

**Addressing Three-Dimensional Learning
with Citizen Science Projects**

By

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Plan B Project

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Abstract

Citizen science, or the inclusion of non-professionals in scientific research, has been used for decades to increase scientific knowledge and involve citizens in problems affecting their communities. These projects can be beneficial to students at the middle school level in that they provide informal learning opportunities in which they can create relationships with professional scientists and researchers, which can increase their interest in different scientific fields. There is also the possibility for citizen science projects to address changing science standards, though research on this topic is lacking.

This study looks at the use of a particular citizen science project, *Girl Scouts in Science: Discovering Wyoming Water*, and its ability to address the Next Generation Science Standards (NGSS) in an informal educational setting. The researcher used observation notes from program meetings as well as focus group discussions with participants of the *Girl Scouts in Science* program to determine which components of the three dimensions of learning were addressed, either by facilitators or participants. Results show that this program inherently addressed the Science and Engineering Practices dimension of NGSS, as the project focused on completing a research project. Disciplinary Core Ideas and Crosscutting Concepts were also addressed, though only several in particular were explicitly used and showed up prominently. This study also suggests that different components of a citizen science program such as this one can address different components of the three learning dimensions.

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Chapter 1

Introduction

Scientific inquiry, and the use of the entire scientific process, from questioning to sharing conclusions, is quickly becoming a greater focus in science teaching (Houseal, Abd-El-Khalick, & Destefano, 2014). The development of the Next Generation Science Standards has also put pressure on teachers to focus more on the process of science, in conjunction with content. The researcher of this study believes that the implementation of these standards can help to guide educators towards more effective inquiry projects, particularly when partnering with a citizen science research based project or program.

As a part of her graduate assistantship at the University of Wyoming, the author had the chance to work with a group of Girl Scouts participating in a citizen science project looking at the restoration of the Laramie River. Their objective was to determine if the restoration was successful or not, by engaging in the entire scientific process, from questioning to sharing conclusions. This sparked the author's interest in the ability of citizen science projects to address science standards required by a state. While Wyoming as a whole has not yet adopted the Next Generation Science Standards, the author was curious about how this project might fulfill the different learning dimensions of the Next Generation Science Standards in the future. As a facilitator of this program, she was also interested in whether or not she and other facilitators explicitly addressed these three dimensions throughout the process, and how. Therefore, she decided to take an action research approach to this study in order to determine where the three dimensions were incorporated, whether or not participants grasped the concepts given, and how to improve facilitation of similar programs in the future.

Citizen Science

Citizen science, often called public participation in ecological research, participatory science, as well as many other names, is the involvement of citizen volunteers, or non-professionals, in scientific research (Dickenson, Zuckerberg, & Bonter, 2010). This involvement can range from simply helping to collect a specific set of data (contributory citizen science), or engaging in the entire scientific process (co-created citizen science), starting with a question, and ending with a presentation of the findings (Miller-Rushing, Primack, & Bonney, 2012). This study will focus primarily on co-created citizen science projects, in order to incorporate students to the fullest extent possible.

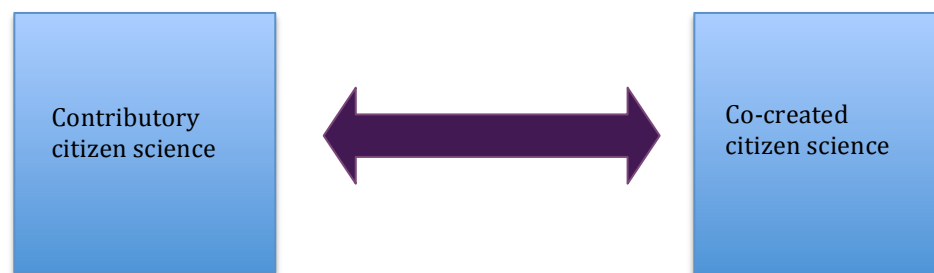


Figure 1. A graphic representation of the spectrum of participation and involvement of participants in citizen science projects. (Created from information provided by Miller-Rushing et al., 2012).

In informal science education settings, such as the *Girl Scouts in Science* program, researchers have previously had difficulty quantifying student learning through surveys, interviews and observations. There is little to tell facilitators that the program is successful other than the continued participation of students. Formal science education settings have had more success at determining learning through the use of grades and assessments (Zoellick, Nelson, & Schauffler, 2012). In either case, there is evidence that citizen science projects have the ability to

create ecological knowledge, scientific inquiry and place-based experiences for those who participate (Dickenson et al., 2010).

So how can citizen science projects be incorporated into educational settings, either informal or formal? Citizen science projects have been shown to not only increase the number of scientific facts that participants can recall, but teach them how to use appropriate scientific principles and processes when given the opportunity to participate in co-created citizen science projects (Bonney et al., 2009a). This idea of learning the scientific process is becoming increasingly popular in the education world, with new science standards being developed around it. If citizen science projects addressed these new standards, it is possible that they could be a valuable tool for science teachers.

Three-Dimensional Learning from NGSS

The Next Generation Science Standards (NGSS) were developed from 2010 to 2013 as a new set of standards to prepare students for college and career readiness in science. These standards require students to have a deeper knowledge of a smaller number of concepts than previous standard formats that emphasized shallower, factual knowledge (Pruitt, 2014). While the United States has previously provided little science education to its students, instead preferring to focus on the select few that later choose to enter into the science fields, this new system of standards is hoped to address science literacy for citizenship among all students, holding them to a higher standard, and providing resources for all (Stage, Asturias, Cheuk, Daro, & Hampton, 2013).

NGSS combines three learning dimensions to create performance expectations for each topic. These dimensions are Science and Engineering Practices, Disciplinary Core Ideas, and

Crosscutting Concepts. The expectation of these standards is for teachers to use the performance tasks as assessment points at the end of instruction (Workosky and Willard, 2013).

Teachers shifting to NGSS from the old set of standards have had difficulty in doing so, as the layout and implementation are vastly different than what they are used to (Reiser, 2013). The focus on process and performance standards, rather than specific content that students should know, has caused scientific education to move into a new realm. There is no longer a focus on facts, but on explaining phenomena, and inquiry is incorporated throughout the entire science learning process (Reiser, 2013).

With this new focus on inquiry and process, old techniques of science teaching may not cut it anymore. Citizen science projects can be designed to incorporate and focus on inquiry and the scientific process, rather than fact based knowledge. It can also be used in informal educational settings, in order to complement what is learned in the classroom. Therefore, this study aims to show that citizen science projects are an instance where Next Generation Science Standards can be accomplished effectively using process, core ideas and crosscutting concepts.

Goals of the Study

The goal of this Plan B paper is to help inform informal science educators about how citizen science projects can be used to teach science in an informal setting by incorporating the three dimensions of learning as presented by the Next Generation Science Standards, as well as to take a look at the facilitation of components of this program. This study was performed using qualitative data collected during observations of meetings, and during group discussion of participant knowledge and opinions of the use of the components of the three dimensions of learning throughout the project.

It is possible that projects like this can be used to cover not only particular science topics, but also the majority of a class' coursework. Citizen science projects can be facilitated in several different ways, including participants in different steps of the process. It is the intent of the author that this study will inform not only their own teaching methods and facilitation of this particular program, but also help both formal and informal educators to effectively incorporate citizen science projects into their curriculum, using NGSS and guidelines.

Research Questions

This study aims to answer the following questions:

- Can citizen science projects address the three dimensions of learning from the Next Generation Science Standards at the middle school level in informal educational settings?
- What aspects of research based citizen science projects can address the three-dimensions of learning from NGSS at middle school level in an informal educational setting?
- How can the facilitation of citizen science projects be improved in the future, to address more explicitly the three dimensions of learning?

Chapter 2

Literature Review

Before beginning this action research project, in order to gain an idea of how citizen science and the Next Generation Science Standards can be helpful to one another at the middle school level, the researchers had to do some research on several topics. These topics include: student interest in science, middle school learners, informal education, place-based education, citizen science and student-teacher-scientist partnerships, the Next Generation Science Standards, the Girl Scouts of America, and water quality. These topics were then used to determine how citizen science projects can address the Next Generation Science Standards, and how facilitators can more effectively address the three learning dimensions within similar projects.

Student Interest in Science

What can we do to increase student interest in science? There are several factors that contribute to students losing interest in science, including family support, knowledge of science careers, and confidence in the subject (Aschbacher, Ing, & Tsai, 2013). In order to look at ways in which science can effectively be addressed by the use of citizen science projects, the researcher believes it is important to look at the reasons students come to “dislike” science and lose interest in the subject over time. An interest in science early on has been correlated with science achievement as well as participation and achievement in advanced science courses later on in life (Chen & Howard, 2010).

As students progress in their academic careers, opportunities to experience science outside of the classroom become scarcer. The science that is done in school is the only science that students know, and for some this is frustrating and lacks excitement (Aschbacher et al., 2013). This “flight” from science, can be addressed using creative instructional strategies and programs, in order to put some excitement back into science learning (McWilliam, Poronnik, & Taylor, 2008). Informal learning environments can have significant impact on a student’s motivation to learn and ability to focus on the topic being studied. Their affect about science improves, and the bridge between informal and formal learning creates a more inviting atmosphere in which to learn (Kanter, Honward, Adams, & Fernandez, 2011).

Coupled with the idea that for students that have low expectations of success, relating an activity to their lives outside of school can have a significant impact on their learning outcomes (Hulleman and Harackiewicz, 2009), citizen science projects can be an intersect where novel, exciting activities and community relevance can be achieved.

Middle School Learners

This research study will focus on the middle school grade levels, as the age range of participants in the study ranges from 9-15, with middle school being the median age. The school arena plays an extremely important role in shaping students’ development, particularly through the middle school and adolescent years. It is during this time that adolescents are developing not only academic skills, but also learning how to interact with both peers and adults, and learning about their own independence (Meece, 2003). The changes that occur during this time can have significant impacts on many areas of life, including academic achievement (Wigfield, Lutz & Wagner, 2005). Sense of self is fragile at this point in life, and middle school students thrive in

classroom environments that can differentiate between the needs of different learners, as well as provide opportunities for students to develop their cognitive abilities, explore opportunities for autonomy and independence, and create meaningful relationships with peers and adults (Meece, 2003). The researcher sees this program as an opportunity for Girl Scouts to not only create even closer relationships with their troop leaders, but with the scientists and facilitators working to guide them through the process of completing a citizen science project from start to finish. One of the goals of this program is to introduce young girls to the world of scientific research and careers in the many fields of science, to encourage them to follow a similar path.

With the transition to middle school comes the lack of interest that was previously addressed. To increase interest in science at the middle school level, motivation must be instilled among young learners. Motivation is a key factor in students that stick with difficult tasks and approach challenging tasks eagerly. Motivation can be increased by several different actions taken by educators. Research has shown that students tend to be highly motivated in cooperative learning environments, such as problem based learning situations. Teachers can also ensure that materials used in the classroom are challenging and allow for students to feel as if they have autonomy over their learning (Liu, Horton, Olmanson, & Toprac, 2011).

Previous science curricula from the National Science Foundation recommended and emphasized the use of guided inquiry to teach science in middle grade classrooms (Dias, Eick, & Brantly-Dias, 2011). The scientific process can be equated to the problem solving process, which requires students to use problem solving and critical thinking skills in a collaborative setting, which as stated above leads to increased motivation in students at this grade level (Liu et al., 2011). Experience is a driving factor of brain and cognitive development. It exposes students to situations in which they can actually experience what they are learning, which will potentially

lead to increased cognitive development (Kuhn, 2006). While the Girl Scouts in Science program is not taking place in a traditional classroom during school hours, the same principles that apply to the classroom environment for middle school aged students can apply in the informal setting of the lab and field.

The participants in the *Girl Scouts in Science* program range in age from 9 to 15 years old, spanning the middle school age range, as well as a couple years further in each direction. Because of this, the average age of the group is that of a middle school student, but the participants range in characteristics of academic, cognitive and personal development. This group resides at different points along the spectrum in ability to engage in elaborate information processing strategies, use reasoning skills, make decisions, and organize and reflect on upon information received (Wigfield et al., 2005). For these reasons, the participants in this study may be able to comprehend and build information at different levels.

Informal Science Education

Informal education and informal science learning can take place in many different settings, such as zoos, museums, nature centers, and National Parks (Hofstein & Rosenfeld, 1996). Most Americans spend only five percent of their life in a classroom, and less than that in science specific classrooms. Therefore, the amount of science knowledge that students receive from formal school settings is quite little. Most science knowledge comes from the aforementioned activities (Falk and Dierking, 2010). Because of this reason, it has been difficult to define the term “science learning”. There is also debate over whether or not informal science learning can take place in a formal setting, such as the classroom. These challenges in defining the term have led to a few different distinct definitions (Hofstein & Rosenfeld, 1996).

One way to define informal learning is to create a clear dichotomy between informal and formal learning. Activities performed within the school setting during school time are formal learning situations, and those outside, such as field trips, are informal learning (Hofstein & Rosenfeld, 1996). Often these activities are less structured than those within formal education, and learning outcomes may not be as developed or even present (Hung, Lee & Lim, 2012). The second definition allows for a more “mixed methods” approach to learning, in which informal learning still refers to activities done outside of the classroom, and on a voluntary basis, but can be used as a supplement to formal learning. This hybrid approach to science education can help educators to reach all students, from those who learn best in a traditional classroom setting, to those who need real world interaction and context to understand a concept (Hofstein & Rosenfeld, 1996).

The idea of “learning by doing” can be achieved by implementing participation and co-determined interaction models. This type of learning strives towards not only learning about a topic, but also learning how to be, enabling students to understand how to make decisions with tangible consequences. Many researchers believe that this approach to teaching and learning is lacking in the formal education setting of the classroom, and therefore students lack the ability to talk about thinking, learning and making meaning of information they obtain (Hung et al., 2012).

With the knowledge that beginning at the middle school level students start to look for new relationships with their peers and adults, the idea of informal science education becomes appealing not only to the student, but to educators as well. Activities that students participate in outside of the classroom such as science clubs, competitions, or even reading about something on the internet, become opportunities for them to have meaningful conversations with their so called

authority figures, which work to break down the barriers that are put in place at school (Adams, Gupta & DeFelice, 2012).

Place-Based Education

With informal science education, comes the idea of introducing students to science by focusing on their own place in this world. Place based education is not a new idea. John Dewey noticed a disconnect that students had between school and the real world, and proposed an explanation for the problem. Children are unable to process ideas about phenomena in their world, and are instead drawn to the actual phenomena going on around them. For this reason, it is important to teach students about place, particularly their own place that they live and contribute to (Smith, 2002).

Studies have shown that place-based education can also help to bridge gaps between generations. In today's culture, there is often a disparity between younger and older generations, as technology and other aspects of our culture continue to develop at a remarkably fast pace. Place-based education inherently includes ways for a community to work together to create a better understanding of place, which can lead to many generations working together and learning from each other (Mannion & Adey, 2011). As with the many informal science education opportunities, this can break down barriers between students and those who have typically been seen to hold power or authority over them. The relationships that students at the middle school level create with their teachers, parents, and older community members can have incredible impacts on their learning environments and motivation.

By involving students in activities and projects that are directly related to their place, they not only become involved in the community around them, but tend to become more attached to

their place, and more likely to get involved in other projects or issues. Studies have shown that school activities allowing students to voice opinions about community concerns, help students to develop leadership and decision making skills (Barratt & Barratt-Hacking, 2011).

Place-based education is inherently multidisciplinary. It has the ability to draw upon many different subjects and topics at the same time, and in many cases can be used to teach several units within a particular curriculum (Gruenewald, 2003). The chance to take field trips and simply go outside to learn can bring back the opportunities to learn science, and any other subject, outside of the classroom that instill curiosity and engagement in students (Aschbacher et al., 2013). Simply telling students about the issues plaguing their world, and how to fix them has been shown to have little impact on their likeliness to go out and confront these issues. When they are given the opportunity to experience for themselves the problems within their communities, and brainstorm their own solutions, it gives them the tools to pursue those kinds of actions in the future (Barratt & Barratt-Hacking, 2011).

Citizen Science and Student-Teacher-Scientist partnerships

Citizen science, like place-based education, is not a new concept. Public participation in scientific research can be traced back at least as far as the 1880s, and since then it has gained momentum and contributed to vast amounts of scientific knowledge (Bonney et al., 2009b).

Citizen science projects have the ability to get the public involved in important environmental and policy based endeavors, as they have the opportunity to directly confront the issues and take part in determining the best course of action (Dickenson et al., 2012). This type of project has the opportunity to be extremely place-based if implemented correctly, and students therefore could have the potential to make a difference in their communities and their place.

In the context of education, citizen science projects are often referred to as Student-Teacher-Scientist Partnerships (STSPs). These partnerships include students and their teachers interacting with scientific professionals to engage in real scientific research. These STSPs provide two categories of benefits to the participants: benefits to the students and their teachers, and benefits to the scientists. Educational benefits for students and teachers include authentic experiences, and scientific benefits for the researchers include the ability to collect larger sets of data (Houseal et al., 2014). Scientists and other professionals also have the opportunity to encourage students to pursue future careers in the area of study addressed by the project (Burrows et al., 2009). Students become involved in local environmental issues, and further understand the scientific background of these issues, which will hopefully encourage future environmental stewardship and involvement (Wormstead, Becker, & Congalton, 2002). In the program being studied by this research study, *Girl Scouts in Science: Discovering Wyoming Water*, Girl Scout troop leaders will fill the teacher component of the STSP, as this is focused on a program being implemented in an informal education setting, outside of the classroom.

Citizen science projects have the ability to address place-based concepts in ever increasing ways. Many researchers have begun to focus on the “Anthromes”, or the places in which people live and work, and the importance of understanding the ecology of these places. Examples include ranches and farms that provide for a community (Dickenson et al., 2012). Participants in citizen science projects can incorporate human attribute data into their study, in order to match ecological data. This could include health statistics, resource use, residential habitat management, or energy use, all of which can help determine human impact on a system (Dickenson et al., 2010). This can address “Earth and Space Sciences”, one of the components of the Disciplinary Core Ideas, as well as “Cause and Effect”, one of the Crosscutting Concepts.

This new way of thinking could lead to citizen science projects centered around communities and place, which in turn can allow for students to create projects that benefit their own communities and engage in the scientific process rather than simply data collection, thus addressing Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts. This direct connection to a student's life and community has been shown within educational research to enhance motivation to learn (Bonney et al., 2009a).

Although citizen science projects, or students-teacher-scientist partnerships can be an engaging way to teach science, there are some challenges that are associated with them. When implementing a citizen science project, collection bias must be addressed. With many participants collecting data, it is likely that data will be collected in different ways or some participants may have more knowledge about the data being collected than others. This is generally true for large citizen science projects that have hundreds or thousands of data collectors, but can be true for smaller groups as well (Dickenson et al., 2010), particularly with middle school students as data collectors.

In most cases, citizen science projects are implemented in order to answer a scientist's research question, not to engage students in learning about science. Scientists come into the study with a specific question in mind, that does not end up addressing any standard or curriculum that the students are supposed to be learning about (Zoellick et al., 2012). Because of this, it is difficult for education and science research to be intertwined with a citizen science project. However, it is important to expose students to science in a way that does not simply feed them isolated knowledge and facts, but instead puts them in real world situations, whether that means taking them into the field to experience it, or bringing real world situations into a classroom (Burrows, Wickizer, Meyer, & Barowczak, 2013).

Next Generation Science Standards and Three-Dimensional Learning

Goals of the Next Generation Science Standards include boosting student interest in science and science based careers. Many students who develop an interest in STEM based careers start developing that interest early on around age eight (Aschbacher et al., 2013).

NGSS is based off of the National Research Council Framework for Science Education, developed in 2011 in response to the need to increase the science, engineering and technology knowledge of American students in order to keep up with international competition. Within this framework, three dimensions of learning are proposed to create well-rounded and holistic scientific learning. The idea behind this framework is that by the time students graduate high school, they will be able to participate in public discussion about local and global issues, and be critical consumers of scientific knowledge presented to them throughout the rest of their lives (National Research Council, 2012). An important message conveyed by the Next Generation Science Standards is that science will be the basis to the solutions that we create to solve the problems of the 21st century (Nargund-Joshi and Liu, 2013).

The three dimensions of learning presented by the National Research Council and NGSS are:

1. Disciplinary Core Ideas
2. Crosscutting Concepts
3. Science and Engineering Practices.

Disciplinary Core Ideas include the four main areas of scientific disciplines: Life Sciences, Physical Sciences, Earth and Space Sciences, and Engineering. The framework was developed with the idea that students build upon their knowledge as they progress in their academic careers, and that knowledge becomes more based in scientific evidence throughout the

process (NGSS Lead States, 2013). It also includes deeper investigations of a smaller number of ideas, rather than a broad, shallow look at many (Duncan and Rivet, 2013).

Crosscutting Concepts refers to the concepts that connect several Disciplinary Core Ideas together. The purpose of these Crosscutting Concepts are to help students make connections between the different Disciplinary Core Ideas, and in the process, develop a deeper understanding of all four disciplines (NGSS Lead States, 2013). There are seven Crosscutting Concepts that NGSS uses:

1. Patterns
2. Cause and effect
3. Scale, proportion and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

These concepts, like the Disciplinary Core Ideas, follow a progression throughout the grade levels, and become more complex as students increase their knowledge.

The last dimension of learning incorporated into the NGSS is the Science and Engineering Practices. The rationale behind including these practices is stated as such: By engaging in the practice of science, students can better understand how scientific knowledge develops, as well as engage their interest in the disciplines of science. The National Research Council states that each of these practices should be addressed at each grade level, as they are accessible to any age in some form (National Research Council, 2012). Eight Science and Engineering Practices are identified:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating and communicating information

Lastly, the framework for K-12 Science Education specifies that each of these dimensions should not be taught in isolation from the others. At any time, a Disciplinary Core Idea should ideally be connected to another using a Crosscutting Concept, and explored using one or more of the Science and Engineering Practices. Figure 2 shows the interaction between the three dimensions, and the intersection of all three, where we hope to end up. This shift in standards thinking aims to not just update science content being addressed, but to shift the way in which K-12 science is implemented and thought of. The process of connecting core ideas, concepts and practices lends science teaching to inquiry-based learning, which emphasizes science as a knowledge *building* endeavor, not just a knowledge *memorizing* endeavor (Duncan and Rivet, 2013).

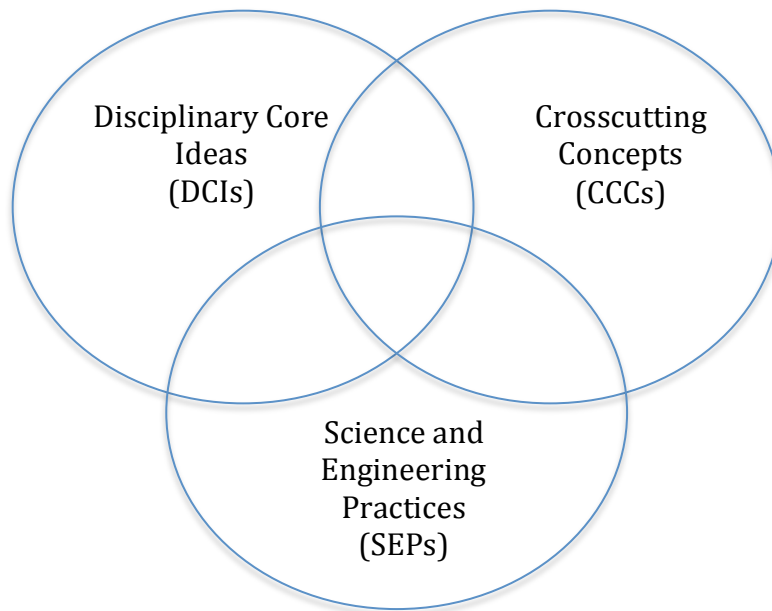


Figure 2. The three dimensions of learning, and the interactions between them (Developed from a figure from Houseal, 2015)

There has been a long-term debate happening about whether citizen science is “science” or “education”. Why does it have to only be one or the other? Sandra Henderson, the project director for Project BudBurst, believes that citizen science, if facilitated correctly, can be valuable both scientifically and educationally (Hendersen, 2012). As NGSS becomes more established across our country, there is a need for professional scientists to become a part of the process. With them as a part of the dialogue about how to implement and succeed with NGSS, it may be possible to incorporate more projects such as citizen science projects into curriculum (Duncan and Rivet, 2013). Many students enter their undergraduate years having never participated in inquiry based learning, so the movement to implement inquiry based projects at the K-12 levels has the potential to prepare students for their futures (Oberhauser and LeBuhn, 2012).

As citizen science evolves, so does its ability to address the learning dimensions of NGSS. For example, technology is constantly changing and improving, and with it, the ability for citizen science projects to collect more data than ever before (Newman et al., 2012). This use of technology can be useful in citizen science projects at the middle school level as well, as it can be used to address Science and Engineering Practices that are required from NGSS; particularly, the steps of “Analyzing and Interpreting Data”, and “Using Mathematical and Computational Thinking”. Programs such as those through Cornell University use technology for their data collection through national and worldwide species identification programs (Bonney et al., 2009b).

The *Girl Scouts in Science* program strives to introduce young girls to the different paths that can be taken to pursue a career in a scientific field, as well as to give them research experience through a citizen science project. If interest and motivation can be increased with projects such as these, particularly among young girls, then it is possible that science both inside and outside the classroom can benefit from incorporating something similar.

Girl Scouts of America

The Girl Scouts of America were founded in 1912 by Juliette Low. Originally called the Girl Guides, based off of the organization of the same name in England, the name was soon changed to the Girl Scouts in 1915 (Arniel, 2010). The original goals and missions of the Girl Scouts revolved around attaining personal goals and independence, while still maintaining ideas of traditional female roles. The organization was founded at a time when women’s and girls clubs were becoming popular in this country, as women’s suffrage became a focus (Revzin, 1998).

While the ideals of the Girl Scouts have changed over the years since founding, many of the original principles can still be seen in the goals and intent of the organization today. In the early 1900's, Girl Scouts were encouraged to learn self-sufficiency, as well as to help others become self-sufficient. There was a focus on encouraging girls to enter into professional careers, as well as to pursue higher education and become leaders in their communities. An emphasis that the researcher feels is most translatable to this particular study is the development of research skills. In the 1920's, this may not have directly applied to the kind of scientific research we are doing here, but early Girl Scouts handbooks emphasized a familiarity with research sources so that young girls may answer their own questions about the world around them (Revzin, 1998). And isn't that what science is all about, according to the Next Generation Science Standards?

The Girl Scouts of America have also been accepting of member diversity from the beginning. Juliette Low emphasized the importance of including those who were not of the "American norm", such as those of different racial and cultural backgrounds and those with disabilities who were often excluded during the times (Arniel, 2010).

Today the Girl Scouts are 2.7 million strong, including 1.9 million Scouts, and 800,000 adult volunteers and troop leaders. Their mission states "Girl Scouting builds girls of courage, confidence, and character, who make the world a better place" (Girl Scouts, 2016).

Water Quality

The *Girl Scouts in Science* program focuses on the uses and functions of water in Wyoming. The citizen science research portion of the program takes a look at the restoration of the Laramie River and gives participants a chance to develop a question and perform a research project that is centered around the issue of water quality. Water quality is an important issue to

address when implementing place-based education, as it can directly affect the citizens of a community. Water quality issues are a major challenge they we are facing worldwide, and as of 2012, research suggests that 44% of streams and rivers in the US were somehow impaired (Enos-Berlage, 2012).

There are many different ways to determine how clean water is. Some common parameters for testing water quality include chemical, physical, and biological analyses (Resh & Unzicker, 1975). For this program, facilitators focused on physical and biological factors, including macroinvertebrates, riparian height, canopy cover, particle size and velocity.

An engaging way to introduce students to water quality monitoring is through the collection and identification of macroinvertebrates to determine pollution levels in a body of water. Macroinvertebrates are small animals (though big enough to be seen without a microscope) without backbones that can be found at the bottom of lakes, ponds and rivers. Because certain macroinvertebrates thrive only under certain water quality conditions, students can use a pollution tolerance index to determine general water quality of the water (Puche & Holt, 2012). Having a variety of different aquatic species is indicative of high water quality and low levels of pollution (Lindbo & Renfro, 2003).

Riparian height impacts not only the aquatic habitat, but also the on-shore species that rely on trees and plants for food and shelter. More diverse habitats, both structurally and compositionally generally provide for a greater number of species to thrive in the area (Merritt & Bateman, 2012).

Canopy cover has a significant impact on several factors of water quality. Greater amounts of canopy cover keep the water cooler, which can increase populations of macroinvertebrates as well as other animal species. A decrease in foliage around the water

causes water temperatures to increase and can lead to major shifts in functional organization of macroinvertebrate populations (Masese et al., 2014).

Particle size can be an indicator of turbidity in water. The smaller the particles in a stream, the more they can become suspended in the water column to create turbid water (Marquis, 2005). High levels of turbidity can affect light penetration and primary production, as well as decrease the quality of habitat for fish and other aquatic organisms (USGS, 2015).

Velocity is an important factor when looking at water quality as faster moving water tends to have higher levels of dissolved oxygen (although participants did not measure dissolved oxygen during this study). Velocity can affect dissolved oxygen because water flowing over rocks and logs becomes aerated. Stagnant waters have lower levels of dissolved oxygen because they are typically warmer than faster moving water (Michigan DEQ, 2012). The Laramie River was straightened in the 1940's, which caused it to flow too fast, and was restored between 2009 and 2012 (Hoch, 2016).

The participants of the *Girl Scouts in Science* program performed tests to determine levels of these water quality parameters, in order to determine if the overall quality of the Laramie River has improved since the restoration that was completed in 2012. The issue of water quality aligns with the goals of the Girl Scouts of America in that it allows for young girls to perform scientific research and act as leaders within their community. It also exposes them to new topics in academia, and encourages them to pursue higher education opportunities in order to continue learning about the issue and how to help within their community, by helping themselves as well.

Chapter 3

Methodology

This study took the form of an action research study to determine what aspects of a particular citizen science project addressed the three dimensions of learning from NGSS, and how effectively the different components of the three dimensions of learning were addressed by the researcher and other facilitators of the *Girl Scouts in Science* program. The researcher performed an observational study during which observations were made of the program, such as what topics were being addresses, how they aligned with the three dimensions of learning, and how participants reacted to these topics.

Definition and Description of Action Research

The origins of action research in general stem from the time of World War II and the work of social science researchers (Reason, 2006). Kurt Lewin, a social psychologist, first coined the term “action research” in the early 1900’s, which he described as “problem centered research” (Afify, 2008). Around this time, pressure from both the public and the government to improve our schools led to an increase in the use of action research to do just that (Mertler, 2014).

There are many definitions of action research, but the general consensus is that it is research carried out by people who want to see change in a social situation in which they are a part of (Somekh, 1995), during which a plan is devised, action is taken, observations are noted, and reflection is strongly incorporated (Afify, 2008). Action research has been implemented in

many different environments, such as health, education, community development and organizations (Afify, 2008).

Action research in the academic setting refers to research done by teachers, administrators, counselors, or anyone else with a vested interest in the teaching and learning process, for themselves and others, in order to make a change in the way that a classroom, school, etc. operates (Mertler, 2014). The researcher decided to embark upon the path of action research for this study because although she was not the primary facilitator of the program, she wanted to know how facilitation of the *Girl Scouts in Science* meetings and events explicitly and implicitly addresses the three dimensions of learning from NGSS, and how facilitation of similar topics in the future can be maximized. Since teachers have the ability to influence the quality of academic performance, as well as motivation among students, with instructional decisions (Chen & Howard, 2010), it is important to take a look at the ways in which teachers and facilitators can improve these decisions.

There are many roles that a researcher can take during an action research project. In this case, the study identifies as an observational study, and the researcher was a full participant in the process. Mertler provides a spectrum on which the researcher can take the role as solely an observer, as a full participant in the program, or somewhere in between (Mertler, 2014). Since the researcher was already an integrated part of the *Girl Scouts in Science* program, it was easy for her to continue being a facilitator, as well as make observations about the participants and the content being addressed.

There are many different methods of collecting data when conducting an action research study. The two methods of data collection that were used in this study are observations and focus group discussions, during which notes were recorded for use later. Observations took the form of

unstructured observations, allowing the researcher to both engage in facilitation and note taking. Observations are useful in action research projects, as they can tell the researcher something about actual student behaviors as they are happening. This is preferable to interviews in which students voice their ideas and behaviors, as the researcher can see them with their own eyes. This type of data collection can also pose some limitations. For instance, the presence of a researcher taking notes in the classroom or field site has the potential to change student behavior (Mertler, 2014).

Three guiding issues and outcomes lie at the heart of most action research projects. These three foci are democratic participation, community empowerment, and social justice (Greenwood & Levin, 2007). Since action researchers are generally interested in the social situations of an issue, these three foci are clearly found in any problem addressed by action research (Somekh, 1995). Democratic participation refers to the involvement of all stakeholders that are affected by the issue or problem being researched in the decision making process to counteract the problem (Reason, 2006). Community empowerment refers to the participation of community members in the research and problem solving process when a community issue is the focus of the study. When community members are empowered to change their community and social situation for the better, new understandings are formed and action is taken (Ozanne & Saatcioglu, 2008). Social justice is a factor of action research because it involves creating a safe environment for everyone to live, contribute and thrive as individuals and as a group. In simplest terms, it refers to distributing all aspects of life evenly across society (Bonnycastle, 2011).

Participant Selection

Participants were chosen based on participation in the *Girl Scouts in Science: Discovering Wyoming Water* program at the University of Wyoming, led by Dr. Brian Barber and Dr. Lusha Tronstad. Part of this program allowed Girl Scouts, ages 9-15 to create a research project looking at the Laramie River Restoration project completed in 2012, to determine whether or not the restoration was successful. All participants in this portion of the program were invited to participate in this research study. Because all participants were under the age of 18, in order to comply with International Review Board policies, parental consent and assent forms were given to parents and Girl Scouts respectively. Both parents and Girl Scouts were informed of the purpose of the research project and what they would be asked to do, before reading and signing the consent or assent forms. The researcher presented this information during a scheduled *Girl Scouts in Science* citizen science meeting, before the scheduled events began. Consent and assent forms detailed information about the research study, participant responsibilities, privacy, confidentiality, and how to withdraw from the study. Of the 14 participants in the *Girl Scouts in Science* Citizen Science project, 10 volunteered to participate in this study. Notes were taken about these students only.

Data Collection

Data was collected during observation of 10 *Girl Scouts in Science* meetings that took place between September 2015 and March 2016, as well as through four focus group discussions with participants about the content covered within the program. During meeting observations, the researcher took notes on the content, topics, participants, and dialogue occurring throughout the meeting. For the first four meetings, these notes were recorded post meeting, as the researcher

had not yet determined that observation notes would be the methods of data collection for this study. Notes were recreated from memory and the less formulated notes taken during these meetings. For the last six meetings, the researcher had a notebook with her and notes were taken as the meeting progressed, including quotes from participants and facilitators. Notes included information about the topics being covered, dialogue and quotes from participants and facilitators, engagement of participants, and general actions of participants and facilitators. After these meetings, the researcher typed up the handwritten notes, and added detail where memory allowed.

Participants also participated in focus group discussions about their opinions of how the three dimensions of learning were included and addressed within the program. During focus group discussions, the researcher asked the participants questions about the three dimensions of learning, including which ones they thought were addressed during the program, how they were addressed, and if certain situations addressed a particular dimension. Questions ranged from simple yes or no responses to more open-ended responses in order to include all participants. The researcher noted participant responses during the discussions. Some example questions are listed below (A full list of questions is provided in Appendix A).

- What are some scientific skills (Science and Engineering Practices) that we have learned over the course of this project?
- What are some of the big topics (Disciplinary Core Ideas) that we've talked about?
- What are some themes (Crosscutting Concepts) that we have covered in many different ways?
- What subject have you learned the most about during this project?
- When we counted macroinvertebrates, were we analyzing data?

- Have you had a chance to discuss your ideas and results with anyone, either within this group or outside this group?
- Do you think that by performing a T-test, you used mathematics?
- If there are macroinvertebrates under large rocks, and not under small ones, is this a pattern?
- There is less shade over the water, and the temperature of the water rises, so we see fewer macroinvertebrates. Is this “Cause and Effect”?

Data Analysis

Notes taken during observations and focus group discussions were then coded by the researcher. Coding was done by hand using colored highlighters to code for each component chosen. For Crosscutting Concepts and Science and Engineering Practices, a broad component was coded, and the researcher then looked for more specific instances of other components that can fall under the umbrella of that larger component. Dimension components were coded accordingly:

- Science and Engineering Practices
 - Planning and carrying out an investigation = pink
 - Asking Questions and Defining Problems = pink
 - Analyzing and Interpreting Data = pink
- Crosscutting Concepts
 - Patterns = blue
 - Cause and Effect = blue

- Disciplinary Core Ideas
 - Life Sciences = green
 - Earth and Space Sciences = yellow

Figure 3 shows a page of raw notes and a page of coded notes from a meeting that occurred on November 7th, 2015.

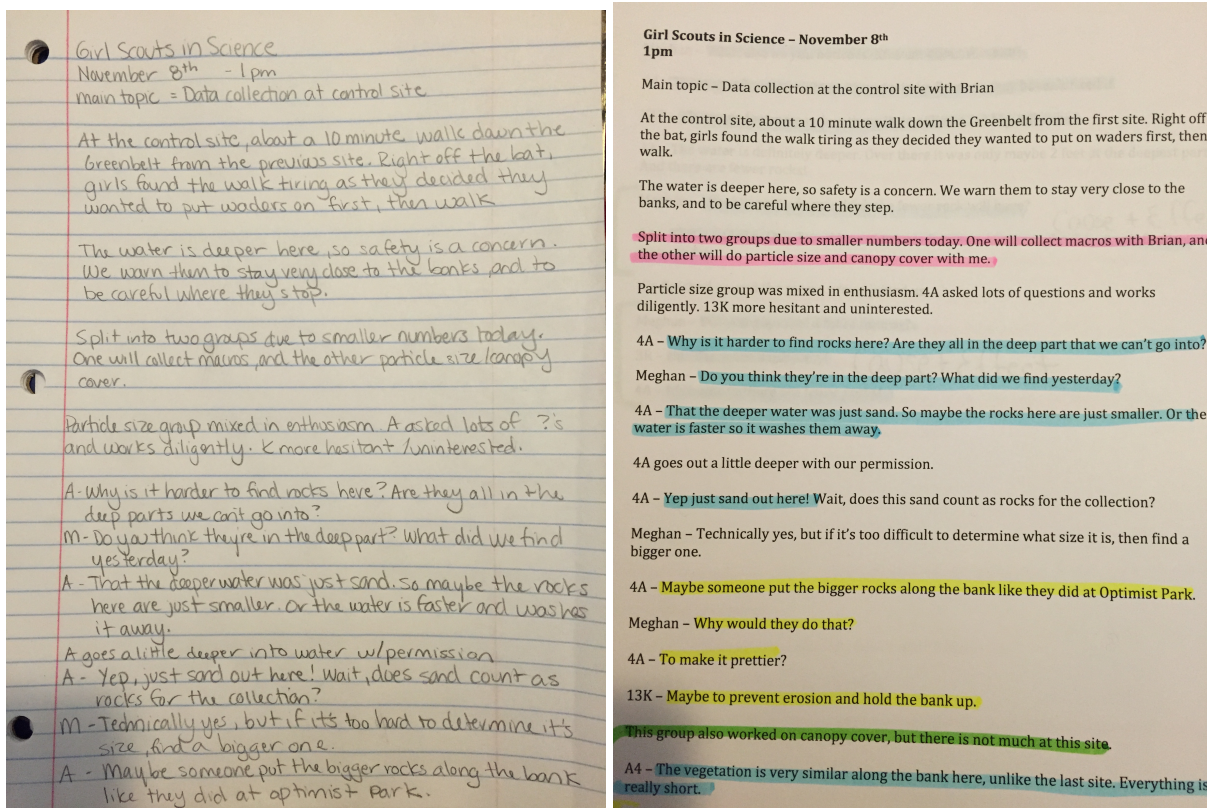


Figure 3. Raw (left) and coded (right) *Girl Scouts in Science* Citizen Science meeting observation notes from November 7th, 2015.

Meetings and focus groups discussions were determined to have addressed the chosen components if:

- Participants or facilitators asked a question that led to discussion of the component
- Facilitators introduced a new topic to participants

- The theme of the meeting, and therefore actions throughout the meetings, addressed the components

The researcher then determined which components were addressed most frequently throughout meetings and focus group discussions. She then determined which aspects of the program addressed each component. Aspects of the program are:

- Planning of the investigation
- Implementation of the investigation
- Public presentation of the findings
- Introduction to new topics
- Dialogue during meetings
- Activity or scientific skill of the day
- Debrief of the day's activity

Chapter 4

Results

After coding the observation and focus group discussion data, the researcher found that while the *Girl Scouts in Science* program addressed all of the components of the three learning dimensions at least once throughout the 10 meetings, there were several that were addressed most frequently. Among the Disciplinary Core Ideas, “Life Sciences” and “Earth and Space Sciences” were addressed with the most frequency of the four categories. Of the Crosscutting Concepts, the author notes that “Patterns” and “Cause and Effect” were the most explicitly addressed. Of the Scientific and Engineering Practices addressed, “Planning and Carrying Out Investigations” stood out, which encompasses several other practices as well, including “Asking Questions and Defining Problems” and “Analyzing and Interpreting data”, both of which were also addressed quite frequently.

Quotes from participants and facilitators were helpful in determining where components were addressed. Tables 1 and 2 include selected quotes from both meeting observations and focus group discussions that are aligned with each component chosen by the researcher to focus on. Because data was not gathered from a recording, the researcher was unable to analyze the data as a literal transcription. Therefore, the analysis was done using implied meaning of dialogue and situations. Since the researcher was present and a part of the activities being facilitated, she was able to interpret and imply meaning from quotes that could be taken out of context by outside readers.

Table 1: Selected quotes from *Girl Scouts in Science* Citizen Science meeting observations and focus group discussions illustrating participant incorporation of the selected learning dimension components.

Learning Dimension	Component	Meeting observations	Focus group discussions
Science and Engineering Practices	Planning and carrying out investigations		<p>“We learned about the science circle, and how to do science”</p> <p>“We definitely planned an investigation, and have been carrying it out to complete the science process”</p>
	Asking questions and defining problems	<p><i>When prompted that the research question needs to be broad and measurable,</i></p> <p>“Was the restoration successful? We can look at whether or not the water is cleaner and the river healthier or not”</p>	<p>“We developed questions at the beginning of the study, and are answering them as we go. And we’re still asking smaller questions all the time”</p>
	Analyzing and interpreting data	<p>“When are we going to make more graphs and analyze data that way? That was really fun!”</p>	<p>Lockwood – “When we counted macros, were we analyzing data?”</p> <p>Participant - “Yes, you have to count them before you do any more analysis, so you know what you’re working with. It’s the first step in analysis”</p>
Crosscutting Concepts	Patterns	<p>“I notice that there seems to be more canopy cover here at the restored site than further down at the control site”</p>	<p>“We’ve seen patterns. Like how in faster water, there are fewer macroinvertebrates than in slower water”</p>
	Cause and Effect	<p>Lockwood – “What impacts do you think the fact that there are fewer rocks will have?”</p> <p>Participant – “Well yesterday they found lots of macros in the rocks, so maybe they aren’t finding as many today”</p>	<p>“The restoration caused the water to be healthier. Or at least that is what we are hoping for, and trying to determine”</p>
Disciplinary Core Ideas	Life Sciences	<p>“I think I know what kind of crane fly larva this is!”</p>	<p><i>When asked if they have addressed life science within the program,</i></p> <p>“Yes, macroinvertebrates are definitely a part of life science. They’re alive and we’ve learned how to identify them”</p>
	Earth and Space Sciences	<p>“Maybe someone put the rocks along the edges of the river here like they did at Optimist park”</p>	<p>Lockwood - “Have we talked about how people are involved in the system?”</p> <p>Participant – “Yes, they were involved in the restoration and making it better”</p>

Table 2: Selected quotes from *Girl Scouts in Science* Citizen Science meeting observations and focus group discussions illustrating facilitator incorporation of the selected learning dimension components.

Learning Dimension	Component	Meeting observations	Focus Group Discussion
Science and Engineering Practices	Planning and Carrying out Investigations	“Now that we have a question, we need a hypothesis. Who knows what a hypothesis is?”	“Which of the following steps are important parts of planning an investigation? Developing questions and hypotheses, determining data to collect, collecting data, and analyzing data.”
	Asking Questions and Defining Problems	“We need to develop a questions. This will guide our study, so what do we want to know?”	“What is the question we are trying to answer? Is this a researchable question?”
	Analyzing and Interpreting Data	“Today we will continue to analyze our data by making figures of the data we collected”	“We used a T-test and statistics to see if we had significant data. Is this a form of analysis?”
Crosscutting Concepts	Patterns	“What patterns do you notice as you’re observing the site?”	“Patterns are not just cool designs that you see, but places where you notice things occurring”
	Cause and Effect	“What impacts do you think the fact that there are fewer rocks will have?”	
Disciplinary Core Ideas	Life Sciences	“We could look at plant growth around the river. Why is that important to us?”	
	Earth and Space Sciences	“Why would the restoration team put bigger rocks along the bank of the river?”	“What about Earth Systems Science? What do you think that is?”

Table 3: Meetings at which each of the components of the learning dimensions were addressed in regards to water quality.

Learning dimensions	Meeting Number									
	1	2	3	4	5	6	7	8	9	10
Planning and carrying out an investigation	X	X		X	X	X	X	X	X	X
Asking questions and defining problems	X	X				X		X		X
Analyzing and interpreting data						X	X	X	X	X
Patterns	X	X		X	X		X	X		
Cause and Effect	X	X		X	X		X	X		
Life Science	X	X		X	X		X	X	X	X
Earth and Space Science	X	X			X					

Table 3 shows at which meetings each component of the learning dimensions were addressed. Of the 10 meetings that the researcher observed and took notes at, “Planning and Carrying Out an Investigation” was addressed in relation to an investigation surrounding water quality by the facilitators at nine of them. The 10th meeting (October 11th) was focused less on water quality, and more on the process and methods of collecting data in general with a guest facilitator. The researcher also looked at “Asking Questions and Defining Problems” as well as “Analyzing and Interpreting Data” which fell under the broad umbrella of “Planning and Carrying Out an Investigation”. A standard that was addressed by the instances in which participants analyzed and interpreted data is standard MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of

organisms in an ecosystem. “Asking Questions and Defining Problems” was addressed at four meetings, and “Analyzing and Interpreting Data” at five. Other instances of addressing investigations included creating hypotheses and collecting or communicating data.

“Patterns” were addressed at seven of the 10 meetings. In this study, the researcher identified an instance where patterns were addressed if a facilitator asked a question about patterns present in the content, or if a participant identified a pattern relating to water quality (ex: macroinvertebrates are found more frequently under rocks than in open water). Within this category, the researcher identified “Cause and Effect” as a pattern. Instances of “Cause and Effect” were addressed at six meetings out of 10. “Cause and Effect” was defined in this study as a particular factor having an effect on the quality of the water, or another factor that can be used to indicate water quality. “Cause and Effect” was addressed in other ways not relating directly to water quality as well.

The two Disciplinary Core Ideas that the researcher focused on were “Life Sciences” and “Earth and Space Sciences”. The instances where life sciences were addressed focused primarily on macroinvertebrates, as four of the six meetings at which it was addressed were spent separating and identifying the macroinvertebrates that had been collected at the two study sites. In total, eight of the 10 meetings addressed life sciences in relation to water quality. In order for a meeting to be determined to address life sciences, the facilitators must have brought up a question or new information about the wildlife (flora or fauna) that is related to water quality, or participants asked questions of their own about the living components of the river system.

The second Disciplinary Core Idea, “Earth and Space Sciences” was addressed primarily in the sense that humans had an impact on the system that was studied during this research project. There was no mention of how the system interacted with the atmosphere. “Earth and

Space Sciences” was addressed at three of the 10 meetings, though it is expected to be addressed at more in the future as participants put together their final presentations to present their findings to the public.

In most cases, all of these components were also present in instances where water quality was not the focus of the situation. For instance, one meeting was dedicated to alternative data collection methods (drawing instead of written observations), and while the main topic of discussion was not the water quality research project, there was discussion about parts of the scientific process that can be considered “Planning and Carrying Out an Investigation”, “Asking Questions and Defining Problems”, “Analyzing and Interpreting Data”, “Patterns”, “Cause and Effect”, and “Life Sciences”.

After determining which components were addressed most often throughout the program, the researcher looked at which aspects of the *Girl Scouts in Science* citizen science program addressed these particular components. Table 4 shows those aspects and components.

Table 4. Learning dimension components addressed during different aspects of the *Girl Scouts in Science* citizen science program.

Program Aspect	Life Sciences	Earth and Space Sciences	Patterns	Cause and Effect	Asking Questions and defining problems	Planning and Carrying out an Investigation	Analyzing and Interpreting Data
Planning an investigation	X	X	X	X	X	X	
Implementing investigation	X	X	X	X	X	X	X
Public presentation of findings	X	X	X	X		X	
Introduction of new topics	X	X	X	X	X	X	X
Daily activities/skills	X	X	X	X	X	X	X
Dialogue	X	X	X	X	X	X	
Debrief of activity	X	X	X	X			

As Table 4 shows, many aspects of the *Girl Scouts in Science* program addressed each of the chosen components, as well as others that the researcher did not code for. The components “Analyzing and Interpreting Data” and “Asking Questions and Defining Problems” were addressed by fewer aspects of the program than the other components.

The components previously discussed are those that were addressed most frequently within the *Girl Scouts in Science* program. Besides these components, there were many others that were addressed with less frequency, though all were addressed at least once. Within Disciplinary Core Ideas, “Engineering” was not a focus of this particular program. The topic was mentioned once in regards to the restoration done on the Laramie River, but not in the context of performing the research project. “Physical Sciences” was addressed only twice, even though the project revolved around water quality, which is a component of physical sciences.

Crosscutting Concepts that were addressed sometimes throughout the program are “Stability and Change” and “Structure and Function”. Those addressed infrequently are “Systems and System Models”, “Scale, Proportion and Quantity”, and “Energy and Matter”.

Science and Engineering Practices addressed with some frequency throughout the program are “Using Mathematics and Computational Thinking” and “Obtaining, Evaluating and Communicating Information”. Practices addressed infrequently throughout this program are “Developing and Using Models”, “Constructing Explanations and Designing Solutions”, and “Engaging in Argument from Evidence”.

Chapter 5

Discussion and Conclusions

Girl Scouts and Water Quality

In the case of this study, a water quality based citizen science project was used to teach the scientific process, increase scientific inquiry, and introduce Girl Scouts to scientific professionals in different scientific careers. The actions they took during the process of the scientific investigation to determine if the restoration of the Laramie River was successful or not, are in alignment with the values and goals of the Girl Scouts of America, and have the potential to make an impact on the community in which they live. The inclusion of professional scientists from the University of Wyoming in the project brings the views and knowledge of masters in their field, to increase scientific knowledge among participants in those specific fields, and to hopefully increase interests in higher academia and scientific careers.

At the time of the completion of this Plan B project, the research project in question has not yet been completed, though a public presentation of the conclusions found by participants will be presented in May of 2016. However, at the time that this paper was written, participants are in the process of analyzing the data that they collected at the control and restored site of the Laramie River. Preliminary analysis shows that the water quality of the restored site is slightly better than that of the control site. Water levels in the restored site are shallower, and velocity is higher, with increased canopy cover to shade the aquatic ecosystem. Macroinvertebrate data also shows that there is more diversity of species, as well as denser numbers of “good” macroinvertebrate species, which indicates a healthy section of water (Puche & Holt, 2012).

Participants have made no conclusions yet, and analysis of other factors is still in progress, but these steps are soon to be completed at future *Girl Scouts in Science* meetings.

The results of a water quality project such as this one impact not only the scientific curiosity of those involved, but can be extended to the community in which the river plays a part. Water quality is a factor that is easily linked to social justice, and environmental justice situations (Enos-Berlage, 2012). If participants find that the water is not of a high quality, then there may be reason to believe that low water quality is affecting other areas of life, which could be related to social justice issues in the area (i.e. Waste dumps, chemical facilities, etc.).

Three-Dimensional Learning and Next Generation Science Standards

The ability of citizen science projects similar to this one to address the three dimensions of learning from the Next Generation Science Standards is plentiful. While the program in question did not have explicit initial goals to address the components of the three dimensions of learning, this study suggests that there is an inherent ability of co-created citizen science projects to address the Science and Engineering Practices, as participants are included in the planning process as well as data collection and analysis.

This particular research project was able to address most explicitly the Science and Engineering Practices of “Planning and Carrying Out an Investigation”, “Analyzing and Interpreting Data”, and “Asking Questions and Defining Problems”. With the planning and implementation of a research project, these steps were easy to address within the context and timeframe of the project. The researcher expects that at the end of the semester, when the project is presented to the public with a poster presentation, that the final practices of the Science and Engineering Practices would be explicitly addressed as well.

Disciplinary Core Ideas were inherently incorporated within the topics that were addressed by the project. As the project focused on the Laramie River and the changes in water quality after restoration, the “Physical Sciences” are the obvious core idea to be addressed. However, the researcher found that two other core ideas were explicitly addressed more often during this project, “Life Sciences” and “Earth and Space Sciences”. “Life Sciences” showed up prominently as there was a significant focus on macroinvertebrates as an indicator of water pollution. Participants worked exclusively with these creatures for five of the 10 meetings, as throughout this process, they learned about different species and families of macroinvertebrates, as well as how to identify and count them in order to analyze the macroinvertebrate profile of the two study sites. “Earth and Space Sciences” was also addressed frequently by both facilitators and participants. “Earth and Space Sciences” addresses the ways in which the earth interacts with the atmosphere around it, as well as how humans affect the systems on earth. Within the *Girl Scouts in Science* program, facilitators addressed how people have had an impact on the Laramie River system, though spent little time on the ways in which the atmosphere plays a role in the system. However, the researcher believes that this idea could be incorporated in the future with more planning. “Engineering”, the last core idea, was not used within the program, though it was talked about briefly in regards to the engineering that was needed in order to perform the restoration from 2009-2012.

Crosscutting Concepts that were most explicitly addressed during this program were “Patterns” and “Cause and Effect”, though others were addressed with less frequency as well. Other components that were addressed briefly were “Stability and Change” and “Structure and Function”. With proper planning and organization, these Crosscutting Concepts as well as others could be addressed with more frequency within the *Girl Scouts in Science* program.

Participants varied in their ability to identify different components of the three dimensions. For example, some participants focused intently on “Patterns” throughout the program, whereas others were quite interested in the scientific practices, particularly “Planning and Carrying Out an Investigation”. In future iterations of this program and project, facilitators might consider assessment of some form throughout to ensure that all participants grasp each concept addressed.

The *Girl Scouts in Science* program was not able to address all of the components of all learning dimensions, but with some more extensive planning and creation of learning outcomes, the researcher believes that it is possible for a project such as this to address all components for a particular grade-band level.

Citizen Science Projects and Student-Teacher-Scientist Partnerships

This study suggests that citizen science projects can incorporate the Next Generation Science Standards, even when implemented in an informal setting. While it may not be necessary for a program that is unaffiliated with science classes at a school to address science standards, there are benefits to students learning science in settings outside of the classroom in order to enhance learning at school.

This particular citizen science project guided the participants through the scientific process, from asking a question to eventually sharing their results with the public. While each component of the process may not have been addressed with equal emphasis, participants had to learn background info about the river, come up with a question to answer during their project, create hypotheses, determine data to collect, collect and then analyze data, and will soon be presenting their findings to the public at a poster presentation.

The *Girl Scouts in Science* program suggests that citizen science can at the very least address the process of scientific inquiry, while also teaching participants some hard facts about different scientific topics. This aligns with what is presented in the literature presented in the literature review (Bonney et al., 2009a). In the future, this project has the potential to continue addressing different topics if there is an explicit effort to incorporate standards into the project.

In addition to this program and others like it being able to address the three dimensions of learning in general, there were also particular aspects of the program that specifically addressed the chosen components of this project. All aspects addressed several components, and some even addressed all of them. Those that addressed all components are “implementation of the investigation”, “introduction of new topics”, and “facilitation of daily skills or activities”.

Components addressed infrequently by this citizen science program could potentially be addressed more explicitly in the future with proper planning. All components of the three learning dimensions were addressed at least once throughout the program, but with intentional planning and objectives, they could be addressed more frequently and explicitly. The researcher recommends for those who are designing and facilitating a citizen science research project that will be carried out in an informal educational setting, to work as closely as possible with teachers and those who are familiar with the Next Generation Science Standards, or any other version of science standards that is in effect with the students they will be working with.

While teachers have limited time to teach their own students, let alone to help with other informal educational programs, this relationship between teachers and citizen science programs would allow for proper learning objectives to be established for citizen science projects. Another suggestion is to have an informal science coordinator assigned to school districts, who could help to plan and facilitate such programs.

Another factor to consider when implementing a citizen science program is participant retention. As an informal educational program or project, participation in citizen science is voluntary and incentives to continue with the program may not be as high as if the project was implemented in a formal educational setting. With this program and those similar to it, the researcher recommends first creating exciting, activity-based lessons and situations to keep current participants engaged and coming back. To increase retention across years, the researcher suggests including younger students and participants in other aspects of the program (such as with the *Girl Scouts in Science* program, in which younger scouts were involved in individual workshops during which the citizen science component of the program was promoted). This encourages other students to become involved in future years of the program.

Place-Based Education

The involvement of young students in activities concerning their communities, such as the citizen science project performed in the *Girl Scouts in Science: Discovering Wyoming Water* program, can expose them to place-based experiences, which have the potential to connect students to the places in which they live, and subsequently increase curiosity about the world around them (Smith, 2002).

The program studied in this study can be considered a place-based experience, as it involves participants directly with a previous project that was implemented to better their community (Barratt & Barratt-Hacking, 2011). The process that the participants go through to determine if the restoration was successful or not, and if the water quality of the Laramie River really has improved, causes them to be hands-on involved with a natural resource within their community. The exposure to projects like this one, and in result the exposure to natural resource

use and quality, is likely to lead to a greater appreciation for and knowledge of the importance of these resources in a community (Aschbacher et al, 2013). It is the goal of place-based education to involve the residents of said communities in decision-making endeavors, and the more that a citizen knows about and is involved with the issue being discussed, the more informed those decisions will be (Barratt & Barratt-Hacking, 2011).

The participants in this study have shown an appreciation for continuing to monitor the river in future iterations of this program, and realize what impacts a clean river can have on the community around them. While place-based education was not explicitly mentioned to participants in this study, the principles of this form of informal learning were implemented by facilitators, and have had a positive impact on participant learning.

Informal Learning

This study suggests that citizen science as a form of informal learning outside of the classroom can have a positive impact on students' knowledge of the scientific process and facts about the topic being researched. Much of a student's knowledge of science comes from situations outside of the school classroom. For this reason, it is important for students to be exposed to programs and projects such as citizen science that can help them to not only have fun, but also learn at the same time (Falk & Dierking, 2010). Having a positive environment outside of school for middle school aged students to be comfortable in their learning is an important factor in increasing motivation at this time in a student's life (Liu et al, 2011).

Informal education settings have the ability to address some of the factors that create a safe and supportive learning environment for these students. For example, this program, *Girl Scouts in Science*, allowed for students to interact with authority figures in a different way than

many schools allow for. Professional scientists helped to guide the research project, but participants were involved in creating it with them, not just performing tasks that they were told. This type of relationship is strived for at this point in an adolescent's life, and programs that can lend themselves to this structure have the ability to increase motivation to learn (Liu et al, 2011).

Participant responses during focus group discussions suggest that they appreciated the freedom they had within the structure of the research project to plan a certain amount of it on their own. While the researcher and other facilitators guided their inquiry, the participants felt as if they were directing the project in the direction they wanted it to go.

This guided inquiry model can be used to address Next Generation Science Standards, particularly the learning dimension of Science and Engineering Practices. Informal education, though it is not typically required to include standards as they are not affiliated with a specific academic setting, can benefit students by including science standards in informal science learning. This would take planning and foresight, and mean that organizations would need to include explicit objectives to address specific standards, but it can be done.

A benefit to teaching to standards in informal settings is that often informal educators have more time in which to plan, and then to teach the topics and activities desired. Classroom teachers may only have students for an hour a day, and it is difficult to really dive into the research process in that amount of time. In informal settings, facilitators might have students for several hours at a time, during which more steps of the process can be covered.

Middle School Learners and Student Interest

This study focused on participants ages 9-15, with the middle school age being the median. In Wyoming, students often do not begin learning science in school until late elementary

school or the middle school level. For those in this program that are younger and have not yet entered the middle school arena, this program may be some of the first introduction that they have had to science. During a particular focus group discussion, one participant asked if they could be considered scientists. This led to a fruitful discussion about what is and isn't science. It was during this discussion that some of the participants mentioned that they learn about science in school, but do not actually "do" science. Within the structure of this program, they feel like scientists.

With interest in science decreasing at the middle school level, it is important to continue to provide informal learning opportunities for students to be exposed to science in different settings, other than the classroom. With the implementation of the Next Generation Science Standards, hopefully science classrooms will be somewhere that the science process is taught, and scientific curiosity is fostered. However, in states like Wyoming, these standards have not yet been adopted, and it may take some time before science in the classroom looks like this.

Since the participants in the *Girl Scouts in Science* program ranged in age from 9-15 years old, they fell upon a spectrum in understanding of the concepts addressed during the research project (Wigfield et al., 2005). The researcher noticed themes in engagement and understanding throughout the program, though they were not the main focus of data collection during meetings and focus group discussions. It was expected that younger students would have a more difficult time understanding the process taken to implement a research project, and the scientific topics approached. However, the researcher noted that younger participants tended to be more engaged in the research process and eager to learn new scientific facts and concepts. The researcher hypothesizes that perhaps younger students have had less exposure to science in the classroom, and are still open to the idea of science as a process and to learning how to "do"

science, whereas older participants have had several years of science learning in school and are more set in the ways that they know how to learn about science.

Participants on the older end of the spectrum were more interested in the data analysis aspects of the program, whereas younger students wanted very little to do with these steps. Perhaps this is because students ages 12 and older have begun to learn basic statistical concepts that were used to analyze data, and therefore feel as if they can transfer the knowledge they have to this program.

Limitations

Throughout this study, some limitations were discovered. The exclusion of any type of qualitative data collection means that there was less variation in collection types, which put this study at a disadvantage by way of analysis.

If the researcher were to perform this study again, she would consider administering a survey to participants before and after the program to determine what knowledge was gained, and how it was connected to the three dimensions of learning. This would have provided a quantitative component to the data collection and allowed for a T-test to be performed. With this analysis, the researcher may have been able to determine what the program taught each participant, and the group as a whole.

The *Girl Scouts in Science* program began in September 2015, but the researcher decided that observation notes and focus group discussions would be the method of data collection in November 2015. Therefore, meeting notes from before November 2015 were written after meetings based on minimal notes taken during the meetings. Starting in November 2015,

meeting notes were taken as the meetings progressed, and in result may include more detail than previous meetings.

At the time of completion of this Plan B paper, the *Girl Scouts in Science* program is still in progress, and participants are still analyzing data and making conclusions about the water quality of the Laramie River in order to present their findings to the public in May 2016. Due to the timeframe of the program and this Plan B project, the researcher was unable to continue to use meeting observations and focus group discussion notes in the write up past March 2016. In the future, the researcher suggests that another study look at the *Girl Scouts in Science* program in its entirety, or another program that has similar characteristics.

Future Research

Other future research projects may include, as stated before, performing a similar study to this one, but including assessment points along the way to determine where participants are in their understanding. Another project could entail looking at more specific sections and standards of the Next Generation Science Standards to determine which this program meets. Lastly, as stated above, another study, with a longer timeframe could look beyond the analysis portion of the program to determine if the rest of the meetings will continue to address the learning dimensions found.

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APPENDIX A

Focus Group Discussion Questions

List of open-ended group discussion questions

- What are some scientific skills (Science and Engineering Practices) that we have learned over the course of this project?
 - Do you think that we addressed all of the scientific practices?
- What are some of the big topics (Disciplinary Core Ideas) that we've talked about?
 - Do you think that we talked about all of the core disciplinary ideas?
- What are some themes (Crosscutting Concept) that we have covered in many different ways?
 - Do you think that we addressed all of the cross cutting concepts?
- What subject have you learned the most about during this project?
 - How much did you learn about it? A lot, a little?
 - Did we talk about it explicitly, or did you infer that we were talking about this subject?
- What is your favorite thing that we did during this project and why?
- What was your least favorite thing about this project and why?
- What would you change about this project if given the chance?
- How have I personally helped you during this project?
- What can I do in the future to help more?

List of Yes or No response Focus Group Questions

Science and Engineering Practices:

Asking Questions and defining problems

- What is the question that we are trying to answer during this study?
- Is this a researchable question? Can we measure it?
- Is this the only instance in which we've answered questions?
- What about each time one of you asks me a question? Have we worked to answer those as well?

Developing and using models

- Are the maps that Tony showed us back in September useful to help us understand the Laramie River system?
- Would you consider these maps models to help you understand the system?

Planning and carrying out investigations

- Which of the following that we've done are important parts of planning and carrying out an investigation?
 - Develop question
 - Develop hypotheses
 - Determine what data to collect
 - Collect data
 - Analyze data
- Can you think of any other important parts?

Analyzing and interpreting data

- When we counted macros, were we analyzing data?
- When we identified macros, were we analyzing data?
- We used a T-test and statistics to see if we had significant data. Is this a form of analysis?

Using mathematics and computational thinking

- Do you think that by performing a T-test, you used math?
- Did the computer and Excel help you to complete this task?

Constructing explanations and designing solutions

- When we ask you to explain why something is the way it is, have you constructed an explanation?
- We asked you to think about why there are more macros at the experimental site than the control site. Did this include constructing an explanation?

Engaging in argument from evidence

- Have you had a chance to discuss your ideas and results with anyone, either within this group or outside this group?

- Do you feel that you used evidence to argue an idea?

Obtaining, evaluating and communicating information

- You listened to Tony Hoch talk about what the Laramie River was like before restoration. Did you obtain information from this?
- You collected data from two different sites. Were you able to collect different information?
- Have you had a chance to tell anyone about what it is you're doing during this project?
- To communicate this information, do you have to do a big presentation?
- Will we be communicating it to a formal audience later this semester?

APPENDIX B

Parental consent form

Citizen Science and Three-Dimensional Learning with Next Generation Science Standards

You are being asked to allow your child to take part in a research study. This document has important information about the reason for the study, what your child will do in this research study, and the way we would like to use your child's information

Description of Research:

My name is Meghan Lockwood and I am completing a Plan B project this year to earn my Masters Degree in Natural Science with a focus in Natural Science Education. The purpose of this research study is to inform my facilitation of citizen science projects such as this one, and to determine what aspects of a particular citizen science research based project (in this case the *Girl Scouts in Science: Discovering Wyoming Water* program) at the middle school level can be used to address three-dimensional learning in an informal setting. I hope to be able to show that citizen science projects can be used to fulfill the learning progressions of the Next Generation Science Standards, and can therefore be implemented to teach science effectively.

What your child will be asked to do:

This study will be conducted alongside the *Girl Scouts in Science: Discovering Wyoming Water* citizen science program, and will require no extra meeting times than is already required for the program. Masters student Meghan Lockwood will facilitate short group discussions (approximately 15 minutes each) during the course of the program, in which participants will answer questions regarding their knowledge of the 3 dimensions of learning associated with the Next Generation Science Standards. These 3 dimensions are core ideas, cross cutting concepts, and science and engineering practices.

Observations of the Citizen Science group and individual students will be made throughout the process of the Laramie River study. These observations will help Meghan Lockwood to collect data about the actions taken during a citizen science project, the ideas that participants present and acknowledge, and the content that they are presented with, as well as how all of these relate to the three dimensions of learning presented by the Next Generation Science Standards.

While participants participate in discussions with Meghan, non-participants will write a personal reflection, reflecting on either what they already know about the scientific process, process, or what they have learned about the scientific process throughout the Girl Scouts in Science program. These reflections will not be collected or reviewed by the researcher, and can be kept by the non-participants.

Risks and Possible Benefits:

Risk involved in this research is minimal, and is limited to possible discomfort or embarrassment in answering discussion questions based on academic level of participants. There will be no direct benefits to participants in the form of compensation or incentives in the process of this

research study. Indirectly, participants may benefit academically by learning to use science and engineering practices to learn core ideas and cross cutting concepts.

Protection of Privacy and Confidentiality:

While full confidentiality cannot be guaranteed, no identifying information other than age range of the participants will be used in the final report. Answers collected during discussions will be used to generate data about student knowledge of the three dimensions of learning associated with the Next Generation Science Standards. Data collected from qualitative observations of the groups and individual students will be used to determine what aspects of Next Generation Science Standards are addressed explicitly and implicitly by citizen science projects such as this one.

Only my faculty advisor and myself will have access to the discussion and observation data. Discussion and observational data will be kept in a locked file cabinet until they are destroyed at the culmination of this research study in May 2016. The final report will be used by Dr. Brian Barber in subsequent years of the *Girl Scouts in Science* program to demonstrate how citizen science, and this program in particular can address 3- dimensional learning in an informal setting.

The researcher or project director shall maintain, in a designated location, the research summary, signed consent forms, and signed assent forms relating to research which is conducted for at least three years after completion of the research

Freedom of consent:

My child’s participation in this study is voluntary, and requires a signature of a parent or guardian, as well as assent from my child. Refusal to participate in this study will involve no penalty or loss of benefits to which my child is otherwise entitled. My child may discontinue their participation at any time. If participants at any time wish to no longer participate in the study, they must tell Meghan Lockwood verbally or by email, and they will be dismissed from the study.

Contact Information:

If you have any questions or concerns regarding this study, please contact:

Meghan Lockwood

mlockwo2@uwyo.edu

(916) 802-5374

If you have questions about your rights as a research subject, please contact the University of Wyoming IRB Administrator at 307-766-5320.

Parental consent required for all subjects under 18 years of age.

As parent or legal guardian, I hereby give my permission for

_____ to participate in the research described above.

(Printed name of participant)

Printed name of parent/legal guardian

Signature of parent/legal guardian

Date

APPENDIX C

Child assent form

Citizen Science and Three-Dimensional Learning with Next Generation Science Standards

Description of Research:

My name is Meghan Lockwood and I want to tell you about a research study I am doing. A research study is usually done to find a better way to treat people or to understand how things work. In this study, I want to find out more about how citizen science projects, like *Girl Scouts in Science: Discovering Wyoming Water*, can be used to teach science more effectively, and how I personally can improve my teaching methods.

What you will be asked to do:

This study will take place at the same time as your Citizen Science meetings for *Girl Scouts in Science*. You will not be required to attend any extra meetings. Several times during the course of the program, I will ask you to answer questions in a group about what you think/know about several ideas used in the Next Generation Science Standards, a new set of standards that has been developed for use in schools, and how they have been used in this program. Discussions will last approximately 15 minutes.

I will also be observing the group as a whole, as well as individual students during the Girl Scouts in Science program in order to determine what aspects of the Next Generation Science Standards are addressed within this citizen science project, and how participants react to different topics.

While participants engage in discussions, non-participants will write a personal reflection, reflecting on either what they already know about the scientific process or what they have learned about the scientific process throughout the Girl Scouts in Science program. These reflections will not be collected or reviewed by the researcher, and can be kept by the non-participants.

Risks and Possible Benefits:

The potential of risk to participants is very minimal. Possible risk might include discomfort or embarrassment to answer discussion questions. There will be no direct benefits to participants in the form of compensation or incentives in the process of this research study. Indirectly, participants may benefit academically by learning to use science and engineering practices to learn core ideas and cross cutting concepts.

Protection of Privacy and Confidentiality:

While full confidentiality cannot be guaranteed, no identifying information other than age range of participants will be used in the final report. Answers collected during discussions will be used to look at a growth of knowledge of the three dimensions of learning associated with the Next Generation Science Standards. Data collected from qualitative observations of the groups and

individual students will be used to determine what aspects of Next Generation Science Standards are addressed by citizen science projects such as this one.

Only my faculty advisor and myself will have access to the discussion and observation data. Discussion and observational data will be kept in a locked file cabinet until they are destroyed at the culmination of this research study in May 2016. The final report may be used by Dr. Brian Barber in future years of the *Girl Scouts in Science* program to demonstrate how citizen science, and this program in particular can address three-dimensional learning in an informal setting.

Freedom of Assent:

My participation in this study is voluntary. My refusal to participate in this study will involve no penalty or loss of benefits to which I am entitled. I may discontinue participation at any time. If at any time I wish to no longer participate in the study, I can simply tell Meghan Lockwood verbally or by email, and I will be dismissed from the study.

Contact Information:

If you have any questions or concerns regarding this study, please contact:

Meghan Lockwood

mlockwo2@uwyo.edu

(916) 802-5374

If you have questions about your rights as a research subject, please contact the University of Wyoming IRB Administrator at (307) 766-5320.

Assent to participate:

Printed name of participant

Participant signature _____ Date _____

APPENDIX D

IRB Proposal form

University of Wyoming IRB Proposal Form

Institutional Review Board
Room 308, Old Main
1000 East University Avenue, Dept. 3355
Laramie, WY 82071
Phone: 307-766-5322
Fax: 307-766-2608
email: irb@uwyo.edu
(Electronic submission via email is encouraged.)

1. Responsible Project Investigator, Co-Investigators, & Faculty Supervisor

Responsible Project Investigator:

Name: Meghan Lockwood Title: Graduate Student (Masters)
Department: Science and Math Teaching Center
Office Address: 1000 E. University Avenue, Dept. 3992
Wyoming Hall 434A
Laramie, WY 82071
Phone number: 916-802-5374 Fax number (if applicable):
Email address: mlockwo2@uwyo.edu
Is the project funded? Y__ N__X__
If Y, from where?
If N, have you applied for funding? Y__ N__X__ Where?

Co-Investigators (add more boxes if necessary):

Name: Title:
Department:
Office Address:
Phone number: Fax number (if applicable):
Email address:
Is the project is funded? Y__ N__
If Y, from where?
If N, have you applied for funding? Y__ N__X__ Where?

Faculty Supervisor (if PI is a student):

Name: Brian Barber Title: Science Coordinator
Department: Biodiversity Institute
Office Address: 1000 East University Avenue, Dept. 4304
Berry Center 208
Laramie, WY 82071

Phone number: 307-766-0880	Fax number (if applicable):
Email address: bbarber4@uwyo.edu	
If the principal investigator is a graduate or undergraduate student, submit the Research Supervisor Approval form from the faculty advisor, thesis or dissertation committee chair indicating review and approval of the proposal for submission to the IRB. The IRB will not approve a proposal without the proper Approval form.	

2. Title of Study:

Addressing Three-dimensional Learning at the Middle School Level with Citizen Science Projects
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3. Anticipated Project Duration:

December 1, 2015 - April 1, 2016

4. Purpose of Research Project:

<p>In LAY LANGUAGE, summarize the objectives and significance of the research:</p> <p>The purpose of this research will be to inform my own facilitation of the three dimensions of learning in the context of a specific citizen science project, as well as to determine what aspects of a particular citizen science research based project (in this case the <i>Girl Scouts in Science: Discovering Wyoming Water</i> program) at the middle school level can be used to address three-dimensional learning in an informal setting. This research will strive to determine how the three components of learning as described by Next Generation Science Standards (core ideas, cross cutting concepts, and science and engineering practices) are explicitly and implicitly addressed in a citizen science project, and thus how citizen science projects can be implemented to effectively teach science by incorporating and integrating all three dimensions.</p> <p>The <i>Girl Scouts in Science: Discovering Wyoming Water</i> citizen science program is in its first year, and strives to expose Girl Scouts to science as a process, by allowing girls ages 10-15 to develop their own research project surrounding the Laramie River restoration project. This project is led by Dr. Brian Barber and Lusha Tronstad of the University of Wyoming Biodiversity Center. This research study will happen alongside of the program in order to determine where and how the three dimensions of learning science from the Next Generation Science Standards are incorporated into a project such as this.</p>
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5. Description of Potential Participants:

<p>A. Age-range and gender: Females ages 9-15</p>
<p>B. Describe how the participants will be recruited and/or selected: Participants will be Girl Scouts ages 10-15 from the Laramie area, currently already participating in a program titled <i>Girl Scouts in Science: Discovering Wyoming Water</i>, funded by a grant written by Brian Barber and Lusha Tronstad from the Biodiversity Institute at the University of Wyoming.</p>

<p>C. Describe the number of participants expected: There are 12 participants in the <i>Girl Scouts in Science: Discovering Wyoming Water</i> citizen science program who will be approached about participating in this research study.</p>
<p>D. Will compensation or incentives be provided for participation? Y___ N_x___ IF Y, please describe:</p>
<p>E. Description of special classes: This research will involve children ages 10-15, and therefore require parental consent and participant assent. Consent and assent forms are attached.</p>
<p>F. Criteria for exclusion from participant pool: Participants must be participating in the <i>Girl Scouts in Science: Discovering Wyoming Water</i> citizen science program to be eligible to participate in this study.</p>

6. Procedure:

<p>A. Description of participants' activities: Participants, as a part of the <i>Girl Scouts in Science: Discovering Wyoming Water</i> program, are completing a year long research study on the Laramie River to determine whether or not the Laramie River Restoration project was successful. They began by learning some background information about the project from the Laramie River Conservation District, creating a question to answer, and developing hypotheses. They will continue to engage in the scientific process by determining parameters to measure, collecting and analyzing data, and presenting their findings at a poster session in May.</p> <p>In addition to their participation in this program, for this research study participants will participate in group discussions regarding their knowledge about the components of the three dimensions of learning: core ideas, cross cutting concepts, and science and engineering practices. These discussions will allow the researcher to determine what aspects of three-dimensional learning are being explicitly and implicitly addressed, which ones the participants grasp, and identify patterns in behavior and knowledge among participants.</p> <p>Participants will also be observed by the RPI during the process of the study, in order to collect data about what aspects of the Next Generation Science Standards three dimensions of learning are addressed at different stages of the process, and how participants react to each topic.</p>
<p>B. What will non-participants do while participants participate? If consent is not given for an individual to participate, they will still participate in the original <i>Girl Scouts in Science: Discovering Wyoming Water</i> program activities. They will not however, participate in discussions.</p> <p>While participants engage in discussion with the researcher, non-participants will write a</p>

<p>personal reflection, reflecting on either what they already know about the scientific process, or what they have learned about the scientific process throughout the Girl Scouts in Science program. These reflections will not be collected or reviewed by the researcher, and can be kept by the non-participants.</p>
<p>C. What will participants be told about the research project? Participants will be told that the RPI is performing this research project as a part of her Plan B Masters project to complete a Masters Degree in Natural Science from the University of Wyoming through the Science and Math Teaching Center. Participants will be informed that the RPI is interested in determining how citizen science projects like this one can be used to fulfill the three dimensions of learning of the Next Generation Science Standards, and how it will help the RPI to alter her facilitation of similar programs in the future. They will also be informed of how confidentiality will be maintained throughout the research process.</p>
<p>D. Will deception be used? Y ___ N <u>X</u>__</p> <p>If Yes, please explain why this is necessary, and how debriefing will occur:</p>
<p>E. Estimated time required for participants: Because this research project will be intertwined with the <i>Girl Scouts in Science: Discovering Wyoming Water</i> program already established, participants will attend about 3 meetings a month, for up to two hours at a time, during which they will be working on the completion of the Laramie River research project. However the discussion portions of this research will happen intermittently (each no more than 15 minutes) during the aforementioned meetings.</p>
<p>F. Where will research take place? Discussions will take place at the University of Wyoming Berry Biodiversity Center during meetings for the <i>Girl Scouts in Science: Discovering Wyoming Water</i> program.</p> <p>Other qualitative observations about the processes, core ideas and cross cutting concepts addressed in the citizen science project will be made during scheduled <i>Girl Scouts in Science: Discovering Wyoming Water</i> meetings at the University of Wyoming Berry Biodiversity Center, and field days along the Laramie River.</p>
<p>G. Method of data collection: Qualitative <u>X</u> Quantitative___ (check one or both). In a paragraph or two, please describe how you will collect your data:</p> <p>Data will be collected from participants by open-ended questions during group discussions. Participants will respond to questions regarding their knowledge of the practices, core ideas and cross cutting concepts included in the three-dimensional learning model of the Next Generation Science Standards, how they feel each was addressed, and if they feel the facilitation was effective. These questions will allow the RPI to determine which concepts have been explicitly or implicitly addressed throughout</p>

<p>the citizen science project.</p> <p>Additional data regarding the processes, core ideas, and cross cutting concepts addressed throughout the citizen science project will be collected by observation of the Laramie River research study.</p> <p>These observations will entail observing the group of students as a whole, as well as individual students at certain points in the process of the study. Observations will be specific to actions taken by students, ideas they present and acknowledge, content they are presented with, and reactions to activities and topics.</p>
<p>H. Please describe how and when participants may terminate participation: Any participant may withdraw from this research study at any time, for any reason. Participants need only indicate this preference to opt out to the RPI. This may be done while questionnaires are being distributed, administered, or at another time.</p>
<p>I. Description of biological samples (examples may include blood or urine): N/A</p>
<p>J. Description of equipment to be used on or by participants: Notes will be taken by the RPI during observations and discussions. No other equipment will be used in data collection.</p>

7. Confidentiality Procedures:

<p>A. Explain whether or not participants will be identified by name, appearance, or nature of data: Participants will not be identified by any identifiable data in the final report. Participants will be known to the RPI, as discussions will be conducted in person. However, no information about names, appearance or any other data will be reported. Only the RPI and research advisor will have access to the raw discussion notes. If any raw data is shared within the final report, pseudonyms will be used instead of identifiable information.</p> <p>Names will not be included in any observations. The word “participant” or “participants” will be used in the case that this data is used in the final report.</p>
<p>B. Are you collecting personal health information? (See the IRB manual at: http://www.uwyo.edu/research/compliance/human-subjects/index.html).</p> <p>Yes ___ No <u>X</u></p>
<p>C. Will the data you collect be anonymous or confidential (check the one that applies)? <i>Note: research is only anonymous if the researcher does not know the identity of the participants and there are no identifiers linking the participant to the research.</i></p> <p>Anonymous _____ Confidential <u>X</u></p>

D. Explain the procedure that will be used to protect privacy and confidentiality:

Raw observation and discussion notes data will exist only in hard copy format, and only the RPI and research advisor will have access to this data. Participants and their responses will be known to the RPI, but individual responses will not be shared by name outside of the discussion groups. Pseudonyms will be used in the case that any raw data information is used in the final report.

Observational data will be collected notes by the RPI in a notebook. The RPI and committee members will have access to this data. Names will not be included in any observations. The word “participant” or “participants” will be used in the case that this data is used in the final report.

E. How and where will data be stored (may be indefinitely)?

Observation and discussion notes will be stored in a locked file cabinet in the office of the RPI until they are destroyed at the end of this study in May 2016.

Analyzed data will be stored on the RPIs computer until the end of the study in May 2016.

F. How long will the data, research summary, and signed consent forms be stored (may be indefinitely)? *Note: The regulations require that The PI or project director maintain the signed informed consent forms, assent script/forms (if applicable), and the written research summary, relating to research for at least three years after completion of the research.*

Raw questionnaire discussion and observational data will be kept until May 2016 when the research study is complete and has been defended to the Plan B committee. Once the RPI has completed all components of the Plan B project, the raw observation data will be destroyed.

The PI or project director shall maintain, in a locked file cabinet, the research summary, signed consent forms, and signed assent forms relating to research which is conducted for at least three years after completion of the research.

G. Who will have access to the data?

Only the RPI and the research advisor will have access to the raw observation and discussion data

Observational data will be accessible to the RPI and committee members.

8. Benefits to Participants:

A. Describe the indirect research benefits for the participants:

Indirectly, participants may benefit academically by learning to implement science and engineering practices to learn core ideas and cross cutting concepts.

B. Describe the direct research benefits or state there are no direct benefits to the participants (do not include incentives in this section):

There will be no direct benefits to participants in the form of compensation or incentives in this research study.

9. Risks to Participants:

This section should include a detailed description of any reasonably foreseeable risks or discomforts to the participants as a result of each procedure, including discomfort or embarrassment with survey or interview questions, exposure to minor pain, discomfort, injury from invasive medical procedures, or harm from possible side effects of drugs. All projects are deemed to involve some level of risk to participants, however obvious or obscure. Consequently, **proposals must state** that minimal risk is involved when the proposed research is viewed as involving little or no risk to participants. Risk is minimal where the probability and magnitude of harm or discomfort anticipated in the proposed research are not greater, in and of themselves, than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests. Even when risk is minimal, investigators must still state what the minimal is and why it is minimal (example would be potential for embarrassment or boredom).

Describe the risks to participants:

There are minimal risks for participants involved in this research study. Possible risk may present itself in the form of some level of embarrassment in participant responses to the open-ended discussion questions about their knowledge and opinions of the three dimensions of learning. Responses to discussion questions will be known to other participants during the group discussions, but raw notes will not be released to anyone outside of the study.

10. Description of procedure to obtain informed consent or other information to be provided to participant:

A. How and when will the participants be approached to obtain consent?

Consent will need to be obtained from parents/guardians as participants will be underage. At a meeting for *Girl Scouts in Science: Discovering Water*, an introduction of this research will be given to participants and parents/guardians. Consent forms will be distributed to parents/guardians to be signed, and collected at the next meeting.

B. Who will be responsible for obtaining consent (check the box that applies)?

Project Director

Member of Project team _____ (list name or position)

Other _____ (Please explain, and include name, affiliation, and title)

C. How will information be relayed to participant (read to, allowed to read, audio-recorded, video-recorded)?

Participants will be given a verbal description of the research study by the RPI, and the consent forms will contain the same information for them to read and review before

consenting.
<p>D. Provide a description of feedback, debriefing, or counseling referral that will be provided if this is relevant to the research:</p> <p>We do not anticipate any need for feedback, debriefing or counseling referral.</p>
<p>E. Explain the procedure that will be used to obtain assent of children, if relevant to the research (See: http://www.uwyo.edu/research/compliance/human-subjects/index.html):</p> <p>Written assent will be obtained from all participants using the assent form attached. Participants range in age from 10-15 years old, some of which fall under the category for verbal assent. However, due to the high aptitude of this group of participants, we feel written assent is sufficient for all.</p> <p>At the same meeting during which parents will be given information and consent forms regarding the study, children will be given a simpler description of the study, as well as assent forms to bring back to the next meeting.</p>
<p>F. If children are involved, who will be responsible for obtaining assent (check the box that applies)?</p> <p>Project Director <input checked="" type="checkbox"/> <u> </u></p> <p>Member of Project team <input type="checkbox"/> _____ (list name or position)</p> <p>Other <input type="checkbox"/> _____ (Please explain, and include name, affiliation, and title)</p>

11A. Attach copies of survey instruments, interview questions, tests, and other pertinent documentation that will be used to conduct the research. Note: Please see the informed consent outline for suggested language for consent forms.

Attachment Name	Description
Attachment 1:	Appendix A: Parental Consent Form
Attachment 2:	Appendix B: Child Assent Form
Attachment 3:	Appendix C: 3-Dimensional Learning Discussion questions
Attachment 4:	Appendix D: Research Advisor Form
Attachment 5:	
Attachment 6:	
Attachment 7:	
Attachment 8:	
Attachment 9:	
Attachment 10:	

11B. If participants will be recruited through an institution such as a school or hospital, or if the research will be conducted at such an institution, provide a letter of agreement/approval to do so from an authorized representative of that institution. The IRB will not approve a proposal without the proper letter(s) of support.