) answered ‘10’ (Figure 20). The average rating of likeliness was 3.4 out of 10.

![Bar chart showing the likeliness to participate internationally](image)

**Figure 20. ‘Likelihood to Participate Internationally’** – This figure shows the students’ likeliness to participate in more citizen science studies or activities internationally or in a foreign location.
Water quality. Similar to the pre-survey again, the students were asked three Level of Agreement with Water Quality Importance questions on a scale of ‘strongly agree’, ‘agree’, ‘neutral/un-decided’, ‘disagree’, and ‘strongly disagree’ (Figure 21):

- The quality of water where I live is important to me.
  - 14 (70%) answered ‘strongly agree’.
  - Six (30%) answered ‘agree’.
  - Zero (0%) answered ‘neutral/un-decided’.
  - Zero (0%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- The quality of water in Costa Rica is important to me.
  - One (5%) answered ‘strongly agree’.
  - 15 (75%) answered ‘agree’.
  - Four (20%) answered ‘neutral/un-decided’.
  - Zero (0%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

- The quality of water everywhere is important to me.
  - Two (10%) answered ‘strongly agree’.
  - 13 (65%) answered ‘agree’.
  - Four (20%) answered ‘neutral/un-decided’.
  - One (5%) answered ‘disagree’.
  - Zero (0%) answered ‘strongly disagree’.

Figure 21. Level of Agreement with Water Quality Importance Post-Survey Questions – This chart shows the students’ level of importance of water quality to them based on location after participating in this study.
Overall Understanding and Benefits

In a second section of open-ended questions, the students were asked, *in your own words, what benefits do you feel you have received from participating?*. Three examples were pulled out of the 22 responses to show a spectrum of negative, neutral, and positive responses. A negative response was defined as a participant who felt they did not receive many or any benefits. A neutral response was defined as a participant who felt they received one benefit. A positive response was defined as participant who felt they received more than one benefit.

**Negative** - “In this specific study I didn't feel like I benefitted that much from participating but I did learn about what citizens science is.”

**Neutral** - “I feel like I gained the knowledge of what citizen science is.”

**Positive** - “I think that I have gained a new appreciation for science and the work that goes into data collecting. I had never done anything like this before so this was a learning experience for me.”

The participants’ answers were studied by the researcher, looking for descriptors and codes. The main descriptors were ‘Gained Knowledge’, ‘Citizen Science’, ‘None’, ‘Water Quality’, ‘Science Process’, and ‘Learned Experience’ (Table 20). The codes for ‘Gained Knowledge’ were better understanding, know more, knowledgeable, and knowledge about water quality and citizen science (Table 20). The code for ‘Citizen Science’ was what it is (Table 20). The codes for ‘None’ were not much, didn't benefit, and never utilize knowledge (Table 20). The codes for ‘Water Quality’ were testing, how to test, different tests, and what it is (Table 20). The codes for ‘Science Process’ were new appreciation and learned about it (Table 20). The codes for ‘Learning Experience’
were communication skills, patience, open mindedness, can do this again, exposure, feels good, save environment, and very important (Table 20). A Word Cloud was created from the actual answers given by the students to compare to the hand-coded descriptors and codes (Figure 22).

<table>
<thead>
<tr>
<th>Main Descriptor</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Gained Knowledge</td>
<td>better understanding, know more, knowledgeable, knowledge about water quality and citizen science</td>
</tr>
<tr>
<td>Citizen Science</td>
<td>what it is</td>
</tr>
<tr>
<td>None</td>
<td>not much, didn't benefit, never utilize knowledge</td>
</tr>
<tr>
<td>Water Quality</td>
<td>testing, how to test, different tests, what it is</td>
</tr>
<tr>
<td>Science Process</td>
<td>new appreciation, learned about it</td>
</tr>
<tr>
<td>Learning Experience</td>
<td>communication skills, patience, open mindedness, can do this again, exposure, feels good, save environment, very important</td>
</tr>
</tbody>
</table>

Table 20 ‘Benefits from Participating in Citizen Science’ Codes
Figure 22. Word Cloud of ‘benefits from participating in citizen science’ (via wordcloud.com) – The students were asked what benefits they felt they received from participating, in their own words. This is a Word Cloud of all of their answers. Similar to the researcher’s codes, the biggest words from this Word Cloud are Citizen, Science, Water, Knowledge, and Learned.
In another open-ended question, the students were asked, *Now that you have participated in water quality testing, in your own words, what do you feel you have gained from participating?*. Three examples were pulled out of the 22 responses to show a spectrum of negative, neutral, and positive responses. A negative response was defined as a participant who felt they did not gain much or anything from participating. A neutral response was defined as a participant who felt they gained one new piece of knowledge or idea from participating. A positive response was defined as participant who felt they received more than one new piece of knowledge or idea from participating.

| **Negative** | “I really didn't feel like I learned much more than what I already knew. I would have needed more exposure with the material to have learned more about the actual water quality, the testing, and what the data really shows.” |
| **Neutral** | “There are many different chemicals in the water that I didn’t know about.” |
| **Positive** | “I have a better understanding of how to do water testing and work in a team setting.” |

The participants’ answers were studied by the researcher. The main descriptors were ‘Gained Knowledge’, ‘Citizen Science’, ‘Not Much’, ‘Water Quality’, and ‘Learning Experience’ (Table 21). The codes for ‘Gained Knowledge’ were more, better, understanding, new, helped to understand, and learned more (Table 21). The codes for ‘Citizen Science’ were what it is, do it myself, understanding, participate, and continuation in future (Table 21). The codes for ‘Not Much’ were never utilize knowledge again, didn't learn anything new, and never do it again (Table 21). The codes for ‘Water Quality’ were testing, how to test, testing for, importance, different chemicals, how it works, how lucky we are, high quality, safe, and knowledge about it (Table 21). The codes for ‘Learning Experience’ were team setting, cool, more exposure to material,
anyone can do it, more people need to do it, benefits from/for environment, and emphasize in future (Table 21).

<table>
<thead>
<tr>
<th><strong>Main Descriptor</strong></th>
<th><strong>Codes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gained Knowledge</td>
<td>more, better, understanding, new, helped to understand, learned more</td>
</tr>
<tr>
<td>Citizen Science</td>
<td>what it is, do it myself, understanding, participate, continuation in future</td>
</tr>
<tr>
<td>Not Much</td>
<td>never utilize knowledge again, didn't learn anything new, never do it again</td>
</tr>
<tr>
<td>Water Quality</td>
<td>testing, how to test, testing for, importance, different chemicals, how it works, how lucky we are, high quality, safe, knowledge about it</td>
</tr>
<tr>
<td>Learning Experience</td>
<td>team setting, cool, more exposure to material, anyone can do it, more people need to do it, benefits from/for environment, emphasize in future</td>
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</tbody>
</table>

Table 21 ‘Benefits from Participating in Water Quality Testing’ Codes

**Conclusion**

There was a large amount of qualitative data to report on in these results. Overall, there were varying results with each instrumentation, depending on the questions asked that ranged between positive, neutral, and negative as well as more interpretive questions with assigned codes to further describe the impact of this study in more detail. The Word Clouds produced in this chapter highlighted key words used by students to show how the researcher found and chose main descriptors that had a profound impact regarding citizen science, learning experience, participation, and benefits. The illustrated graphs were a quantitative display of qualitative data based on pre- and post-survey responses. The
results were purposefully formatted in this chapter to align with the research questions. These results will be interpreted by the researcher to answer the research questions and are further discussed in Chapter 5.
CHAPTER V
DISCUSSION

The discussion chapter takes the results noted in Chapter 4 to answer the research questions through qualitative analysis and interpretation. Following a similar layout as the results, the discussion is formatted into specific sections to round out and conclude this study: Answering the Research Questions, Influence of Participating in Citizen Science, and Successes, Limitations, and Other Considerations.

Answering the Research Questions

The results from the previous chapter were analyzed with the objective of being compared and discussed in order to answer the three research questions of this study:

1. What are student perceptions of citizen science, before and after participating in an international citizen science activity?
2. What do students gain from participating in an international citizen science activity?
3. Does location matter in an international citizen science learning experience?

Research Question One

Answering Research Question One, *what are student perceptions of citizen science, before and after participating in an international citizen science activity?*, the students’ perceptions before participating were minimal, open-minded, and unknowing of what citizen science is. This is mainly because they were Business majors, and were not focused on the sciences or concerned about it in their everyday lives. The students’ perceptions shifted after participating in citizen science to mostly negative or disagreeing, but with more knowledge in citizen science and less desire or seeming importance to participate. Therefore, while they felt like this citizen science activity was long, boring,
or difficult, they also expressed their increased gratitude and appreciation for citizen science. Most students also felt they would do something like this again as long as the citizen science activity was on a topic something that interested them. These claims are supported below from analyzing the survey and focus group results.

Pre-survey vs. post-survey. For question one, what are student perceptions of citizen science, before and after participating in an international citizen science activity?, the results show that the students were not fully aware of what citizen science was before participating. Thus, they had minimal pre-perceptions of citizen science before this study. An example of this comes from the responses to the pre-survey question, in your own words, what do you think the term ‘citizen science’ means? (Table 1 & Figure 6). Comparatively, when asked a similar question in the post-survey, in your own words, please define what it means to participate in citizen science, students appeared to have had a better understanding of the term ‘citizen science’ and what it means to participate in citizen science (Table 19 & Figure 16). The students’ perception change is also shown in Figure 14, where 70% of students felt they had a ‘basic understanding’ of the term ‘citizen science’ after participating in this study.

On top of their perceptions changing about what the term ‘citizen science’ means, there was a change in their responses to the Level of Agreement questions between the pre- and post-survey (Figures 5 & 15). For example, with the statement, I want to help or enhance the environment, and its counterpart, I feel like I have helped or enhanced the environment, the number of responses for ‘Strongly Agree’ dropped from 8 to 0. Similarly, ‘Agree’ dropped from 11 to 8, ‘Neutral’ increased from 1 to 4, ‘Disagree’
increased from 0 to 8, and ‘Strongly Disagree’ did not change. Overall, the number of ‘Strongly Agree’ responses for the Level of Agreement questions decreased and the number of ‘Disagree’ responses increased. This shows that the students’ perceptions changed before and after participating in this study. Specifically, the change shown in these Level of Agreement questions is negative in the sense that the students had a more positive, or agreeable, perspective before participating and had a more negative, or disagreeable, perspective after participating, which is displayed when comparing Figure 5 and Figure 15.

To continue, their perceptions were also found to change before and after participating in the Scale of 1-10 questions (Figures 7-10 & Figures 17-20, respectively). For discussion purposes, the students’ Scale of 1-10 questions were combined into overall average ratings between the pre-survey and post-survey, showing the change in the students’ perceptions (Figures 23 & 24 below). These figures display how less important citizen science was to the students after participating, how less comfortable they were with participating in more citizen science activities, and how less likely they were to participate locally or internationally. Overall, the students’ minds changed negatively after participating in this study, showing that the students have less interest in citizen science after having done it. This is contrary to my hypothesis that incorporating citizen science into short-term study abroad programs could positively change students’ perceptions about citizen science as a whole.
Focus group. Several questions from the focus group were broken down into positive and negative answers, showing the students’ varying reactions to participating
and how that changed before and after participating in this study. With the questions, 
what are your immediate reactions and thoughts about citizen science? and how do you 
think this citizen science study went? What are your thoughts and feelings about citizen 
science now that you’ve participated in it?, the overall response led to the students 
thinking that citizen science could be fun if the activity is something they’re interested in, 
but it probably won’t be something that they go out of their way to do in the future 
(Tables 2 & 3). Because these were Business students, I noticed that their minds were 
more open to learning about citizen science before participating, but then were more 
closed off after participating, which is shown in their responses as well as the descriptors 
and codes for these questions in Tables 2 and 3. Because they do not ‘do science’ every 
day as Business majors, several found this work to be too tedious or difficult. 

The negative change in their perceptions is also displayed in the main descriptors 
and codes for the question, what were you expecting before participating in this study? 
(Table 7). This is because their expectations were not the same as the reality of this study. 
The students made this aware in their answers to the questions, 1) was it fun or boring to 
you to be using these test kits? Would you use them again?; 2) How are your thoughts, 
feelings, and expectations of water quality testing and citizen science different after 
participating?; and 3) did you feel like any part of this process was too difficult or not 
engaging? Which part and why? as well. As shown in each of these questions’ main 
descriptors and codes, the main themes from the students’ answers all pointed towards 
boring, negative or no change, and high difficulty (Tables 5, 8, & 9).
However, Figure 12 shows more of a positive response to the question, *is this something you can see yourself doing again?*, with 54.5% of the students answering ‘Yes’. The caveat to this though, is that several students said ‘Yes’ only if it was something they were interested in. This indicates that the citizen science activity may have been of slight interest to them, while water quality testing was not interesting to them at all. So, while the students’ perceptions of citizen science before and participating mostly shifted from positive to negative due to the ‘difficulty’ of water quality testing, over half of them were still willing to do something like this again, showing that their perceptions were not all bad or negative.

**Research Question Two**

Answering Research Question Two, *what do students gain from participating in an international citizen science activity?*, the students’ pre-survey and post-survey responses demonstrate their lack of gaining specific details or remembering ‘hard science’ terms. However, while the students may not have taken away education-specific knowledge that is taught in a science class, they did take away more of an awareness and mental-understanding of citizen science. This is shown in their open-ended responses and in the focus group discussion. The students illustrate a basic understanding of the concept of citizen science and what they were doing for the activity, showing gained knowledge, understanding, and an appreciation of citizen science overall. To support these claims, a detailed analysis of the surveys and focus group results are as follows.

**Pre-survey vs. post-survey**. Research question two, *what do students gain from participating in an international citizen science activity?*, is also answered using some of
the same pre- and post-survey questions as research question one. For example, since students had an increased understanding of the term ‘citizen science’ from the question, *in your own words, what do you think the term ‘citizen science’ means?*, it can be said that they learned and gained knowledge of what citizen science means and what it means to participate in citizen science (Tables 1 & 19, Figures 6, 14, & 16).

This is also true for the Level of Agreement questions. When comparing *I want to learn new skills or new knowledge while volunteering* from the pre-survey to *I feel like I learned skills or new knowledge during this study* from the post-survey, 85% answered ‘Strongly Agree’ or ‘Agree’ in the pre-survey and 90% answered ‘Strongly Agree’ or ‘Agree in the post-survey (Figures 5 & 15). This slight increase shows that the students felt they gained more skills or knowledge from participating in this activity. However, Figures 5 and 15 show that the percent of ‘Strongly Agree’ and ‘Agree’ for *I feel like I have helped or enhanced the environment*, *I feel like I have helped the community*, and *I feel like I have contributed to scientific knowledge* all significantly decreased, meaning that the students felt they did not gain anything pertaining to these topics.

The students’ comfortability in participating in citizen science also decreased, with the average rating of comfortability dropping from 6.5 out of 10 to 6.05 out of 10 (Figures 8 & 18). This is contrary to my hypothesis that the students would feel more comfortable after participating. However, this decrease can be attributed to the type of citizen science, which was water quality testing. This is considering how the students’ Level of Agreement with Water Quality Importance questions significantly decreased after participating (Figures 11 & 21). With the statement, *the quality of water where I*
currently live is important to me, those that answered ‘Strongly Agree’ decreased from 85% in the pre-survey to 70% in the post-survey. Similarly, the percent of ‘Strongly Agree’ answers for the quality of water in Costa Rica is important to me decreased from 45% to 5% and the quality of water everywhere is important to me decreased from 55% to 11%.

From the post-survey, the students were asked a few more open-ended questions. From these questions, I was able to truly understand what the students felt they gained from this activity. These open-ended questions were 1) in your own words, what benefits do you feel you have received from participating? and 2) now that you have participated in water quality testing, in your own words, what do you feel you have gained from participating? (Tables 20, 21 & Figure 22). From the main descriptors for these questions, we see that the student did in fact gain knowledge, a better understanding, what citizen science is, what water quality is, how the science process works, and a new learning experience.

Focus group. The modified focus group helped grasp the concept of what the students felt they gained from this activity. More specifically, the students showed an increase in motivation when participating in citizen science with people they know, describing the activity as ‘a lot easier’ and ‘flows better’ when asked, how do you feel being acquainted with everyone? Does being acquainted increase your motivation to do citizen science? Does being acquainted determine your level of motivation and knowledge growth? (Table 11).
In contrast, the students indicated that their expectations for this activity were not met overall, saying that it was ‘confusing’, ‘too long’, and ‘didn’t understand’ (Table 12). These not met expectations suggest that the students did not necessarily gain the knowledge and understanding they were hoping for and/or expecting, but this does not mean that they did not gain any knowledge at all from this activity. From the question, *what have you gained from this experience?*, Table 13 and Figure 13 speak for themselves. The students did feel they gained something from this experience, such as ‘the importance of citizen science’, ‘what regular people can do’ with citizen science, ‘a regained appreciation for science’, and an increased ‘awareness’.

**Research Question Three**

In general, to answer Research Questions Three, does location matter in an international citizen science learning experience?, the location of participating in citizen science did not seem to matter to these students. This is mainly due to the fact that they were Business majors and not overly interested in water quality testing as the citizen science activity. Many also noted that they would prefer to do citizen science locally, because that is where it affects them and their lives most. However, the students did seem to have an understanding of why I had them do this study internationally and how location could matter. This shows that they have an understanding of the idea behind how location can play a role in citizen science, but did not feel it affected them personally. Overall, the students demonstrated that location does not necessarily matter to them in an international learning experience, with the exception that a few may have preferred to do this activity locally.
Pre-survey vs. post-survey. Research question three, does location matter in an international citizen science learning experience?, is answered using the Level of Agreement with Water Quality Importance questions as well (Figures 11 & 21). All students answered either ‘Strongly Agree’ or ‘Agree’ for the quality of water where I currently live is important to me for the pre-survey and post-survey. Whereas, the students agreed less with the statements, the quality of water in Costa Rica is important to me and the quality of water everywhere is important to me, after participating in this activity. This indicated that location matters to the students, but with more importance on their home locations. This is in contrast to my hypothesis that the students would find more importance and inclination to participated in international/foreign locations.

The Level of Agreement questions also show how location matters to the students (Figures 5 & 15). All three statements related to where the students would feel more inclined to participate in citizen science showed an increase in ‘Neutral/Un-decided’ and ‘Disagree’ responses from the pre-survey to the post-survey. This shift from positive to neutral or negative responses suggests that the students did not necessarily care about the location of participating in citizen science.

When asked how likely they were to participate in citizen science studies locally, the average rating of likeliness decreased from 5.85 out of 10 in the pre-survey to 4.45 out of 10 in the post-survey (Figures 9 & 19). Similar results are shown when asked how likely the students were to participate in citizen science studies internationally, with a an average rating decrease from 5.50 to 3.4 between the pre-survey and post-survey. Again,
these results demonstrate the students’ neutrality on where the citizen science activity takes place.

**Focus group.** The focus group questions pertaining to how location matters to the students had an overarching theme of neutral or negative answers, similar to the pre-survey and post-survey. For example, all responses to, *does participating in a citizen science seem more fun or interesting to you because it is in a new-to-you location?*, were summed up to ‘No’, meaning that the students felt that ‘location doesn’t matter’ due to the fact that their ‘priority isn’t this’ and they ‘want to relax, not do citizen science’ (Table 16). This indicates that the students liked Costa Rica more as a vacation spot and less as an educational trip. With this in mind, it reflected in the students’ other responses of why they did not want to do citizen science and/or did not like this activity. When asked how likely they were to participate locally or internationally, similar responses were given and deduced to ‘Maybe’ as the main descriptor (Tables 17 & 18). For both, the likeliness depended upon the ‘opportunity presenting itself’ and needing a ‘motivating’ factor. This also shows the students’ neutrality in how location plays a role in participating in citizen science activities.

Although location did not seem to matter to the students with their level of participation, they did seem to grasp why I had them do this study and how a foreign location influenced how they did this study. Tables 14 and 15 show the main descriptors and codes of these two questions, such as ‘comparison’, ‘beneficial’, and ‘perspective’. These responses indicate that the students understood the importance of connecting to a place through citizen science, and how comparing water quality in different countries can
increase that understanding. The students’ motivations had also changed when in a new location, stating that they ‘travelled all the way here’ and ‘made the effort’ as compared to back home (Table 15). However, when asked if this is something they would do back home or if it is more beneficial to do it in a foreign location, the main theme from the two responses was that as an interesting of an activity this was, they were unlikely to do it again (Pg. 58). This is similar to their responses in the surveys on the likeliness questions, showing how location did not seem to matter to the students in this activity.

**Influence of Participating in Citizen Science**

From the results, I gathered that the students found citizen science to be generally interesting and important to know about, but not necessarily something that would be of interest specifically to them in the future outside of this study. This supports Brossard et al. (2005) that citizen science does increase data collection and knowledge within the community, even if a lack of interest is apparent. With that said, the students did feel that they might participate in other citizen science activities if it was something that they were passionate about. Interest, passion, and knowledge of the subject were key elements in the students’ decisions to participate in other citizen science activities.

Participating in citizen science also increased their general knowledge of water quality and how location impacts a citizen science activity. The students’ increased knowledge of water quality adds to the findings of Burt et al. (2014), that long-term water quality monitoring is important to understanding the health of our planet, by beginning with the awareness of water quality to these students. However, I found that many of these were looking for international opportunities for vacation and not education,
indicating that they would likely not retain much of the information they learned from this citizen science activity in the long term. These findings support of Jiang et al. (2018), that perceptions data can be exceptionally useful in citizen science studies, because it was found that the perceptions of these students showed the interest gap from school-age kids to adults participating in citizen science.

This is also apparent in the students’ perceived benefits from participating in citizen science. Brossard et al. (2005) found that there were no significant changes in participants’ attitude toward citizen science, which I also found to be true within this study based on the students’ increasingly negative responses in the post-survey and focus group. This contradicts Alender’s (2016) findings that the strongest motivation to participate in citizen science was to help the community, environment, and scientific knowledge. The students did not show an increase in caring for the community, environment, or scientific knowledge from participating in this study. Their strongest motivation to participate in citizen science was based on interest level and difficulty of the activity tasks.

Supporting the findings of Carlson and Cohen (2018), it is clear that participants should be better trained to do water quality testing before participating in citizen science. Lastly, the students showed more interest in participating locally, where it affects them most on a daily basis, rather than internationally. This supports Clary et al. (2012) findings, that local citizen science is useful and convenient. While the student did not show a significant interest in an international water quality citizen science activity, I am hopeful, that some of these students will remember this study when presented with
another citizen science opportunity. While they may not know it now, this activity may have broadened their horizons and opened their minds to future citizen science projects.

**Successes, Limitations, and Other Considerations**

Working with college students was a great starting point for this study. They were well educated, polite, and focused. This made the training and time to do the citizen science activity go quickly. Although one of the points of this study was to use non-science students, I found that college students outside of the sciences have lost interest in ‘rediscovering’ science again. This is understandable because of the way higher education is made to have students hyper-focus on only certain topics of interest (i.e. business and business-related classes for these students). The main limitation to this group was the size. The student to instructor ratio was 1:22. This led to a modified focus group and also the need to break up into groups for the citizen science activity. In terms of qualitative methods, the proper sample size is about 10 participants, again showing how the size of this group may have impacted this study.

The participation level in the surveys and modified focus group was phenomenal, with a 90% response rate for the surveys and 100% participation in the focus group. In the modified focus group, the students also felt more comfortable talking because they knew each other beforehand. However, the focus group was too large compared to a traditional focus group size, causing the structure of it to be modified to an ‘ask and answer’ style, which could have impacted the results and responses to the focus group questions. Survey123 was a great tool to distribute the surveys to the students, so online surveys are useful in grabbing the participants’ attention and gathering immediate results.
A few students mentioned that their willingness to participate was because they felt like they were helping a fellow UNI student, which made them feel good. I found this to play a factor in how they responded to the citizen science activity, thus it would be of interest to try this with students from a separate university that aren’t necessarily invested based on ‘helping out another UNI student’.

The interpretation of the results can also be viewed differently depending on the analysis process used. A coding process with main descriptors and themes was used because of the amount of data that came from the instrumentations. Additionally, different instrumentations outside of surveys and a focus group could lead to different results or research questions for a similar study. Triangulation of the surveys and focus group was used to fully gather the participants perceptions, however, other qualitative methods may be just as useful in gathering this kind of data.

Having Costa Rica as the location of this study was great because of the lack of knowledge of this location. With having limited knowledge on Costa Rica’s water quality, the students were able to increase their personal knowledge of this international place and its water quality. On top of that, the students felt more comfortable performing the water quality tests in Costa Rica because of the practice/training session they completed prior to leaving the U.S. However, water quality testing was not an interesting citizen science activity to this group of students. Other citizen science activities (i.e. butterfly counting, bird watching, etc.) could potentially positively increase the students’ motivations and overall perception of citizen science.
While there were several successes, it should be noted that this study is highly focused on undergraduate students in an international learning experience setting, meaning that timing, subjects, and location are key components. These aspects can also be seen as limitations because of the need to find undergraduate students with enough time to participate in a citizen science activity internationally. This study does not wholly reflect all citizen science studies and participants; it is simply a gateway to increasing the use of citizen science overall.

Conclusion

This study was about perceptions of citizen science in an international setting. Perceptions of citizen science from a college student’s perspective gives us a glimpse into how to engage them better with citizen science. What do they gain from participating in citizen science? What are their motivations? Does location matter? It was found that they gain a better understanding, knowledge, and awareness of what citizen science is and how they can participate in it. Their motivations are mainly topics that interest them, helping other peers, and feeling like they’ve made a difference. And location matters, but rather, how it affects them personally and not foreign locations.

To conclude this discussion, I would like to point out how much was learned both on my end and on the students’ end. While their learning was not measurable in a traditional sense, this citizen science activity was still impactful. I learned just how non-science students react to certain aspects of citizen science and water quality testing, as well as what location means to them in terms of this citizen science activity. This study grasped the thoughts and perceptions about citizen science, and what it means to these
students. Citizen science is important and meaningful, but how do we engage more
college students with it? International learning experiences is just the start, but the
students showed more interest in local participation. However, this single study cannot
rule out all citizen science international learning experiences. There is more work to be
done on this in the future.
REFERENCES


*Study Abroad Data*. (2017, June 5). USA Study Abroad. https://studyabroad.state.gov/value-study-abroad/study-abroad-data


APPENDIX A

CITIZEN SCIENCE WATER QUALITY PRE-SURVEY

This is a pre-survey to gauge the current knowledge-base and perceptions on citizen science and water quality testing. This survey will take no longer than 10 minutes to complete. This survey is completely voluntary, you are allowed to withdraw at any time. All answers are completely confidential and anonymous. Thank you so much for your time and efforts!

Demographics
1. How old are you?
   a. Please Select-

2. What is your gender?*
   a. Please answer with the gender you identify as.

3. What is your college major(s)?*
   a. Please answer with the major(s) you plan to get with your degree.

4. What year in school are you?*
   a. Please answer with the official level at which the college identifies you at.
   b. Freshman
   c. Sophomore
   d. Junior
   e. Senior
   f. Graduate
   g. Other

5. Where is your hometown?*
   a. Please type the city and state in which you consider home.

6. Did you enjoy science classes in grade school/high school?*
   a. Yes
   b. Somewhat
   c. No

7. Do you consider yourself scientifically literate?*
   a. Please check one.
b. Yes
c. Somewhat
d. No

8. **Level of Agreement with Reason for Volunteering - location and demographics (baseline data)**
   a. Please select the degree at which you agree or disagree with each statement.
   b. Strongly Agree, Agree, Neutral/Un-decided, Disagree, Strongly Disagree
c. I want to help or enhance the environment.*
d. I want to help the community.*
e. I want to get outside or connect with nature.*
f. I want to contribute to scientific knowledge.*
g. I want to learn more about water quality.*
h. I want to learn new skills or knowledge while volunteering.*
i. I want to have fun while volunteering.*
j. I want to engage with other people while volunteering.*
k. I would be more inclined to participate in citizen science if it was close to where I live.*
l. I would be more inclined to participate in citizen science if it was in an international location.*
m. I would be more inclined to participate in citizen science if it was in a place I had never been before.*

9. In your own words, what do you think the term 'citizen science' means?*
   a. This is an open-ended question. There is no right or wrong answer. Please answer honestly.

10. How important do you think participating in citizen science is?*
    a. On a scale of 1-10, 1 being the lowest or least important, and 10 being the highest or most important. Please select the degree at which you think it is important.

11. How comfortable do you feel participating in citizen science?*
    a. On a scale of 1-10, 1 being the lowest or least comfortable, and 10 being the highest or most comfortable. Please select the degree at which you are most comfortable.

12. Have you had previous experience with citizen science? If so, what did you participate in?*
    a. This is an open-ended question. There is no right or wrong answer. Please answer honestly.
13. How likely are you to participate in a citizen science study locally (near your hometown)?
   a. On a scale of 1-10, 1 being the lowest or least likely, and 10 being the highest or most likely. Please select the degree at which you are most likely to participate locally.

14. How likely are you to participate in a citizen science study in a foreign (international) location?
   a. On a scale of 1-10, 1 being the lowest or least likely, and 10 being the highest or most likely. Please select the degree at which you are most likely to participate internationally.

15. **Water Quality Importance**
   a. Please select the degree at which you agree or disagree with each statement.
   b. Strongly Agree, Agree, Neutral/Un-decided, Disagree, Strongly Disagree
   c. The quality of water where I currently live is important to me.*
   d. The quality of water in Costa Rica is important to me.*
   e. The quality of water everywhere is important to me.*

16. Have you had previous experience with water quality testing before? If so, what did you do it for?*
   a. This is an open-ended question. There is no right or wrong answer. Please answer honestly.

17. How comfortable do you feel doing water quality testing?*
   a. On a scale of 1-10, 1 being the lowest or least comfortable, and 10 being the highest or most comfortable. Please select the degree at which you are most comfortable.

18. Comments you have for me:
   a. This is open-ended. There is no right or wrong answer. Please answer honestly.
APPENDIX B

FOCUS GROUP QUESTIONS (WITH SUB-QUESTIONS)

1. Has it set in yet that you are in a different country? What is different here to you?
   a. Why do you think I had you do this study while in an international place?
   b. Do you feel as though this impacted how you did this study? If so, how?
   c. Is this something you would do back home? Do you feel as though it is more beneficial to do this in a foreign location?

2. How do you feel about being acquainted with everyone?
   a. Does being acquainted increase your motivation to do citizen science?
   b. Does being acquainted determine your level of motivation and knowledge growth?
   c. Do you feel more comfortable being acquainted and does it help with doing this study?

3. What are your immediate reactions and thoughts about water quality testing?
   a. “I haven’t seen your surveys yet, but raise your hand if you’ve done water quality testing before. Is this different? How?”
   b. How do you think the testing went? What are your thoughts and feelings about water quality testing now that you have done it?
   c. Was it fun or boring to you to be using test kits to test water? Would you do this again in a different setting?
   d. Do you feel like you understand what you were doing and why you were doing it?

4. What are your immediate reactions and thoughts about citizen science?
   a. “I haven’t seen your surveys yet, but raise your hand if you’ve participated in citizen science before. Is this different? How?”
   b. How do you think this citizen science study went? What are your thoughts and feelings about citizen science now that you have participated in it?
   c. Was it fun or boring to you to be part of a citizen science study? Would you do this again in a different setting?
   d. Do you feel like you understand what you were doing and why you were doing it?

5. What were you expecting before participating in this study?
   a. How do you feel your expectations were met, not met, or exceeded?
   b. How are your thoughts, feelings, and expectations of water quality testing and citizen science different after participating in this study?

6. What have you gained from this experience?
   a. Go around circle - tell me one or two words that describes this experience
for you.

b. (It's okay if you need more than one word)
c. *If nothing* - please explain to me what your story is as to why this is “nothing” to you.
d. Back up question: What did you learn today?

7. Out of what you gained and learned today, how is this beneficial to your education and/or personal life?
   a. Go around circle - name one way it is beneficial to your education. Name another way it is beneficial to your personal life.
   b. *If it’s not* - Please elaborate to me why you feel this is not beneficial to you.

8. What was your favorite part of the whole process today?
   a. Why?

9. Did you feel like any part of this process was too difficult or not engaging?
   a. If so, which part?
   b. Why?

10. How does location matter to you in this situation?
    a. How do you feel being in a foreign location affects your participation and motivation?
    b. Does participating in citizen science seem more fun or interesting to you because it is in a new-to-you location?
       i. Why or why not?

11. How likely are you to participate in local citizen science studies now? What about international citizen science studies?
    a. Is this something you would do back home or is it because you’re in a different location that you feel more inclined to do this?
    b. Do you feel more inclined to participate locally or in a not-as-well-known location?
       i. Why or why not?

12. What is one question this water testing and citizen science study makes you want to ask?
    a. What do you want to know?
    b. Do you have suggestions for me to make this a better experience for you?

13. What is one takeaway from today that you will remember forever?
    a. How do you think that information is important to take with you?
    b. Is this something you can see yourself doing again?
APPENDIX C
CITIZEN SCIENCE WATER QUALITY POST-SURVEY

Now that you have participated in a citizen science water quality study, this is a post-survey to understand and comprehend final perceptions of citizen science and perceived gains in participating. This survey will take no longer than 10 minutes to complete. This survey is completely voluntary and you may withdraw at any time. All answers are completely confidential and anonymous. Thank you so much for your time and efforts!

1. **Level of Agreement with Reason for Volunteering**
   a. Please select the degree at which you agree or disagree with each statement.
   b. Strongly Agree, Agree, Neutral/Undecided, Disagree, Strongly Disagree
   c. I feel like I have helped or enhanced the environment.*
   d. I feel like I have helped the community.*
   e. I feel like I was able to get outside and connect with nature.*
   f. I feel like I contributed to scientific knowledge.*
   g. I feel like I learned more about water quality.*
   h. I feel like I learned skills or new knowledge during this study.*
   i. I felt like I had fun during this study.*
   j. I feel like I engaged with other people during this study.*
   k. I feel more inclined to participate in citizen science that is close to where I live.*
   l. I feel more inclined to participate in citizen science in an international location.*
   m. I feel more inclined to participate in citizen science in other places I haven’t been to before.*

2. In general, when you hear or read the term 'citizen science' do you have:* 
   a. (Please check one)
   b. A clear understanding of what it means
   c. A basic understanding of what it means
   d. Little understanding of what it means
   e. No understanding of what it means

3. Now that you’ve participated in this citizen science study, how comfortable do you feel participating in other citizen science studies?
   a. On a scale of 1-10, 1 being the lowest or least comfortable, and 10 being
the highest or most comfortable. Please select the degree at which you are most comfortable.

4. How likely are you to participate in more citizen science studies at a local level (near your hometown)?
   a. On a scale of 1-10, 1 being the lowest or least likely, and 10 being the highest or most likely. Please select the degree at which you are most likely to participate locally.

5. How likely are you to participate in more citizen science studies at an international level?
   a. On a scale of 1-10, 1 being the lowest or least likely, and 10 being the highest or most likely. Please select the degree at which you are most likely to participate internationally.

6. How important do you think participating in citizen science is?*
   a. On a scale of 1-10, 1 being the lowest or least important, and 10 being the highest or most important. Please select the degree at which you think it is important.

7. In your own words, please define what it means to participate in citizen science:
   a. This is an open-ended question. There is no right or wrong answer. Please answer honestly.

8. In your own words, what benefits do you feel you have received from participating?*
   a. This is an open-ended question. There is no right or wrong answer. Please answer honestly.

9. Water Quality Importance
   a. Please select the degree at which you agree or disagree with each statement.
   b. Strongly Agree, Agree, Neutral/Un-decided, Disagree, Strongly Disagree
   c. The quality of water where I currently live is important to me.*
   d. The quality of water in Costa Rica is important to me.*
   e. The quality of water everywhere is important to me.

10. Now that you have participated in water quality testing, in your own words, what do you feel you have gained from participating?*
    a. This is an open-ended question. There is no right or wrong answer. Please answer honestly.

11. Comments you have for me:
a. This is open-ended. There is no right or wrong answer. Please answer honestly.
### APPENDIX D

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