Impacts of Authentic Science Experiences for Underserved Youth: Design, Research, and Evaluation of an Upward Bound Watershed Science Summer Course

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by
Sarah K. Olsen

Major Professor: Brant G. Miller, Ph.D.
Committee Members: Tonia Dousay, Ph.D.; Kristin Haltinner, Ph.D.; Alan Kolok, Ph.D.
Department Administrator: Matthew Morra, Ph.D.

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Authorization to Submit Dissertation

This dissertation of Sarah K. Olsen, submitted for the degree of Doctor of Philosophy with a Major in Water Resources and titled "Impacts of Authentic Science Experiences for Underserved Youth: Design, Research, and Evaluation of an Upward Bound Watershed Science Summer Course" has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

Major Professor: ______________________________ Date: __________
Brant G. Miller, Ph.D.

Committee Members: ______________________________ Date: __________
Tonia Dousay, Ph.D.

______________________________ Date: __________
Kristin Haltinner, Ph.D.

______________________________ Date: __________
Alan Kolok, Ph.D.

Department Administrator: ______________________________ Date: __________
Matthew Morra, Ph.D.

Abstract

Based on the findings of this doctoral research project, out-of-school science experiences targeting low-income and first-generation youth (LIFG) have the power to positively impact STEM career interest and science identity. This body of work contributes a program design case, research, and evaluation of an authentic science summer program designed for an Upward Bound Math Science (UBMS) program at the University of Idaho. Using a model of instructional design, the first article outlines the development of a watershed science-focused summer program designed for LIFG high school students, aligned with the UBMS goal of making science degrees/careers more accessible. Article two applies a model social influence theory to understand student integration into science at the program level, investigating science identity, self-efficacy, science values, and intention to pursue STEM as program outcomes using a convergent mixed method, quasi-experimental design. Finally, article three is an exploratory case study evaluation to provide a summary of the summer program in two parts: (a) a report on program effectiveness for facilitating accessibility of science degrees/careers; and (b) a discussion of recommendations and implications for future Upward Bound summer program improvement. A recommendation is for future programming and research to develop strategies to address the barriers to STEM identified through this work including fixed mindsets, fixed theories of interest, and low academic achievement.

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Dedication

I would like to dedicate this work to my friends and family whose unconditional support made this work possible, and for which I am truly grateful. To my grandmother, a trailblazer whose academic and professional accomplishments inspire me endlessly. To my mother, whose courage to be the change she wants to see motivates and energizes me. To my father, a deep thinker and lover of nature, for sparking and stoking my curiosity of the world. And to Zak, for his patient ability to soothe the stresses and trials of this journey with love and compassion.

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Introduction

The objective of this introduction is to provide background information about authentic science education for underserved populations, introduce the chosen theoretical framework, present the statement of the problem, and review the purpose of the study. The research questions will then be presented followed by a discussion of the significance of the research project and overview of the three articles it includes. The final sections include the study limitations, delimitations, and definition of terms.

The goal of "science for all," advocated by science education reform in the 1990's (NRC, 1996; Rutherford & Ahlgren, 1991) highlights inequalities in achievement and success in science for specific populations of students (Carlone, Johnson, & Eisenhart, 2014). Minority and female students, known as historically underserved minorities, continue to be underrepresented in science fields, as evidenced by their low participation in professional positions and college majors (Kim, 2011; National Science Foundation, 2017). While there are a number of complex factors that influence a student's trajectory into the sciences (Tytler, 2014), researchers have cited the failure of classroom science education to accurately represent what scientists do as a factor of concern (Chinn & Malhotra, 2002; Crawford, 2013; Packard, 2015). This research seeks to improve our understanding of how authentic science experiences impact students and whether they facilitate the development of factors important to perseverance in science.

Proponents of *authentic science* education suggest that classroom science activities that simulate the practices of scientists allow for more meaningful science instruction than traditional textbook or "cookbook" instructional methods (Chinn & Malhotra, 2002). Just as music teachers want their students to have experiences of playing music, "...so science teachers would want students to have experience of doing science and doing science of a form which is not dissimilar to that done by practicing scientists" (Woolnough, 2000, p. 293-294). Authentic science in the classroom strives to be representative of science as practiced by scientists, while considering the limitations of the school setting such as space, time, money, and expertise (Chinn & Malhotra, 2002). As authentic science is adapted for student learning, it also strives to be relevant to students' lives in order to be engaging and personally meaningful, which helps reduce cultural barriers (Crawford, 2013; Carlone, Johnson, & Eisenhart, 2014). Authentic science learning experiences can therefore help to overcome barriers to science for underrepresented students.

Statement of the Problem

A lack of racial, economic, and gender diversity in science fields has been a critical concern for several decades, prompting investigation into the underlying causes for disproportionate achievement in science in high school, college, and beyond. Race, class, and gender are socially constructed identifiers that can misrepresent the complexity of lived experiences of individuals, but such groupings can serve as analytic tools to better understand the social patterning of inequality in education (Lee & Luykx, 2006). Education researchers believe that schools have failed to provide equitable learning opportunities in science education whereby all students can succeed (Lee & Luykx, 2006). Although young students of all demographic backgrounds are initially interested and adept in science, that interest declines in middle school and high school, and especially for female, minority, and economically disadvantaged students (Aschbacher, Li, & Roth, 2010; Tytler, 2014). For example, during high school, the percentage of females interested in STEM careers declines, whereas for males it remains stable (Sadler, Sonnert, Hazari & Tai, 2012). Once enrolled in college, female and minority students, except for Asian American students, are less likely than male or White students to declare a STEM major (Mau, 2016). Patterns in how and when students from non-dominant backgrounds are dropping out of the STEM pipeline point to deeper social-cultural problems in science education.

Research investigating the reasons students are put off by science suggests a web of environmental and psychosocial variables. For example, an investigation following high school students who were initially interested in pursuing science careers found that those who gave up on science by the end of high school "… cited poor instruction, lackluster curriculum with few hands-on inquiry activities or meaningful projects, and little encouragement to study or do science from teachers, counselors, and administrators alike" (Aschbacher, Li, & Roth, 2010, p. 579). Student perspectives reveal interconnections between how students see themselves in relation to science and how others see them, and whether or not students continue in science. Students from underrepresented groups are best able to succeed when curricula incorporate aspects of their everyday experiences (Buxton, 2006; Lee & Luykx, 2006). In other words, science teaching that fails to incorporate the cultural experiences of underrepresented groups will likely fail to recruit or increase the interest of underrepresented students. Although science curriculum is a critical component in preparing students to succeed in science, student persistence in science is dependent on learning environments that attend to psychosocial variables such as recognition of science skills by self and others, identification with science, and connection to personal and community life. How best to incorporate these 'outside of the textbook' aspects of science education is less clear.

Because resource inequality can be a barrier to science degrees and careers for underrepresented minority students, supporting programming offering guidance, experience, and encouragement to continue on in the sciences is sometimes provided through supplementary science experiences (Chemers et al., 2011). Supplementary science experiences exist outside of formal classroom education and provide students the opportunity to participate in authentic science. There is strong evidence that supplementary science experiences increase science self-efficacy and science identity which in turn contribute to student persistence in science (Ballen, Wieman, Salehi, Searle, & Zamudio, 2017; Chemers, Syed, Goza, Zurbriggen, Bearman, Crosby, & Morgan 2010; Chemers, Zurbriggen, Syed, Goza, & Bearman, 2011; Eccles & Barber, 1999; Estrada, Woodcock, Hernandez & Schultz, 2011; Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013; Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2009). Such findings echo the importance of psychosocial variables for success in science, in particular self-efficacy and science identity.

Researchers have called for further investigation into what facilitates diverse young people's interest in science, development of science identity; perceptions of their abilities to do science; societal conditions that maintain the factors; and why those initially interested in science do not continue on in science learning or careers (Aschbacher, Li & Roth, 2010; Lewis, Menzies, Nájera & Page, 2009). Relatively little research has investigated the academic preparation of minority students, and the impact of early interventions for underrepresented students in order to recruit and guide them into STEM college-majors and careers (Mau, 2016).

Upward Bound Math and Science (UBMS) has been identified as one such intervention to prepare low-income and first-generation high school students to pursue degrees and careers in math and science (Mau, 2016). A nationwide, federally-funded program, Upward Bound Math Science programs are most often affiliated with higher education institutions from which they serve a regional population of students and provide year-round academic support and intensive summer programming. The Upward Bound Math Science program at University of Idaho provides students with supplementary science experiences which allows students the opportunity to engage with scientists and science in their community. The program is designed to provide authentic science experiences that are student-centered and personally-relevant and provide a meaningful context for science education. For example, students collecting water quality data with a scientist, and analyzing, interpreting, and communicating that data similarly to how a water resources specialist would. Despite the promise of an authentic, supplementary science experience for positive impacts on student persistence in science, the program has yet to investigate impacts in this way. Such understanding will contribute to an evidence base and have implications for the design and implementation of similar programs to increase underrepresented student achievement in science.

Theoretical Framework

Social Influence Theory

While the concept of communities of practice (Lave & Wenger, 1991) helps to define a context for learning within a community, social influence theory identifies the processes of integration into a particular community as facilitated by a person's orientation to the rules, roles, and values of the community (Kelman, 2006). Identifying with the community, achieving skills necessary for participation, and internalizing the values of the community indicate integration into the community. Using social influence theory in the context of student persistence in science fields will help to identify the extent to which a student is integrated into the community of science. From this perspective, students who feel they can do the work of scientists (possess science self-efficacy), identify as scientists (possess science identity), and value the objectives of science (possess science values) will be more likely to pursue a scientific career.

Purpose Statement

The purpose of this research is to improve our understanding of how authentic science experiences impact students. Specifically, by examining science identity, self-efficacy, values, and demographic variables, we will better understand how and whether authentic science experiences influence the factors that lead to perseverance in science. This research fills a gap in our understanding of how demographic variables impact authentic science learning experiences and will aid in the development of evaluation tools and adaptation of theoretical models appropriate for the Upward Bound STEM Access program. In addition, this research contributes to a greater body of literature that seeks to understand the types of educational experiences to prepare students of all backgrounds for success in science. Findings of this study will be useful for the design, development, implementation and evaluation of authentic science experiences.

Research Objective

The research objective is to describe and characterize the design and evaluation of an Upward Bound summer program and investigate the impacts of authentic science on factors contributing to perseverance in and commitment to science.

Research Approach

This work is divided into three main parts encompassing the design, study, and evaluation of an Upward Bound summer program. This approach provides a wholistic perspective on a single case, with each part building off of the others. The first article describes the design of a summer program for low-income and first-generation high school students, presented as a design case. The aim of the design case is to describe how the summer program was designed to provide authentic science experiences and in alignment with Upward Bound program goals. The second article takes an empirical approach to study the impacts of the summer program through the investigation of factors related to persistence in science. The research questions investigated in the study include:

1. How does a summer program that focuses on authentic science experiences impact students':
   a. Science identity
   b. Science self-efficacy
   c. Science values
   d. Intentions to pursue science?
2. Were there any differences in how students were impacted by the program?

Lastly, the third article evaluates the program through a case study in order to understand what can be learned to inform future summer programming for Upward Bound.

Significance of the Research Project

An educational intervention cannot be adequately assessed or improved upon unless the context, design, evaluation, and reflection are reported to those who can learn from and act upon the findings. If educational interventions go unstudied, there is no data to inform the development or improvement of similar interventions. Thus, it is essential for educational programs to be intentionally designed, implemented, and evaluated, especially for programs seeking to have significant impacts for participants such as the Upward Bound program. Limited research has been conducted to understand individual Upward Bound summer programs in this way, and this research can therefore fill a gap for a nationwide program serving tens of thousands of students each year.

Overview of The Three Articles

This dissertation takes a three-pronged approach to understanding the impacts of authentic science education program by focusing on design, research, and evaluation. First, the program design process describes how the program was developed using research-based approaches as well as program principles. This work contributes to design-based research, which seeks to bring clarity to the murky process of educational design (McKenney & Reeves, 2014). Second, an empirical article contributes to the broader research community that seeks to understand factors related to informal science education, particularly for underserved populations. By investigating how authentic science learning experiences impact students' science identity, self-efficacy, science values, and intention to pursue science, this work further contributes to our understanding of how students develop an orientation towards science. Third, an evaluative case study examines the program through reflective practice and elucidates aspects of the program that were most impactful for developing students' orientation toward science, as well as lessons learned. This research product is particularly useful for the Upward Bound program and is tailored to meet program evaluation needs.

Research products from this study will be useful beyond academia and may help facilitate more successful collaborations between scientists and educational outreach programs such as Upward Bound. As a body of work, this study adds to an important conversation around equity in STEM education.

Article 1 (Chapter 1): "Design Case of an Out-of-School Summer Program for Underserved Youth"

Out-of-school science experiences are an especially impactful way to learn for students who face barriers to science in the typical classroom environment. Authentic science experiences provide real world contexts which can make science learning more accessible. Programs with goals to support underserved student access to STEM degrees and careers are tasked with designing effective out-of-school science experiences. Instructional Design (ID) methods play an important role in guiding the design of learning experiences which meet both the needs of students and the desired program outcomes. Using an instructional design model, this chapter outlines the development of a watershed science summer course for underserved high school students that incorporates local field-based learning experiences and project-based learning designed to make STEM degrees/careers more accessible for students. Included in the development of the program is the application of the ID model to each step of the process: characterizing the needs of learners, determining learning objectives, identifying strategies to support learning, and assessment of learning. A program-based curriculum framework and Environmental Science Agency model of learning were used to guide the curriculum development.

Article 2 (Chapter 2): "Understanding the Impacts of Authentic Science Experiences Through a Model of Social Influence Theory"

This study reports on the impacts of an authentic science summer program endeavoring to meet the goal of making science, technology, engineering and mathematics (STEM) degrees and careers more accessible for low-income and potential first-generation college students. Convergent mixed methods were used to identify the impacts of the intervention on students' science identities, self-efficacy, science values, and intention to pursue STEM through the perspective of social influence theory. Student self-perceptions of science identity and intention to pursue STEM increased during the program, with little change six months afterwards. Interviews with students three months after the program revealed strong connections between science identity and skill development, group dynamics, communication to others, and contextualizing science in their community and society. Findings suggest that the program positively impacted students' orientation toward science. However, survey data indicated differences across demographic variables such as gender, ethnicity, and low-income or first-generation status, as well as academic achievement, suggesting demographic differences in program impacts. Implications for developing effective interventions to retain low-income and first-generation students in STEM and for translating social influence theory into practice are discussed.

Article 3 (Chapter 3): "A Case Study Evaluation of an Authentic Science Upward Bound Summer Program."

This exploratory case study evaluation examines the impacts of a place-based, authentic science summer program for Upward Bound participants. The three-week summer program involved youth in a variety of activities designed to develop their science skills, science identity, and feeling of inclusion in the science community. By focusing on an individual summer program, this descriptive evaluation provides in-depth description of participant experience through mixed methods. This report provides an evaluative summary of the 2018 STEM Access summer program in two parts: (a) A report on program effectiveness for enhancing student orientation toward science as measured by science identity, science self-efficacy, science community values, and intention to pursue a STEM degree/career; and (b) A discussion of possible implications for future Upward Bound summer program improvement. Outcomes suggest that participation in the summer program increased science identity, affected science self-efficacy and community values differently for different students, and increased participant intention of pursuing a STEM degree/career. Findings are suitable for insight into programmatic learning, but do not attribute causality and are therefore generalizable.

Study Limitations & Delimitations

The limitations of a study refer to those influences that are outside of the researcher's control. For this study, there were three primary limitations:

1. The context of the study is an Upward Bound summer program, and the results should be considered within that context.
2. The evaluation and research were conducted with survey data collected before, immediately following, and six months after the program, and interview data was collected three months after the program with a subsample of the total student population of program participants. Any conclusions should be further investigated with different populations of students and in different contexts.
3. As the program designer, researcher, and instructor, some compromises were made during the study in an effort to ensure a positive student experience above all else. The researcher made

every attempt to limit the 'burden' of research felt by students by keeping surveys and interviews short, and prioritizing quality instruction over data collection needs.

Delimitations are the boundaries set by the researcher. For this study, there were two primary delimitations:

1. A one-time intervention as opposed to multiple iterative pilot programs.
2. The study was concerned with student perceptions rather than objective measurement related to their science identity, self-efficacy, and community values.

Definition of Terms

Authentic Science

Authentic science learning experiences allow students to experience doing science the way scientists do in real world contexts. It is different from traditional classroom science learning with textbooks and "cookbook" instruction because it emphasizes engaging in science rather than just reading about it (Carlone, Johnson & Eisenhart, 2014; Chinn & Malhotra, 2002; Crawford, 2013; Woolnough, 2000).

Science Identity

Science identity is seeing oneself as a science person. Carlone and Johnson (2007) identified competence (perceived abilities), recognition by others (as a science person), and performance (actually doing science) as three components of science identity.

Science Self-Efficacy

Self-efficacy is one's perceptions of competence, or the conviction that one can successfully execute a behavior to produce an outcome (Bandura, 1977). Science self-efficacy is one's perception of science competence, including abilities to do science (science skills).

Science Values

Science values refer to the cultural norms of those who practice science. Internalizing science values marks integration into the science community (Estrada et al., 2011; Kelman, 2006). Shared values also help to engender a sense of relatedness and motivation to continue despite difficulties (Hilts, Part & Bernacki, 2018).

Low Income

Federal TRIO programs define a low-income individual as “an individual whose family's taxable income for the preceding year did not exceed 150 percent of the poverty level amount” (U.S. ED, 2019).

First-Generation

A potential first-generation college student is an individual neither of whose natural or adoptive parents received a baccalaureate degree; or a student who, prior to the age of 18, regularly resided with and received support from only one natural or adoptive parent and whose supporting parent did not receive a baccalaureate degree (U.S. ED, 2009).

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Chapter 1: Design Case of an Out-of-School Summer Program for Underserved Youth

Program Setting and Purpose

The Upward Bound Math Science program at University of Idaho (UI) is called STEM Access (SAUB) and connects a local population of students with opportunities to experience college and careers, especially in the areas of science, technology, engineering and mathematics (STEM). Students in the program receive support through information, counseling services, field-trips and campus experiences to assist them on the path to college. While regulations govern the services UBMS projects can provide (34 C.F.R., §645.10-§645.14, 2010), the specifics of programming are left up to the individual UBMS program. Designing relevant and contemporary program activities to ensure students are exposed to a variety of careers and STEM content and skills creates a challenge because designing and planning a program is a time-consuming and resource-intensive process.

Each summer, SAUB offers six weeks of programming encompassing individual courses of one to three weeks on topics related to academic and college preparation. The courses can focus on an individual subject such as chemistry, or integrated subjects such as computer programming combined with movement sciences. Often, SAUB hires university-affiliated faculty, staff, and graduate students to lead the courses. While these individuals may have content expertise, they may be unfamiliar with designing a course or program.

One way to facilitate the design of a summer program is to utilize an instructional design model, which can help to guide development and ensure a strong foundation in pedagogical concepts. The purpose of this design case is to capture the design process for a SAUB summer program and share lessons learned, which may be applicable to other programs with similar objectives. By explaining and reflecting on the design process and components, we can better understand program impacts and build capacity for continuous improvements.

Role of the Designer

During the second year of my doctoral studies I was approached by the director of SAUB to design and instruct a three-week summer program due to my research interests in designing authentic science learning experiences which were in alignment with the program's goals. The opportunity to design and instruct the summer program eventually expanded to include research and evaluation of the summer program as well, and the whole of this work became my doctoral project. As the program designer, my specific responsibilities were to design the course curriculum in coordination with the director, identify and organize the necessary materials for course delivery, construct specific lessons with objectives and goals serving the overall expected course outcomes, identify appropriate locations for lessons, and plan for assessment. I worked closely with the SAUB team to create an intentionally integrated summer learning experience with student-relevant results, however designing a summer program for an organization with which you have only just begun working presents challenges such as limited understanding of processes and resources. It is from this novice perspective of designer and SAUB staff member that I present this design case, meant to illustrate lessons learned which may be useful for others new to designing SAUB programs.

Instructional Design Model

One of the first decisions I made as the instructional designer makes was to choose a model to facilitate the design process.

> Instructional design is a complex process that promotes creativity during development and results in instruction that is both effective and appealing to students. Instructional design models convey guiding principles for analyzing, producing, and revising intentional learning contexts (Branch & Dousay, 2015, p.15).

In *Survey of Instructional Design Models*, Branch and Dousay (2015) review models used to guide design for curriculum, courses, and training, and then classify each into one of three categories: classroom-oriented, product-oriented, and system-oriented. While several of the classroom-oriented models would be suitable for SAUB instructional design purposes, the Morrison, Ross, Kalman and Kemp (2013) model was chosen because of the learner-centered approach, which aligns with the participant-centered approach of Upward Bound Math Science, as well as the iterative nature of the model, which allows for design flexibility in a dynamic context such as Upward Bound programming. For example, from the time program planning started to the day instruction began, participant numbers changed drastically, requiring me to adjust logistics and lesson planning accordingly. In addition, programs like SAUB must also balance competing priorities with other program activities throughout the design process, requiring planning to occur in non-linear ways. As a novice designer, this model appeared to be relatively straightforward so that even those without extensive experience with instructional design could navigate it relatively easily, an important consideration also for other SAUB staff who may interested in using the model for other program designs. Four fundamental planning elements for systematic instructional planning are guided by the following questions posed by Morrison, Ross, Kalman and Kemp (2013):

1. For whom is the program developed? (learners)
2. What do you want the learners or trainees to learn or demonstrate? (objectives)
3. How is the subject content or skill best learned? (methods)

4. How do you determine the extent to which learning is achieved? (evaluation)

Questions one through three will guide the description of this program design case and question four will guide the evaluation and assessment of the program discussed in chapter 4.

The Morrison, Ross, Kalman and Kemp (MRKK) model is comprised of nine interdependent but distinct elements described in Table 1, along with an overview of the application of the element to the watershed science summer program. Although not entirely unique among models in this way, the MRKK model is adaptive and flexible in that designers may use it to best suit their particular context, without a prescribed order or structure to adhere to (Morrison et al., 2013).

Table 1.1 Elements of the Morrison, Ross, Kalman and Kemp Model (2013)

Element	Description	Application
Instructional Problems	Identify the problem or need to understand the underlying issues. A needs assessment or other tools can help identify the problem	Address cultural barriers to science for rural, low-income, first-generation students who have few opportunities to engage in authentic science
Learners and Context	An analysis of the target learners' characteristics in relation to the goals of the project. Contextual analysis includes factors of the learning environment that will affect the design and delivery of instruction	Incorporate socially-relevant and local field investigations and research projects allowing students to draw upon their own funds of knowledge. Use local watershed issues for the learning environment.
Task Analysis	Defines the content knowledge and procedures to include in instruction to help learners meet the objectives	What are water quality issues affecting our community? How is science being used to address them? How might you go about addressing a problem in your community?
Instructional Objectives	The specific, measurable outcomes that learners are to achieve as a result of instruction	Students will be able to: -Define local water quality issues -Collect and assess water quality data -Identify natural resource management strategies -Propose a research project to address a local issue
Content Sequencing	Choose a strategy to sequence curriculum based on the project objectives and task analysis	Morning work on research projects and afternoon field investigations
Instructional Strategies	Pairing of instructional methods with the type of content to best support objectives	Active engagement in field investigations with scientists in a supportive environment.
Designing the Instructional Message	Consideration of the course materials to maximize learner understanding	Activities designed to address stereotypes of who can be a scientist, and opportunities to get to know scientists on a personal level
Development of the Instruction	Bringing together the resources, interactive materials, audio/video, needed for learning	iPads and internet access, journals. classroom space, vans for transportation, water quality testing materials, graduate student mentors and scientists, and equipment to rent such as bikes and kayaks
Evaluation Instruments	The assessment instruments to evaluate learning against objectives	Pre-post survey measuring science identity, self-efficacy, values, and intention to pursue science

Application of Model to Summer Program Design

Instructional Problems

Before addressing any other aspect of the design, I first had to address the instructional problem. Upward Bound Math Science programs work under the overarching goal of making STEM degrees and careers more accessible for the low-income and first-generation students they serve. Here I address the problem most relevant to the Upward Bound Math Science program: Addressing the barriers to STEM degrees and careers for underrepresented student populations. The lack of diversity in STEM professional positions and college majors is a persistent problem (Kim, 2011; NSF, 2017), and one that continues to merit the focus of instructional designers who seek to address the gap in science achievement among populations of students underrepresented in the sciences (e.g. Ahn et al., 2016; Brown, Ring-Whalen, Roehrig, & Ellis, 2018). I draw upon the literature of underrepresented student persistence in science to identify barriers to STEM for underserved youth and identify the associated knowledge, motivation, and resource gaps the program is designed to address in Table 1.2.

Table 1.2 Barriers to STEM for underserved youth and the targeted gaps the program seeks to address

Barrier	Gap to Address Through Program Designs
Inauthentic classroom science experiences (Chinn & Malhotra, 2002; Crawford, 2013; Packard, 2015)	Knowledge gap: First-hand experience of science practices in real world contexts.
Science taught in a way that is disconnected from students' everyday lived experience and culture (Buxton, 2006; Lee & Luykx, 2006).	Motivation gap: Failure to connect science to the students' local community.
Lack of access to supplementary educational resources (Ballen et al., 2017; Eccles & Barber, 1999; Hernandez et al., 2013; Hurtado et al., 2009).	Resource gap: Opportunities to experience science outside of the classroom and in a supportive setting.

Key Design Decisions

Here I will briefly describe three key design decisions I made while developing the watershed science summer course:

1. Designing the learning context to be the students' home communities
2. Drawing upon my connections with water resource scientists and graduate students
3. Choosing learning activities which also afforded physical exercise and novel science experiences

Designing the learning context to be the students' home communities

One strategy to bridge the cultural worlds between the students' community and the community of science is to focus on the points of intersection - that is, science-based local issues that have impacts in the students' local communities. Real world, place-based education can increase personal relevance and lead to increased student interest toward science learning (Soorbard 2011, Gunckel 2012). Controversial issues bridging science and society have been termed socioscientific issues, examples of which include environmental problems like global climate change (Sadler et al. 2006). The intent of bringing socioscientific issues into education is to make learning more reflective of the society in which it exists, thereby empowering students to manage the science-based issues that shape their current world and will determine their future world (Sadler, 2003). Water as a socioscientific issue connects the social and ecological in obvious ways - we all rely on clean drinking water, and it is impacted by both ecological and human systems. There are a number of education programs which have focused on the investigation of local watershed issues to make learning relevant and related to students' lives, allowing them to be scientists in their own communities (Donahue, Lewis, Price, & Schmidt, 1998; Rittenburg et al., 2015; Squires, Jennewin, Engels, Miller, & Eitel, 2016). Watershed investigations at the local level can engage students as active participants in a community-inclusive view of science.

Drawing upon my connections with water resource scientists and graduate students

Because I was designing the program for students to be actively engaging in authentic science experiences, I needed to find scientists doing real research in the community who were also willing to allow students to participate in some way. As a graduate student in the water resources program at the University of Idaho, I was part of an interdisciplinary cohort of 24 doctoral students. I reached out to my colleagues asking who might be interested in hosting students in field activities, data collection, or analysis during the summer program. I pursued a number of potential field experiences through conversations, and then narrowed them down to those that fit under the theme of water resource investigations in the local community and provided novel science experiences for students. I also reached out to natural resources professionals I knew, or who were recommended to me by colleagues. I noticed that my graduate student colleagues were more willing to invest time into planning the field experiences.

Choosing learning activities which also afforded physical exercise and novel science experiences

When some students think of the daily life of a scientist they imagine labs with beakers and sedentary work. It was important to me that students get a chance to experience science happening outside of a lab, and in their own backyards. Science learning in a classroom setting typically doesn't allow for students to be experiencing first-hand what they are learning about due to the reasonable constraints of time and resources. With more hours in the day, a relatively small group size, and financial support for learning activities, SAUB programs have the ability to expose students to new opportunities and experiences they otherwise wouldn't have access to. Therefore, I looked for opportunities for students to be actively involved in the learning environment, for example through hiking, snorkeling, kayaking, and biking. It was also important that students get experience using science tools and equipment, for example students used the plant identification books that the restoration specialist uses when they identified a plant, and they wore wet suits, wading boots, and snorkel masks when surveying for steelhead. By using tools and equipment the way scientists do, students can develop confidence in their scientific skills.

Learners and Context

The Upward Bound program requires that two-thirds of the participants in a project must be both low-income and potential first-generation students. The remaining one-third must be either low-income, first-generation college students, or students who have a high risk for academic failure. Federal TRIO programs define a low-income individual as "an individual whose family's taxable income for the preceding year did not exceed 150 percent of the poverty level amount", which varies depending on family size but was $37,625 for a family of four at the time of the program (U.S. ED, 2019). A potential first-generation college student is

> an individual neither of whose natural or adoptive parents received a baccalaureate degree; or a student who, prior to the age of 18, regularly resided with and received support from only one natural or adoptive parent and whose supporting parent did not receive a baccalaureate degree (34 CFR, § 643.7, 2011).

SAUB had 73 participants at the time of this program, eight of whom were low-income only, 17 first-generation only, and 48 both low-income and first-generation. SAUB participants are highly encouraged to participate in at least one summer program. While 23 participants were initially signed up for the program, 16 students ultimately participated. These 16 students were 71% female, 71% both low-income and first-generation, 77% in 10^{th} and 11^{th} grades, 78% White, 14% Hispanic/White, and 7% Asian/White.

The summer program was designed to be accessible to students of different grade levels and academic abilities, and so little prior knowledge was needed. Because students were from two different communities, there was a significant amount of team building built into the program in order to facilitate a positive group dynamic.

Learning context: Science in our watersheds

I chose two primary areas for our investigation of water resource issues - Lapwai Creek, which is only 10 miles from where the Lewis-Clark Valley participants live, and the Coeur d'Alene Basin, which encompasses much of Benewah County. The two areas face different watershed issues and so provided opportunity for comparison.

Lapwai Creek. Lapwai Creek is located 10 miles east of Lewiston, ID and is a tributary of the Clearwater River. Land use activities within the Lapwai watershed like agriculture, logging, road construction, grazing, irrigation diversions, and floodplain development have impacted resident salmonid populations by altering natural hydrology and sedimentation – causing habitat destruction, fragmentation, and degrading water quality. This has led to many ecological problems such as low summer flows, fluctuating stream temperatures, increased flood events, sedimentation, fish migration barriers, riparian degradation, channel/bank instability, introduction of exotic organisms, and loss of salmonid rearing/spawning habitat (Rasmussen, 2007). The Lapwai watershed has been designated as a critical habitat for the Snake River Basin steelhead by the Endangered Species Act. Restoration initiatives have been underway to improve habitat to benefit various resident and anadromous species and increase the potential of the Lapwai watershed for spawning and rearing in the Lower Clearwater River Subbasin (Richardson & Rasmussen, 2007).

Lapwai Creek restoration initiatives present an excellent opportunity for students to understand water resource issues, and possible solutions through restoration and water conservation. I reached out to professionals including a restoration specialist for the Nez Perce tribe; a graduate student studying the relationship between anadromous fish, habitat, and food sources; and a community-health worker who had created a community garden in Lapwai. Students participated in the daily work of these experts during field investigations, engaging in science practices and developing an understanding of the watershed issues affecting the community and seeing science in action as a tool to address them (see Table 1.4 for lesson plan examples).

Coeur d'Alene Basin. The Coeur d'Alene Basin in Idaho once held the world's richest lead, zinc, antimony and silver deposits (Sprenke, Rember, Bender, Hoffmann, Rabbi, & Chamberlain, 2000). Decades of mismanagement have caused waste rock and mine tailings to be transported from the mines in the Silver Valley of Idaho and deposited in the sediment and waters of the lower Coeur d'Alene River floodplain and Lake Coeur d'Alene via the Coeur d'Alene River (Sprenke et al., 2000). These sediments are laden with toxic metals (lead, arsenic, zinc) which can cause harmful biological effects at excessive levels (Sprenke et al., 2000). The Bunker Hill Superfund Site was declared in 1983 as a result of increased blood lead levels in children and environmental decline (NRC, 2005).

Since then, clean-up efforts by the EPA in collaboration with local land management agencies have addressed these concerns through a variety of mitigation and remediation efforts (von Lindern, Spalinger, Stifelman, Stanek, & Bartrem, 2016). However, toxic metals in soils and lake sediments continue to have harmful ecological effects and continue to pose risks to vulnerable populations and those with repeated exposure (NRC, 2005; von Lindern et al., 2016). Historically, these impacts to the Basin have had cultural implications as well for the neighboring Coeur d'Alene Tribe, which once depended on the health of the ecosystem for hunting, fishing, and cultivation (Sprenke et al., 2000).

The complex social-ecological issues of the Coeur d'Alene Basin present many opportunities for investigation and discussion. I reached out to scientists and experts working on this issue including a watershed education specialist of the University of Idaho, Education and Natural Resources specialists for the Coeur d'Alene Tribe, a graduate student studying the role of aquatic plants in the distribution of metals in lake ecosystems, and a graduate student using field sketching in her research of avian species.

Instructional Objectives

Four objectives were established for the summer course in coordination with the director of SAUB. These are the specific (cognitive and behavioral), measurable outcomes that learners are to achieve as a result of instruction.

Students will be able to:

1. Define local water quality issues
2. Collect and assess water quality data
3. Identify natural resource management strategies
4. Develop a research project to address a local issue

Content Sequencing

Daily program activities were structured to adhere to a consistent format when possible in order to provide a clear program structure (see appendix 1.1 for program agenda). Each day began with community building activities. For example, a team building game and then a more reflective activity to share personal interests and goals. Daily work on student research projects focused on one aspect of research projects per day. Students could work independently or in groups at their tables (4-5 students) and received help from program staff and mentors. Local field investigations or service learning experiences took place in the afternoons, with time for reflection at the end of each day.

The experiences during the first two weeks of the program were designed to take place in the local communities of the students, however the students were from three different communities. Some participants were from the Lewis-Clark Valley, while others were from Plummer and Potlatch. To ensure students experienced science investigations in their local community, the first week of the program took place in the Lewis-Clark Valley, and the second week took place in the lower Coeur d'Alene lake area (closer to Potlatch and Plummer). Week one focused on the impact of habitat quality on water quality and fish, and week two focused on water quality issues of the Coeur d'Alene basin. The program agenda can be found in the appendix.

Instructional Strategies

STEM Access Curriculum Framework

Over the past decade, SAUB identified seven program elements that are essential for increasing STEM skills, motivation, and identity, preparing students for college, and building grit and personal agency. The STEM Access Curriculum Framework identifies the seven essential elements and aligns them with program activities. The seven essential elements include:

- STEM Skills & Motivation
- Experiential, Hands-on Learning
- Academic and Social Preparation for College
- Community Building
- Financial Literacy & Awareness
- Personal Agency & Responsibility
- Grit

The seven elements were based on previous research done through a literature review and focus group interviews with students and staff identifying the most important elements of STEM Access programming, college readiness, and STEM career preparation. Therefore, the elements are based on both research and practice.

Drawing upon research in science education, I developed five student-centered instructional strategies to support the instructional objectives (Table 1.3).

Table 1.3 Selected instructional strategies enacted in an Upward Bound summer program.

Instructional Strategy	Enactment in Summer Program	Related Instructional Objective
Students actively engage in science practices (Ballen et al., 2017; Ballard, Dixon, & Harris, 2017; Freeman et al., 2014)	Students participate in scientific research through authentic field experiences including water quality testing, analysis, sampling, comparison, and reporting.	1, 2, 3
Students investigate complex social-ecological systems in the context of community (Ballard, Dixon, & Harris, 2017)	Authentic science field experiences take place in the local community and are connected to local social issues	1, 2, 3
Students' feelings of belonging are supported (Freeman, Anderman, & Jensen, 2007; Trujillo, & Tanner, 2014)	Team building, attention to emotional and intellectual safety, small group work, and opportunities to get to know scientists both personally and professionally	2, 4
Students' ways of knowing are legitimized and connected to science learning (Aikenhead, 2006; Buxton, 2006; Lee & Luykx, 2006)	Students design their own community-based research project (mastery experience), receive mentoring (process feedback), but are not graded on their projects	2, 3, 4
Students share their newly acquired science knowledge and skills to authentic external audiences (Ballard, Dixon, & Harris, 2017; Crawford, 2013).	Students teach younger students at a service learning event, students share their research projects with a larger audience.	1, 2, 3, 4

Designing the Instructional Message

Here I consider the course materials to maximize learner understanding. Important considerations were to allow students to use the science tools as scientists use them, and to engage students in high-interest activities such as biking, kayaking, snorkeling.

To facilitate student work on the research projects, we provided students with iPads with internet connection. A previously developed template was used for student research posters. Students also received journals used for writing down data in the field, making observations, field sketches, and for end of day reflections on field experiences. A film, "Treaty Talks" was shown before a field experience to facilitate discussion of hatcheries and the impacts of dams. For field investigations, we used water quality and habitat assessment kits borrowed from the University of Idaho extension. We also borrowed snorkeling equipment including wetsuits and stream boots and rented kayaks and bikes for some of the field investigations. Importantly, professional scientists and graduate students were recruited to lead field investigations related to their work, and to mentor students on their research projects. A list of questions was provided to STEM professionals to help them share their STEM trajectory with students.

Development of the Instruction

Here I describe the process of curriculum development, and a brief description of some lessons and their instructional objectives.

In the development of the program I ensured that the seven essential elements were incorporated into at least one aspect of the program. For me, the most logical way to do this was to create a chart to link the program activities to the related essential element. Here, I demonstrate the alignment of the key program content elements identified in the task analysis with the STEM Access Curriculum (Table 1.4).

Table 1.4 Key program content elements aligned with STEM Access Curriculum Framework.

Key Program Content Elements	Connection to STEM Access Curriculum Framework
Watershed investigation at local, regional, and comparative scales. Students actively engage in science practices through field experiences. Students interact with scientists doing addressing water resource issues in their community.	Experiential, Hands-on Learning Community building Personal Agency & Responsibility STEM Skills & Motivation
Alternative engagement with science through art and writing (e.g. field sketching, reflective writing in journals)	Personal Agency & Responsibility STEM Skills & Motivation
Mentorship Component - Connections with scientists and science students are formed through field experiences, as well as mentoring on student research project (*backstage* science experiences)	Academic and social preparation for college Community building Personal Agency & Responsibility STEM Skills & Motivation
Student Research Projects- Students work on a research question related to water/community alone or in groups. A project poster is presented at the end of the second week (Student-directed research projects)	Community building Academic and social preparation for college Personal Agency & Responsibility Grit STEM Skills & Motivation
Service Learning - Students will learn about and volunteer in the Lapwai community garden, and volunteer at the CDA lake celebration to teach younger students about water quality by guiding them through water quality testing.	Community building Academic and social preparation for college Personal Agency & Responsibility Grit STEM Skills & Motivation

Curriculum was designed in collaboration with scientist partners leading field investigations (for lesson plans see appendices 1.2.1-1.2.7). Together we identified program activities, selected appropriate learning objectives, and planned logistics. Therefore, it is important that I acknowledge the willingness of these collaborators to not only dedicate time and energy to facilitate an enriching science learning opportunity for students, but their commitment to the process of developing meaningful lesson plans. A brief description of four of the lesson plans is included in Table 1.5.

Table 1.5 Selected lesson plan descriptions.

Lesson	Description	Instructional Objectives of Lesson	Task/Activity
Creek Investigation	Students learn about the connections between water quality, food availability, and habitat quality to understand the impacts on native fish populations.	Students will be able to 1) Observe how fish behavior changes in response to the environment 2) Identify fish in Lapwai Creek 3) Collect and assess water quality data 4) Collect and identify macroinvertebrates and make assessments of water quality based on the assemblage	Students test various water quality parameters, collect and identify macroinvertebrates, and snorkel for fish and other aquatic life.
Restoration Investigation	This lesson takes students on a nature hike through the Nature Trail to learn about the role of the native and culturally important plants in wetland restoration. Differences in soils are related to hydrology and plant composition, and students have the opportunity to engage in an observation and plant identification activity.	Students will be able to... 1) Identify socially significant plants 2) Discuss the differences between natives and invasive plants 3) Identify elements of project management for natural resource management	Students tour the native plants restoration project along Lapwai Creek with a restoration specialist. They learn how to identify native plants, their impact on soils, and select a plant to identify and sketch.
Metal Contamination in the Chain Lakes	This lesson takes students on a bicycle tour of the chain lakes to learn about metal contamination in the Coeur d'Alene (CdA) Basin from a socio-ecological perspective. This place-based lesson is intended to broaden the students' awareness of the primary water quality issue facing the CdA Basin from a biophysical, historical, and cultural perspective.	Students will be able to... 1) Define toxic metals. 2) Diagram the biogeochemical cycling of metals within riverine and lake systems 3) Explain (via journal entry and class discussion) the impact of toxic metals on water resources from a socio-ecological perspective 4) Develop solutions to disseminate the implications of toxic metal exposure from a public health perspective	Students bike on the trail of the Coeur d'Alenes with a scientist. Students learn about metal cycling in the lake system and observe public health signs to consider alternative solutions.

After curriculum was developed it was reviewed and approved by the director. Only one major modification was suggested by the director, which was that a financial literacy component be added to the student research poster projects.

Assessment and Evaluation

Student learning was assessed formatively through reflective questions at the end of every field experience through a reflective activity at the end of each field experience that included journaling and sharing of reflective writing. Students received informal feedback to guide the development of their research projects from staff, peers, and mentors. At the end of the program, students prepared an oral presentation to accompany their research posters. The presentations were somewhat formal, with student posters projected onto a screen, 5-10 minutes of presentation, and time at the end for the presenter(s) to answer questions from the audience. Although scientists and mentors were invited to the presentations, none were able to attend as it took place in the middle of the day and in a relatively remote location. However, SAUB staff were present including the program director. Students did not receive a grade on their posters. Program evaluation included baseline and post-program assessment of students' confidence in their science skills, intention to pursue science in college or as a career, and their identification as a science person. Chapter 4 includes more detail related to the evaluation of the summer program.

Conclusion and Design Reflection

Many programs are tasked with meeting goals through the design of an intervention, without clarity in the process of how to do so. There are many design considerations based on the program (who makes decisions?), the learners (how do they learn best?), the type of intervention (when/where/how?), and overall program objectives (why?). The instructional design process is often messy and iterative, and it is easy to feel lost in the process. There are few examples of design cases for Upward Bound programming, making it difficult to understand what goes into designing a program. This design case may be helpful for those looking for inspiration or guidance, although due to the nature of the case it is not a directly transferable design. Rather, it is an explication of academic knowledge in a practical application. In practice, many elements were developed simultaneously and iteratively with SAUB staff, and dependent on the context. A summary of each instructional design element as applied to the summer program design case can be found in Table 1.6.

From my perspective as program designer and facilitator, some of the most important aspects to the program's success stemmed from personal connections, novel experiences, I drew heavily upon my connections through the water resources program at the University of Idaho, and the fact that a majority of the scientists students met were my friends made for a certain level of informality that made the field experiences more personal. One of the most validating of student responses to the program was the novelty. Although most students had lived in the area for their entire lives, they had not done the activities they participated in during the program. Students were able to deepen their connection to place.

If I were to facilitate the program again I would spend more time preparing the scientists. Some missed the point of the STEM expert prep sheet, which is to give students a realistic look at what it takes to become a scientist. Often, they would say something like, "I always liked math" instead of describing something they struggled with, which would have helped students to relate with them more. I would also have students' final presentations take place on the University campus, so that a greater number of university community members could attend. Balancing student research project time with field investigations was sometimes difficult, but I think overall the sequence of doing both each day provided balance. I made the decision not to collect students' journals so that they would feel comfortable being honest and open in their daily reflections, however I think collecting them for assessment would enhance accountability and quality of student responses. Lastly, I think the mentoring component was incredibly beneficial for students, and students were most engaged the hour when they were working with their mentors than any other time spent on their research projects. I would think that more mentoring opportunities would be beneficial.

Table 1.6 Application of the Morrison, Ross, Kalman and Kemp Model (2013) to the summer program.

Element	Description
Instructional Problems	Based on the literature of underrepresented student persistence in science, a gap in preparation for STEM degrees/careers was identified: • Inauthentic classroom science experiences • Science taught in a way that is disconnected from their everyday lived experience and culture • Decreased access to supplementary educational resources
Learners and Context	The learners were identified as high school age Upward Bound participants of low-income and first-generation backgrounds from the Lewis-Clark Valley and Benewah and Latah counties. Potential barriers for this population were identified, including: • Academic preparation • Preparation for college life • Navigating college without parental experience • Navigating different cultural worlds • Educational attainment limitations statewide
Task Analysis	The task analysis identified key program content elements to include: • Watershed investigations in Lapwai and Coeur d'Alene Basins • Alternative engagement with science through art and writing • Mentorship • Student Research Projects • Service Learning
Instructional Objectives	In coordination with the program director, three program objectives were established: • Students will deepen their understanding of watershed science content and practices. • Students will develop a community-based research project. • Students will become more connected to the community of science as measured by their science skills (self-efficacy), ability to see themselves as a science person (science identity), science community values, and their intention to pursue STEM.
Content Sequencing	Daily work: community-building activities, research projects, field investigations or service learning, reflective writing. Week 1: (Lapwai Watershed): Impact of habitat quality on water quality and fish Week 2: (Coeur d'Alene Basin): Water quality issues of the CDA basin
Instructional Strategies	Based on the literature, model of learning, and STEM Access Upward Bound Curriculum Framework, five principle strategies were identified: • Students actively engage in science practices • Students investigate complex social-ecological systems in the context of community • Students' feelings of belonging are supported • Students' ways of knowing are legitimized and connected to science learning • Students share their newly acquired science knowledge and skills to authentic external audiences
Designing the Instructional Message	Important considerations were to allow students to use the science tools as scientists use them, and to engage students in high-interest activities such as biking, kayaking,

	snorkeling. Primary resources included water quality testing kits, scientist mentors, iPads, and journals.
Development of the Instruction	Collaboration with scientists leading field investigations to develop lesson plans.
Evaluation Instruments	Student learning was assessed through reflective writing after field experiences, and through student research project presentations. Students' development of science identity, science self-efficacy, science community values, and intention to pursue STEM was assessed through pre/post surveys and interviews.

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Chapter 2: Understanding the Impacts of Authentic Science Experiences Through a Model of Social Influence Theory

Introduction

Researchers have called for further investigation into what facilitates diverse young people's interest in science, development of science identity; perceptions of their abilities to do science; and why those initially interested in science do not continue on in science learning or careers (Aschbacher, Li & Roth, 2010; Lewis, Menzies, Nájera & Page, 2009). A lack of racial, economic, and gender diversity in science fields has been a critical concern for several decades, prompting investigation into the underlying causes for disproportionate achievement in science in high school, college, and beyond for these groups. Some education scholars believe that schools have failed to provide equitable learning opportunities in science education for all students (Lee & Luykx, 2006). Although young students of all demographic backgrounds are initially interested and adept in science, that interest declines in middle school and high school, and especially for female, minority, and economically disadvantaged students (Aschbacher, Li, & Roth, 2010; Tytler, 2014). For example, during high school, the percentage of females interested in a STEM careers declines, whereas for males it remains stable (Sadler, Sonnert, Hazari & Tai, 2012). Despite overall increases in college attendance, significant gaps in college go-on rates persist for low-income, minority, and prospective first-generation to college (first-generation) students (McFarland et al., 2018). For those that do enroll in college, female and minority students, except for Asian American students, are less likely than male or White students to declare a STEM major (Mau, 2016).

Because of the barriers underrepresented students face in their pursuit of science degrees and careers, targeted programming offering guidance, experience, and encouragement to continue on in the sciences is sometimes provided through supplementary science experiences (Chemers et al., 2011; Hernandez, Usselman, Rana, Alemdar, & Rao, 2018; Lane, Morgan, & Lopez, 2017; Linnenbrink-Garcia et al., 2018). Supplementary science experiences exist outside of formal classroom education and provide students the opportunity to participate in authentic science practices, often through a research experience or a mentoring relationship with a scientist. Proponents of authentic science education suggest that engaging students in science as a practice of discovery in real-world context increases relevance to lived experience, reducing cultural barriers to science (Crawford, 2013; Carlone, Johnson, & Eisenhart, 2014). Rather than teaching science as a body of knowledge, authentic science learning is more representative of science as practiced by scientists, while considering the limitations of the educational setting such as space, time, money, and expertise

(Chinn & Malhotra, 2002). Authentic, supplementary STEM learning experiences that incorporate aspects of students' everyday lived experiences are promising interventions to support underrepresented student success in STEM fields (Buxton, 2006).

There are an increasing number of programs with goals to support academic preparation of underrepresented students in order to recruit and guide them into STEM college-majors and careers (Hernandez, Usselman, Rana, Alemdar, & Rao, 2018; Lane, Morgan, & Lopez, 2017; Linnenbrink-Garcia et al., 2018). Upward Bound Math Science is one such program, providing support to prepare low-income and first-generation high school students to pursue degrees and careers in math and science through a variety of programming which includes intensive summer courses featuring authentic research experiences with faculty and graduate students (Mau, 2016; Olsen et al., 2007). Upward Bound Math Science programs offer an opportunity for in depth understanding of program impacts on student integration into science, however individual Upward Bound Math Science programs have yet to be investigated in this way. This study examines the impacts of an intensive science summer program for low-income and first-generation high school students using a quasi-experimental mixed methods approach, in order to better understand how authentic science experiences can support persistence in science for these populations. Specifically, the research questions under investigation for this study were:

1. How did the summer program impact students' science identity, self-efficacy, science values, and intention to pursue science?
2. What barriers keep students from developing an orientation toward science?

We also wanted to understand whether demographic variables accounted for any differences in how students were impacted by the program. This research has implications for the design and implementation of interventions which hope to increase underrepresented student achievement in science.

Background

Barriers to STEM for Underserved Youth

Research investigating the reasons initially interested students become less interested in science suggests both environmental and psychosocial causes. For example, an investigation following high school students who were initially interested in pursuing science careers found that those who gave up on science by the end of high school "… cited poor instruction, lackluster curriculum with few hands-on inquiry activities or meaningful projects, and little encouragement to study or do science from teachers, counselors, and administrators alike" (Aschbacher, Li, & Roth, 2010, p. 579). In this study, students' science identity, self-confidence, perceived ability in science and acknowledgement by others were important mediators of whether they continued in science, suggesting a strong connection between these variables and behaviors. Therefore, a lack of support for these environmental and psychosocial variables can pose barriers to continued student interest in pursuing science.

Access to learning opportunities is another significant barrier. Low-income, first-generation students are more likely to enter college with less academic preparation than their peers, and therefore to take remedial courses (Engle & Tinto, 2008). There is a direct effect of secondary school academic preparation on postsecondary science and engineering persistence and completion (Seymour & Hewitt, 1997). Therefore, inadequate academic preparation of low-income and first-generation college students presents a significant barrier to both college and STEM persistence (Gibbons & Shoffner, 2004). The 2011 report, National Assessment of Educational Progress (NAEP), found that eighth-grade students from all demographic backgrounds who report doing science-related activities outside of school score higher on national science assessments. Science outside the classroom not only impacts achievement but also science identity. In their investigation of science identity among young students, Archer et al. (2010) found that students of higher socio-economic backgrounds linked their science identities to their science interests and activities at home, which were often encouraged and financially supported by their parents. Access to science experiences outside of the classroom appears to be especially impactful for disadvantaged students. In their investigation of the factors contributing to persistence for underrepresented students in science, Chemers et al. (2011) found supplementary science experiences to be a major contributing factor. In fact, there is strong evidence that supplementary science experiences increase science self-efficacy and science identity which in turn contributes to student persistence in science (Ballen, Wieman, Salehi, Searle, & Zamudio, 2017; Chemers et al., 2010; Chemers, Zurbriggen, Syed, Goza, & Bearman, 2011; Eccles & Barber, 1999; Estrada, Woodcock, Hernandez & Schultz, 2011; Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013; Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2009). Supplementary science experiences are therefore a promising intervention for addressing barriers to science for underserved youth.

Upward Bound Math Science in Idaho

Upward Bound Math-Science (UBMS) is a federally-funded program created to address the need for specific support in the fields of math and science for low-income and first-generation students, and to encourage students to pursue postsecondary degrees and careers in math and science (U.S. ED, 2009). UBMS works to meet these goals through a variety of programming, including summer programs with intensive math and science training, year-round counseling and advising, exposure to university settings and faculty research, and participant conducted research under the guidance of faculty or graduate students. In addition, the program works to improve financial and economic literacy, enhance college readiness, and otherwise meet the needs of the underserved students in the program. In 2018, there were 213 individual UBMS programs affiliated with institutions of higher learning in the United States. Upward Bound Math Science at the University of Idaho is called STEM Access and is the context of this study.

Educational attainment in Idaho lags behind the rest of the nation in terms of graduation rates for high school and college. Idaho is among the states with the lowest high school graduation rates, with 20% of the students who enter ninth grade failing to graduate (McFarland et al., 2018). Disadvantaged and minority students in Idaho are at higher risk of drop out. According to Ed Trend Report (2018), the 2016 graduation rate for students in poverty was 71.9%, Hispanic students graduated at a rate of 73.7%, and students with disabilities graduated at a rate of 60%. For these students who graduate high school, less than half go on to higher education. In 2016, only 45% of Idaho teens went to a college, university, or trade school, placing Idaho well below the national go-on rate of 69% (McFarland et al., 2018). Idaho students who do choose to enroll in college may end up leaving empty-handed. A recent National Student Clearinghouse report found that only 50% of Idaho students who enter four-year public institutions graduate within six years, compared with the national rate of 64.5% (Shapiro et al., 2019). Facing not only lower graduation rates but lower success rates once in college, Idaho students are in need educational support, and in particular lower income students.

In addition to issues of educational attainment, Idahoan students are presented with education barriers due to the cultural context of the state. Idaho is a religiously and politically conservative rural state facing economic challenges. Rural youth are less likely to attend college than youth from metropolitan areas (Herzog & Pittman, 1999). Further, high rates of poverty, long distances to colleges, and lack of educational role models present obstacles to education for these rural youth (Grimard & Maddaus, 2004). The sociopolitical context of Idaho has implications for K-12 STEM education in particular. Mihelich, Sarathchandra, Hormel, Craig and Storrs (2015) found that more politically and religiously conservative Idahoans were less supportive of STEM education measures, which may also affect their students' engagement with STEM. Services offered by Upward Bound Math Science programs serve a critical need in the state of Idaho and may help students to overcome educational resource barriers. It is therefore important to understand the extent to which STEM Access programs may lead to positive educational outcomes such as persistence in science.

Theoretical Framework

This study draws on social influence theory (Kelman, 2006; Estrada et al., 2011) to understand student integration into the science community through authentic science learning experiences. Social Influence Theory (SIT) identifies the processes of integration into a particular community as facilitated by a person's orientation to the rules, roles, and values of the community (Kelman, 2006). According to SIT, identifying with the community, achieving skills necessary for participation, and internalizing the values of the community indicate integration into the community. Estrada et al. (2011) used SIT to understand minority undergraduate and graduate student integration into the scientific community through a nationwide longitudinal study. Findings of the study showed that undergraduate and graduate students in STEM disciplines who felt they could do the work of scientists (possessed science self-efficacy), identified as scientists (possessed science identity), and valued the objectives of science (possessed science values) were more likely to intend to pursue a scientific career. Identification and internalization of values were stronger indicators of integration than self-efficacy for graduate students. Estrada et al. postulated that graduate students' long-term intention is more influenced by students' identity and values than their abilities. Although science self-efficacy may lack predictive power for long-term integration in the sciences, it was still positively and significantly correlated with intention to pursue STEM, which suggests an important role of self-efficacy for initial entry into the sciences. Investigating the mediators of SIT in the context of an intervention designed to make STEM degrees and careers more accessible will help to identify the extent to which the intervention facilitates integration into the science community.

Science Self-Efficacy

Self-efficacy is one's perception of competence, or the conviction that one can successfully execute a behavior to produce an outcome (Bandura, 1977). As conceived by Bandura (1977), self-efficacy is based on four factors: mastery experiences, vicarious experience, verbal persuasion, and emotional association. Mastery experiences help us to feel assurance in our abilities. Vicarious experiences make us feel capable when we observe that others are capable. Verbal persuasion is when others convince us that we are capable. Emotional association with a behavior can inhibit (as in in stress or vulnerability) or enhance (as in excitement) our perceived abilities. In social cognitive theory, Bandura (1986) hypothesized that self-efficacy beliefs determine motivation, affect, and action, making the concept a common predictor of actual performance. For example, self-efficacy beliefs have predicted decisional outcomes including academic achievement, occupational choice, and persistence in scientific pursuits even when variations in actual ability, prior achievement, aptitude, and interests were controlled (Hilts, Part, & Bernacki, 2018; Ballen, Wieman, Salehi, Searle, & Zamudio, 2017; Lent, Brown, & Larkin, 1986).

Self-efficacy beliefs are contextual in that they are domain specific. Science self-efficacy is one's belief in his or her ability to succeed in science tasks, courses, or activities (Britner & Pajares, 2006). In relation to social influence theory, orientation to the rules of a community are indicated when students believe they can perform science skills (Estrada et al., 2018). Broadly, these include the skills necessary to accomplish science tasks, for example - making observations, collecting data, asking research questions, or carrying out an investigation. Science self-efficacy beliefs are important because they are predictive of academic achievement in science subjects (Hilts, Part, & Bernacki, 2018; Ballen, Wieman, Salehi, Searle, & Zamudio, 2017). Additionally, students who demonstrate higher self-efficacy are also more likely to persist in the face of difficulty (reviewed in Zimmerman, 2000; Usher & Pajares, 2008). For college students, perceived competence in STEM predicts achievement in a STEM course and lessened intention to leave their STEM major, especially for underrepresented students (Hilts, Part, & Bernacki, 2018). Programs with goals to support student achievement in science must therefore also be concerned with students' science self-efficacy. Self-efficacy beliefs can be measured through self-report instruments.

Science Identity

Identity is a complex concept, entailing cognitive, psychosocial, and environmental factors (Carlone & Johnson, 2007; Tytler, 2014). In the 2000's, researchers began to use science identity as a lens to understand why some students succeed in science education and others do not, especially in the context of underrepresented groups. Brickhouse, Lowry, and Schultz (2000) investigated a fundamental question of science education through the lens of school science identity - whether students see themselves as the kind of people who would want to understand the world scientifically and thus participate in scientific activities. Their conceptualization of science identity recognized "both individual agency as well as societal structures that constrain individual possibilities" (p. 444). Most researchers attend to the socially-situated nature of science identity (Tytler, 2014). Carlone and Johnson (2007) developed a model of science identity that includes recognition by others, performance, and competence. They proposed that possessing science content knowledge and skills, demonstrating science competence, and being recognized by others as "a science person" are factors that can lead to a stable science identity over time. Importantly, their model highlights the issue of recognition for underrepresented students who don't represent the status quo of scientists (Carlone & Johnson, 2007). External social forces can influence the extent to which a student feels like a science person. Gender, race, class, and ethnicity intersect to create disadvantages in differing ways. A longitudinal investigation into students' science identity from elementary to middle school found that race, class, and gender influenced students' deep engagement with science and identity work related to becoming scientific, more so than academic success (Carlone, Scott, & Lowder, 2014). Additionally, a science identity increases the likelihood a student will pursue a science degree or career, especially for underrepresented groups (Chemers et al., 2011; Estrada et al., 2011; Estrada et al., 2016; Hernandez et al., 2013; Robinson et al., 2018). Understanding persistence in science is critically connected to the concept of science identity, especially for underrepresented students.

There is not agreement on how or even whether identity is measurable, but those who have analyzed science identity have done so through artifacts, personal interviews, discourse analysis, and self-report measures (Bell et al., 2018).

Science Community Values

In social influence theory, similar to the concept of communities of practice, membership into the community entails commitment to the domain as well as cultural norms (Kelman, 2006; Lave & Wenger, 1991). Cultural norms in the context of the science community may include commonly held beliefs among scientists such as the value of curiosity and the pursuit of knowledge through empirical investigation. Integration into a community can therefore be marked by the internalization of values and preferences of the group (Kelman, 2006). According to Estrada et al. (2011), "a measure of the importance of a belief, rather than intrinsic enjoyment or usefulness, most clearly captures Kelman's conception of internalization" (p. 8). Understanding the extent to which someone rates a social group value as important indicates the degree of internalization of the group value system for that individual. Applying this concept to the summer program, student self-reports of their science community values can help to determine the degree to which they have integrated into the science community.

Shared values also help to engender a sense of relatedness and motivation to continue despite difficulties (Hilts, Part, & Bernacki, 2018). For example, if students perceive that their friends value science then they are less likely leave their STEM major (Hilts, Part, & Bernacki, 2018). Additionally, the perception that an academic activity is valuable, useful, or important is strongly associated with sense of belonging, suggesting the similarity between the concepts of belonging and identification with the values of science (Freeman, Anderman, & Jensen, 2007). Estrada et al. (2011) also found that students who internalized science values had longer-term academic perseverance in the sciences. Therefore, science community values are an important indicator and measurement of potential student persistence in science.

A learning Model for Authentic Science Experiences

Ballard and et al. (2017) adapted the Critical Science Agency concept from Basu et al. (2010) to propose Environmental Science Agency, a concept specific to science learning in the context of citizen science, or the public participation in scientific research. Through citizen science, students can contribute to scientific research, often through data collection for scientists conducting investigations (Jordan, Ballard, & Phillips, 2012). Critical science agency looks at student identity within science in ways that lead to behavioral outcomes such as participation in the community, and environmental science agency uses a similar frame to understand outcomes specific to environmental science, such as participation in conservation actions, and capacity for future conservation actions. The authors used case studies to identify key student practices that lead to environmental science agency. These practices included rigorous data collection, disseminating scientific findings to authentic external audiences, and investigating complex social-ecological systems. The model of Environmental Science Agency (depicted in Figure 2.1) includes the processes and outcomes of student learning during participation in citizen science and was chosen as the learning model for this program due to the nature of the program content and design, and alignment with Social Influence Theory due to the emphasis on community participation.

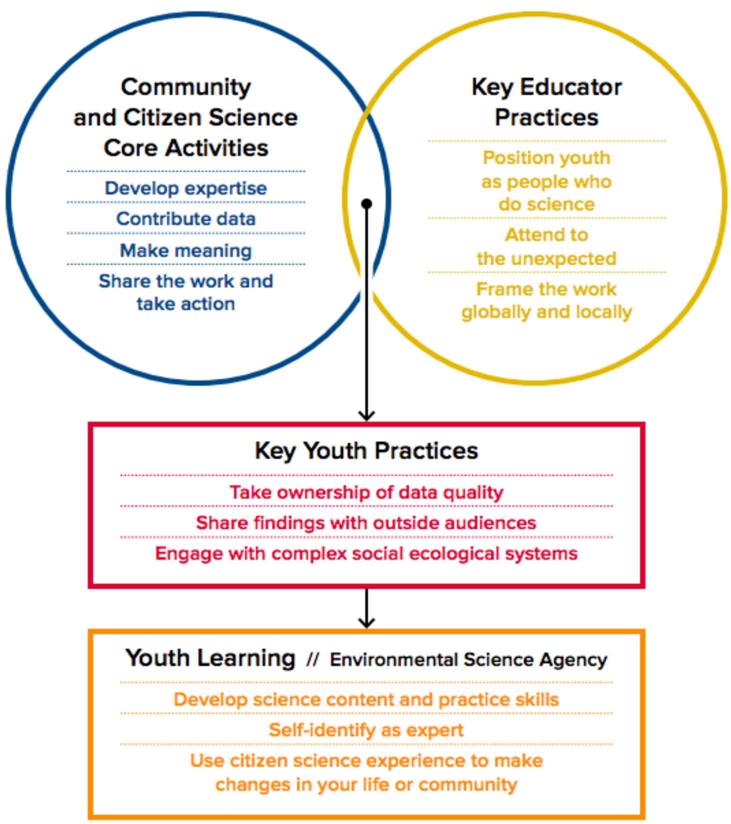

Figure 2.1 The Framework for Youth Centered Citizen Science helps educators facilitate citizen science activities in ways that support youth learning (Ballard et al., 2017).

Present Study

Relatively few studies examine the effectiveness of educational contexts explicitly designed to holistically support multiple mediators of integration into STEM for students typically underrepresented in science. Thus, for this study, I developed an intervention designed to enhance science self-efficacy, science community values, and science identity as measured by scales refined by Estrada et al. (2011). Drawing upon the Environmental Science Agency learning model (Figure 2.1), and the literature investigating science self-efficacy, science identity, and science community values described above, I identified five design principles that guided the intervention (Table 2.1).

Table 2.1 Design principles supporting integration into STEM in summer program.

Design Principle	Mediator of Integration into STEM	Enactment in Summer Program
(1) Students actively engage in science practices (Ballen et al., 2017; Freeman et al., 2014)	Self-Efficacy Science Identity	Students participate in scientific research through authentic field experiences including water quality testing, analysis, sampling, comparison, and reporting.
(2) Students investigate complex social-ecological systems in the context of community (Ballard, Dixon, & Harris, 2017)	Science Community Values	Authentic science field experiences take place in the local community and are connected to local social issues
(3) Students' feelings of belonging are supported (Freeman, Anderman, & Jensen, 2007; Trujillo, & Tanner, 2014)	Science Identity Science Community Values	Team building, attention to emotional and intellectual safety, small group work, and opportunities to get to know scientists both personally and professionally
(4) Students' ways of knowing are legitimized and connected to science learning (Buxton, 2006; Lee & Luykx, 2006)	Science Identity Self-Efficacy	Students design their own community-based research project (mastery experience), receive mentoring (process feedback), no summative evaluation.
(5) Students share their newly acquired science knowledge and skills to authentic external audiences (Ballard et al., 2017; Crawford, 2013).	Self-Efficacy Science Identity	Students teach younger students at a service learning event, students share their research projects with a larger audience.

The current study utilized these five design principles to create an authentic science summer enrichment program for SAUB participants. I then evaluated the effectiveness of the program in supporting science self-efficacy, science identity, science values, and science degree/career intentions. I anticipated that some students would come to the summer program with pre-existing high levels of science identity and science self-efficacy, and that these students would show less impact. I hypothesized that students starting with the lowest levels of science identity and self-efficacy would show the greatest increases.

The current study contributes to both theory and practice in several key ways. While social influence theory has been used to understand persistence in STEM for underrepresented students at the college and graduate level, it has not been used in the context of a pre-college preparation program. Most recently, researchers have begun to use SIT to identify the most impactful program components for persistence in STEM, finding that quality mentorship and two semesters of research experiences had significant and positive effects on STEM career choice (Estrada et al., 2018). However, SIT, in the context of persistence in STEM, has yet to be investigated in tandem with qualitative methods, and at the level of an individual program. This study builds off of previous research that has successfully used social influence theory to predict persistence in STEM for underrepresented students, by investigating a particular case in-depth, providing program-level data to build evidence of how research experiences contribute to variables predictive of persistence in STEM. This research has important practical implications for individual programs interested in impacts on integration into STEM, without the time or resources to conduct large-scale longitudinal studies. By relating qualitative data describing student experience from the student perspective to previously validated scales, we can better understand how and why authentic science experiences are impactful for underrepresented students.

Methods

This study uses a quasi-experimental mixed method design to investigate the impacts of the Upward Bound summer program using variables predictive of participants' persistence in STEM. Quantitative data included a pre-post and six-month follow-up questionnaire consisting of previously validated scales of science identity, science self-efficacy, and science values, as well as summative assessment of student research posters. Qualitative data included semi-structured interviews with program participants. This study used a convergent mixed-methods design, meaning after analyzing both quantitative and qualitative data sets, the results are merged and compared (Creswell, 2014). This is a common approach in program evaluation when quantitative and qualitative findings are meant to contribute equally to findings (Cresswell, 2014).

Participants

A self-selected population of 16 high school students enrolled in a three-week summer STEM Upward Bound experience were asked to participate in this research study. Their participation in the present study was entirely voluntary and contingent on parental approval. In total, 14 students participated in the survey (Table 2.2) and 10 students participated in the interviews. Figures 2.2 and 2.3 show student eligibility status in relation to ethnicity and pre-program grade point average (GPA).

Table 2.2 A demographic summary of participants who took the pre/post surveys.

Gender		Percent
Female	10	71.42%
Male	4	28.57%
First Generation	11	78.57%
Low Income	11	78.57%
Both LI FG	10	71.42%
Grade Level		
9	1	7.14%
10	6	42.86%
11	5	35.71%
12	2	14.28%
GPA		
Less than 2.5	5	35.71%
2.51-3.0	0	0%
3.1-3.5	3	21.42%
3.51-4	5	35.71%
Ethnicity		
White	11	78.57%
Hispanic white	2	14.28%
Asian/white	1	7.14%

Note. *n=14*.

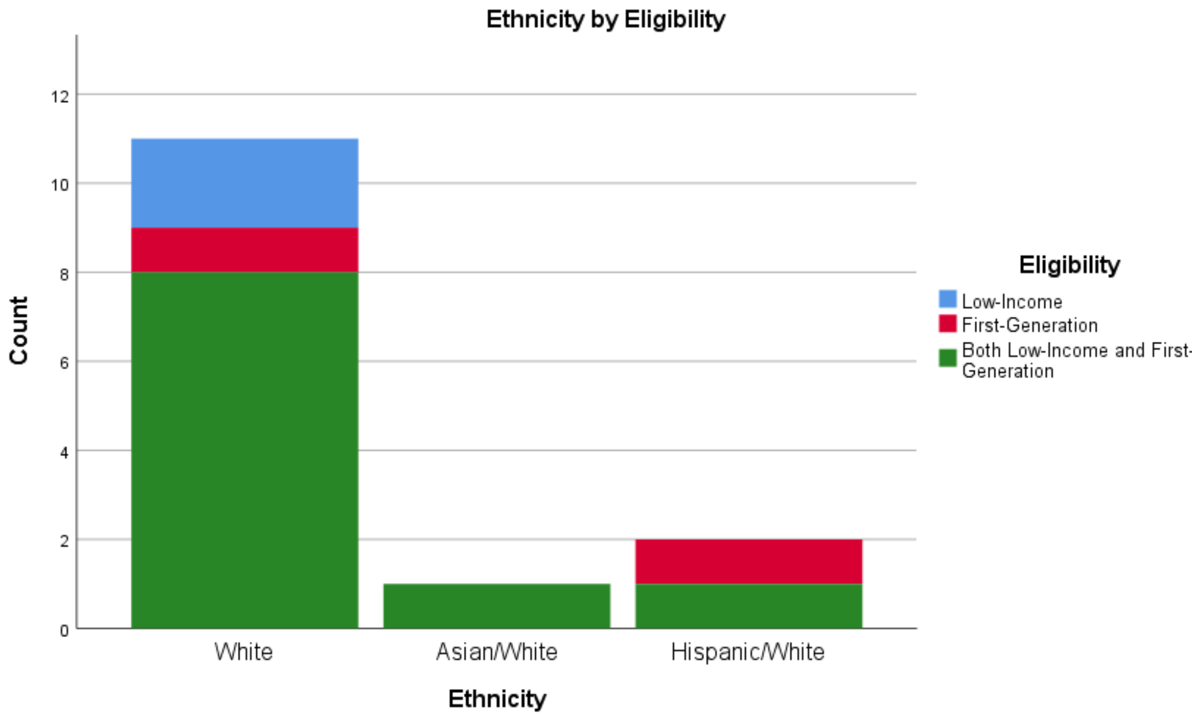

Figure 2.2 Histogram of student ethnicity by eligibility status.

Figure 2.3 Histogram of student GPA by eligibility status.

Measures

Previously developed scales by Estrada et al. (2011) measuring scientific self-efficacy, scientific identity, scientific community values, behavior, and intention were adapted to be more appropriate for the reading level of 14-18-year-olds. The Flesch-Kincaid readability score is a common indicator of reading level and was used while adapting scale items to the appropriate reading level. The adapted versions of the scales were field tested prior to use, and authors who had previously used the scale were consulted for expert review and to ensure the meaning of the items remained intact. Estrada had only one concern, about the second item on the science identity scale, but otherwise approved of the adaptations. Original and adapted scales along with their readability scores can be found in Appendix 2.2.

Scientific self-efficacy scale

Estrada et al. colleagues (2011) created a six-item scale from Chemers et al. (2010) original 14-item scientific self-efficacy scale. The modified scale had high internal consistency ($\alpha = .91$). On a scale of 1 (not at all confident) to 5 (absolutely confident), the scale asks participants to assess their ability to function as a scientist in scientific inquiry tasks.

Scientific identity scale

Estrada et al. (2011) modified Chemers et al. (2010) Scientific Identity scale, containing 5 items, and the resulting scale had a high internal consistency ($\alpha = .86$). The scale asks participants to assess on a scale of 1 (strongly disagree) to 5 (strongly agree) the extent to which a series of statements is true of them.

Scientific community objectives value scale

Estrada et al. (2011) developed a new scale to assess the extent to which participants valued the objectives of the scientific community, because none was yet created. The researchers validated the reduced items through pilot testing, and the resulting 4 item scale had high internal consistency ($\alpha = .85$). The scale asks participants to rate "how much the person in the description is like you?" Response options included "not like me at all," "not like me," "a little like me," "somewhat like me," "like me" and "very much like me."

Intention

Estrada et al. (2011) measured the level of integration into the scientific community by asking each participant to rate on a scale of 0 (definitely will not) to 10 (definitely will) their intention to pursue a science related career.

Interview guide

Open-ended questions were co-developed with Upward Bound program coordinators based on the themes of the research that include feelings of identity with science, sense of belonging, interest in science, educational and career goals, the program experience, and ongoing challenges and obstacles with science. Similarly, Hurtado et al. (2009) developed a semi-structured focus group protocol that broadly addressed thematic categories that included developing an interest in science and subsequent educational and career goals, understanding the role and requirements of a scientific research career, the program experience, and ongoing challenges and obstacles. The interview guide was field-tested and refined, and the final version is included in Appendix 2.3.

Scientific literacy rubric

Student research posters were assessed using the Scientific Literacy Rubric authored by Susan Schultz at Stanford Center for Assessment, Learning, and Equity (SCALE) with input from the teachers in the Ohio Performance Assessment Pilot Project and is included in Appendix 2.5. The rubric was designed to align with the Next Generation Science Standards to assess students' ability to articulate a science-related issue, make a claim, identify evidence, justify a claim, and evaluate an argument, using a scale from "developing" to "advanced." The scientific literacy rubric was an appropriate fit for the goal of the research poster project which was for students to develop research skills on a community-based science issue of their choosing and articulate it to a broader audience.

Program

The three-week summer program involved youth in a variety of activities designed to develop their science skills, science identity, and feeling of inclusion in the science community. Activities included: developing a research proposal for a community-based project of their choosing; collecting data with graduate students in STEM fields; being mentored by graduate students in science; service learning; teaching younger students newly acquired science skills; presenting their research proposal to a broader audience; and exploring STEM careers in the local community through field experiences (see Table 2.1). Students were not evaluated on their performance in the program as in the typical science classroom. Rather, students were invited into science experiences, allowing them to practice science without the pressure to perform or be judged in relation to their peers. This emphasis on trying out new experiences was embedded in the culture of the program and the types of activities chosen (for example kayaking, biking, snorkeling), which also supported a growth mindset toward science skill development. Exposure to STEM careers, research, and training is a critical component the UBMS goal of encouraging students to pursue postsecondary degrees and careers in math and science, and thus a variety of field experiences and STEM professionals were included in the program.

Procedures

Students were asked to take the survey before and after the program, and 13 students completed both surveys. Six months after the program, students were asked to take the same survey, and seven students completed it. One student completed only the post survey and the six months after survey, therefore a total of 14 responses are included here.

Student responses to each of the scale items were assigned a numeric value. For example, strongly agree was assigned a five, while strongly disagree was assigned a one. A composite score was calculated for each student for each of the scales by taking the mean of the numeric values of their responses. This indexing process allowed for a single numeric value for each scale for each student based on their responses to the items in that scale. “High” and “Low” levels were created for each variable by using the median response as a dividing point. Student grade point average, “GPA.” was divided into “High” “Medium” and “Low” categories. The Scientific Literacy categories were kept (“Emerging,“ Developing,” “Proficient,” and “Advanced”).

Student research posters were scored by the investigator using the scientific literacy rubric. An overall score for each student poster was generated by calculating the mean.

Ethnographic-style semi-structured interview methods were conducted with ten students to provide more descriptive data. Nine of the students interviewed had completed both the pre and post surveys, one completed the post and six month follow up survey, and five of the students interviewed completed the 6 month follow up survey. Interviews were arranged with outreach coordinators to take place three months after the program at the students’ high schools. To reduce the burden of the interview on students, the interview was limited in length, and took around 15-30 minutes. Interviews were recorded using a voice recorder, and pseudonyms applied to the transcribed interviews.

Analysis

Quantitative data

Student research poster scores were added to the survey data under the variable name “scientific literacy.” Non-parametric analysis methods were chosen due to the nature of the data. A Wilcoxon signed-rank test was used to compare the before and after surveys to assess differences in mean ranks. A Friedman test was used to assess differences between the before, after, and six-month after test.

Qualitative data

Codes and themes were generated from the transcripts using a thematic analysis approach to generate a codebook (Savin-Baden & Major, 2013). The thematic analysis focused on identifiable themes and patterns of living and/or behavior. Codes were developed based on repetitions and regularities, by comparing and contrasting responses, and by identifying significant concepts in the data (Bazeley, 2007). Interpretation drew on the codes as well as related literature to develop a storyline. A peer debriefing process was used to enhance validity, with six people participating.

Results

Quantitative Findings

Analysis of pre and post survey data suggest statistically significant increases in science identity and intention. A Wilcoxon signed-rank test showed that the summer program did not elicit a statistically significant change in self-efficacy ($Z = -.534$, $p = 0.593$) or values ($Z = -1.489$, $p = 0.137$) but did elicit a statistically significant change for identity ($Z = -2.047$, $p = 0.041$) and intention ($Z = -2.511$, $p = 0.012$) of participants. Scale reliability was very good for Self-Efficacy (α=.921), Identity (α=.923), and Values (α=.905). Results of the Friedman test showed no statistically significant differences between the before, after, and long-term measurements for any of the variables. Descriptive statistics for all measurements are reported in Table 2.3. There was notably greater variation in responses after the program when compared to before and six months after (Figure 2.4). Line graphs for all measurements can be seen in Figure 2.5 and show extreme changes for a few students for all subscales except intention. Correlations among variables are shown in Table 2.4 and show that science identity and science community values subscales were most highly correlated with intention.

Table 2.3 Descriptive statistics of survey results

	n	Scale Range	Median	Mean	SD
Self-Efficacy		1-5			
Before	13		4	3.7692	.70481
After	14		3.915	3.7736	1.24544
Six Months	7		4.33	4.0471	.81843
Identity		1-5			
Before	13		3.2	3.200	.8718
After	14		4.1	3.871	.9754
Six Months	7		4	3.629	.9827
Values		1-6			
Before	13		4.75	4.9038	.85109
After	14		5.165	4.7021	1.30065
Six Months	7		5	4.9286	.92099
Intention		0-10			
Before	13		6	6.54	2.602
After	14		8	7.79	2.155
Six Months	7		7	7.43	2.070

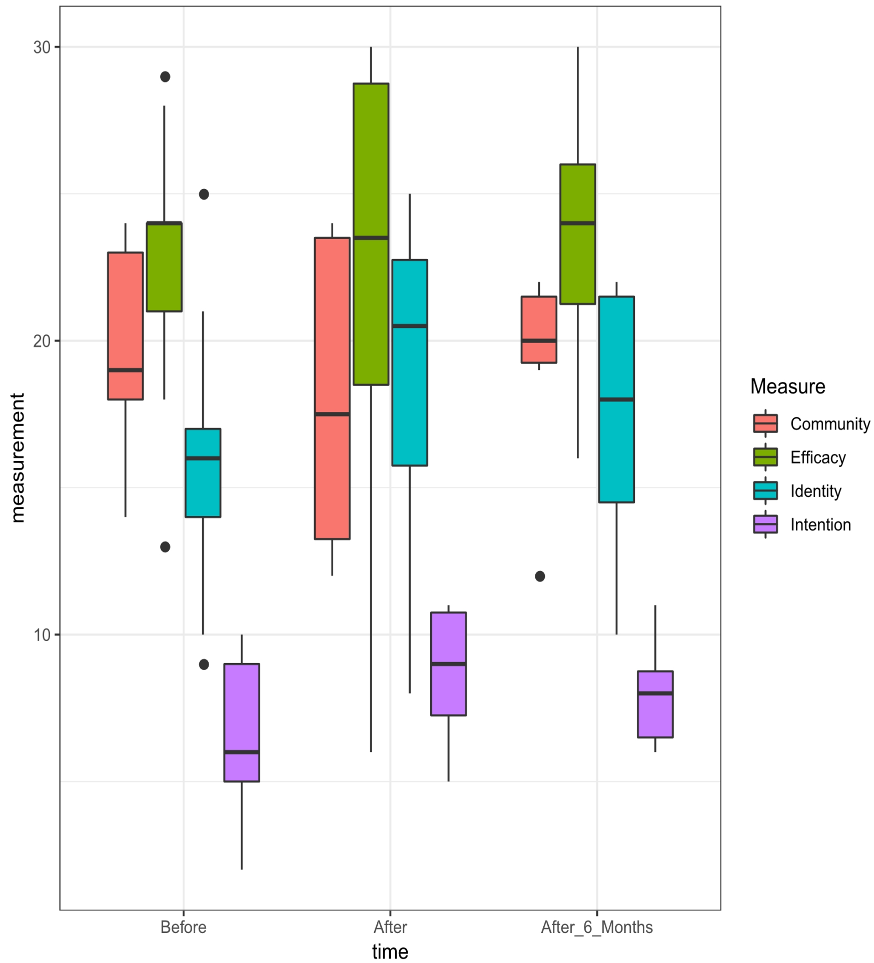

Figure 2.4 Box plots for all measures before, after, and six months after the program.

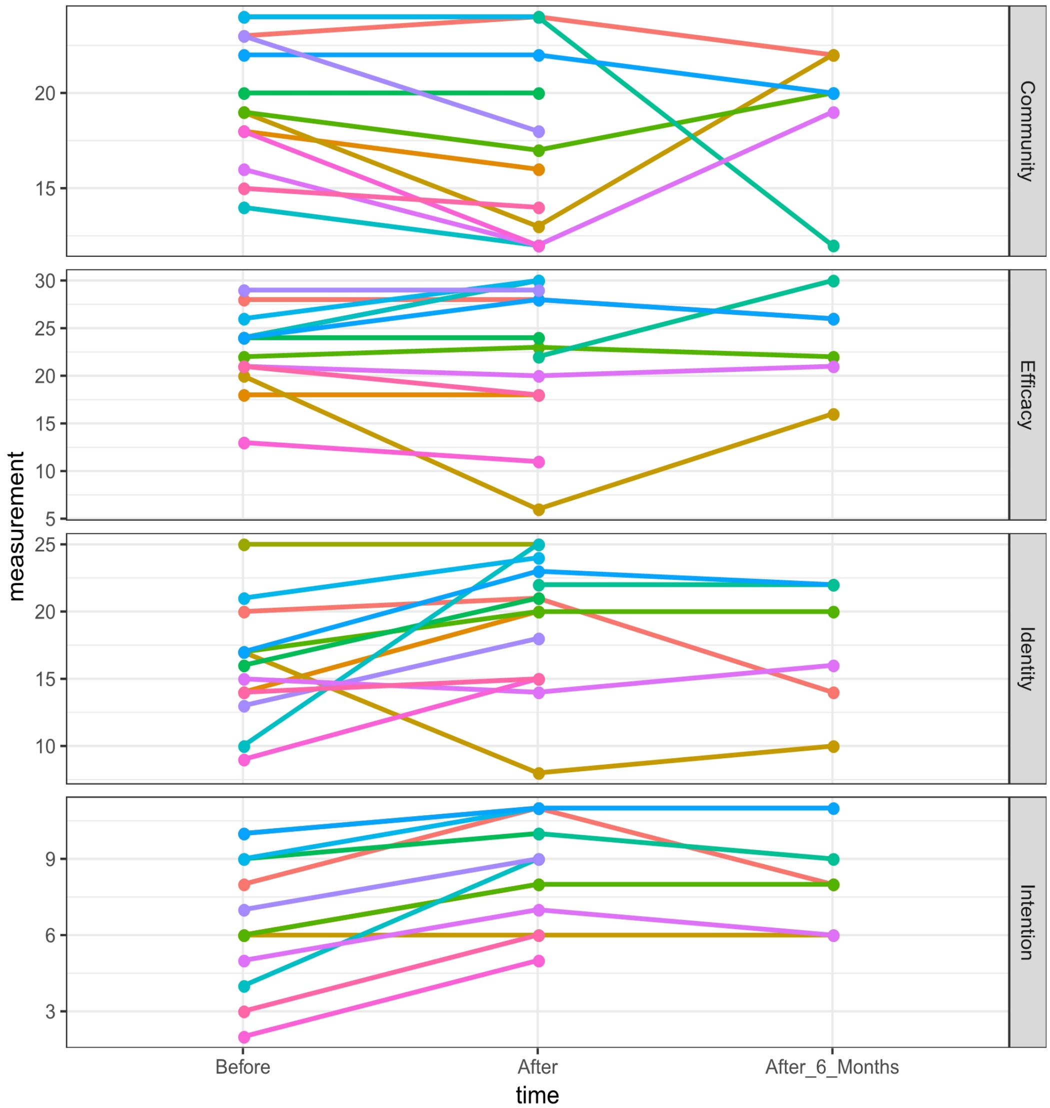

Figure 2.5 Line graphs for each measurement before, after, and six months after the program.
Note. Each line represents one student. The Y axis represents the student's mean score for each of the variables.

Table 2.4 Pearson Correlations between subscales.

	Self-Efficacy	Identity	Values	Intention
Self-Efficacy	1	.465	.576*	.641*
Identity		1	.670*	.786**
Values			1	.748**
Intention				1

Note. *Correlation is significant at the .05 level (two-tailed) **Correlation is significant at the .01 level (two-tailed).

Self-Efficacy

While change in mean self-efficacy from before to after the program was insignificant, important patterns emerged when demographic variables were taken into account. Students with medium and high GPAs saw a slight increase in self-efficacy from before to after the program, and low GPA students saw a decline (Figure 2.6). Gender was also distinguishing: Males saw a slight increase while females saw a slight decrease (Figure 2.7). Students who were both low-income and first-generation, as opposed to those who were only one or the other, saw a decline in comparison to their peers (Figure 2.8). Looking at self-efficacy in relation to student scientific literacy scores as measured through their posters, the students with higher scores also increased the most in self-efficacy (Figure 2.9).

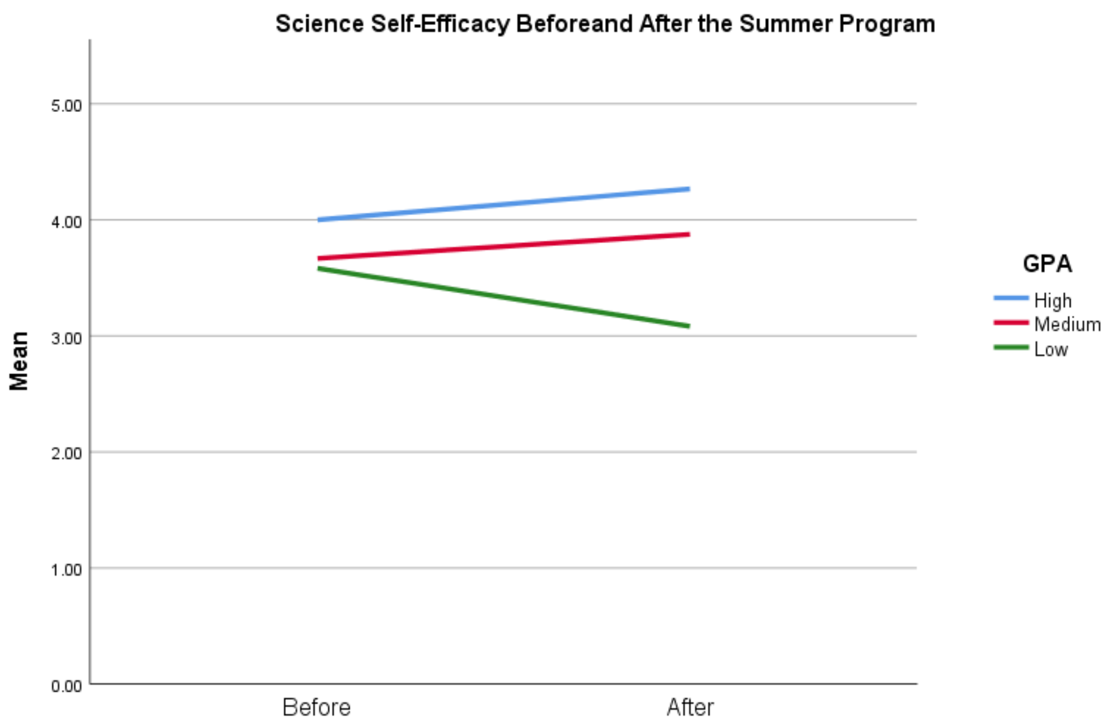

Figure 2.6 Science self-efficacy by GPA.

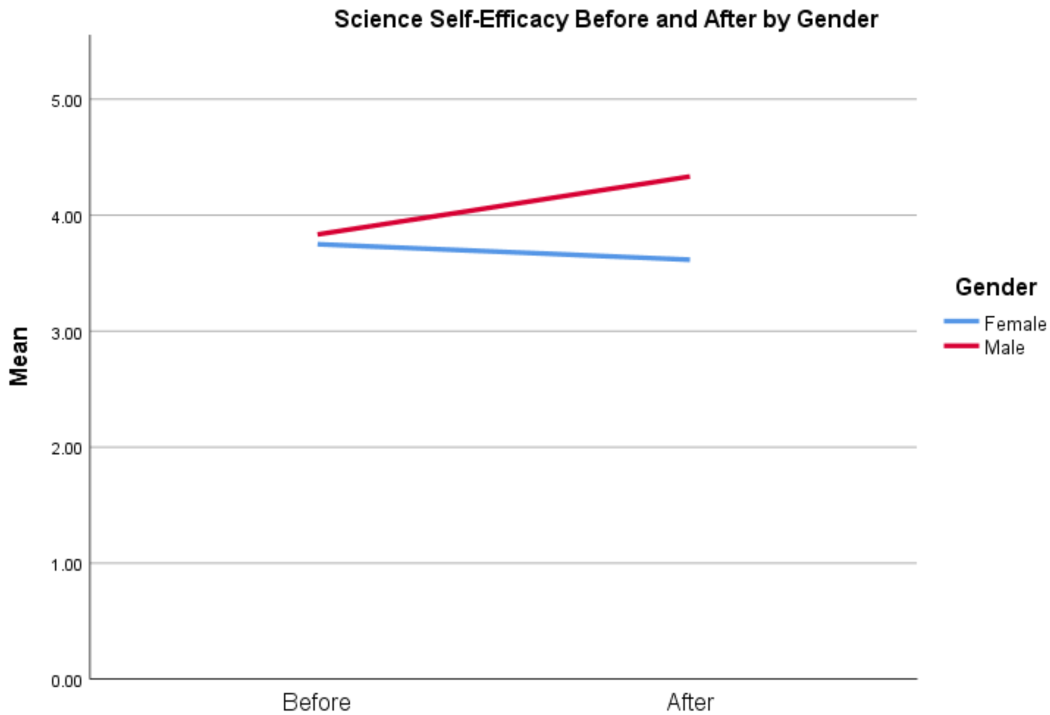

Figure 2.7 Science self-efficacy by gender.

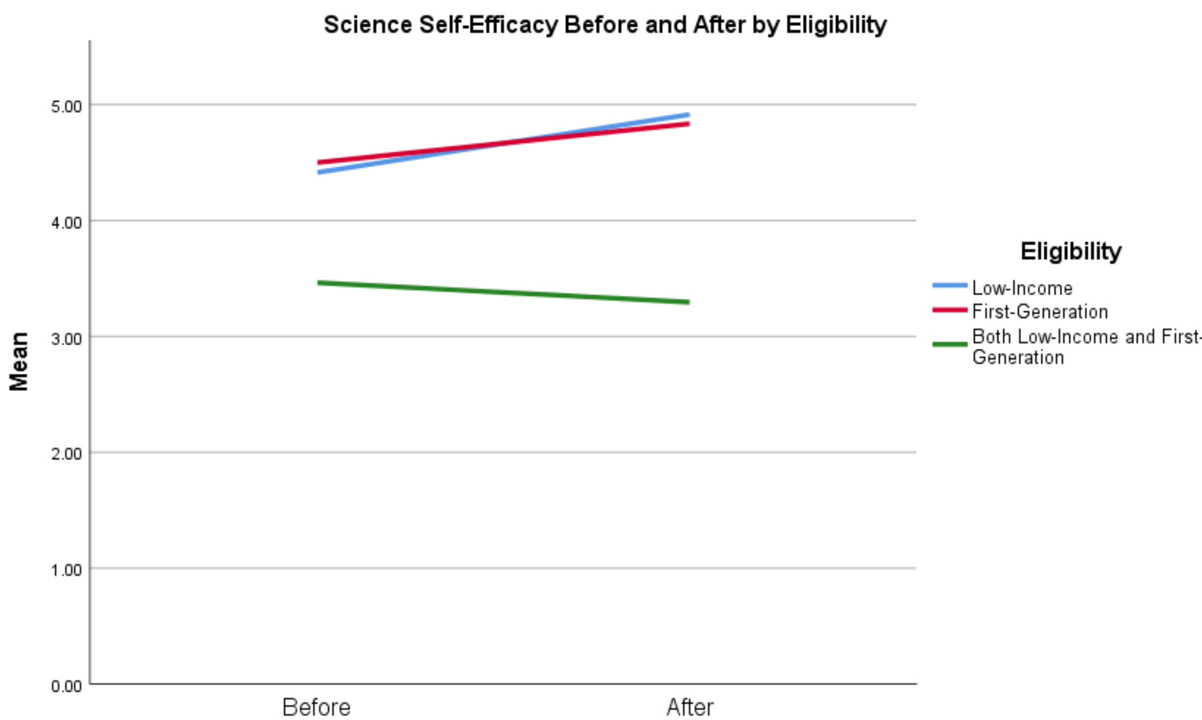

Figure 2.8 Science self-efficacy by eligibility status.

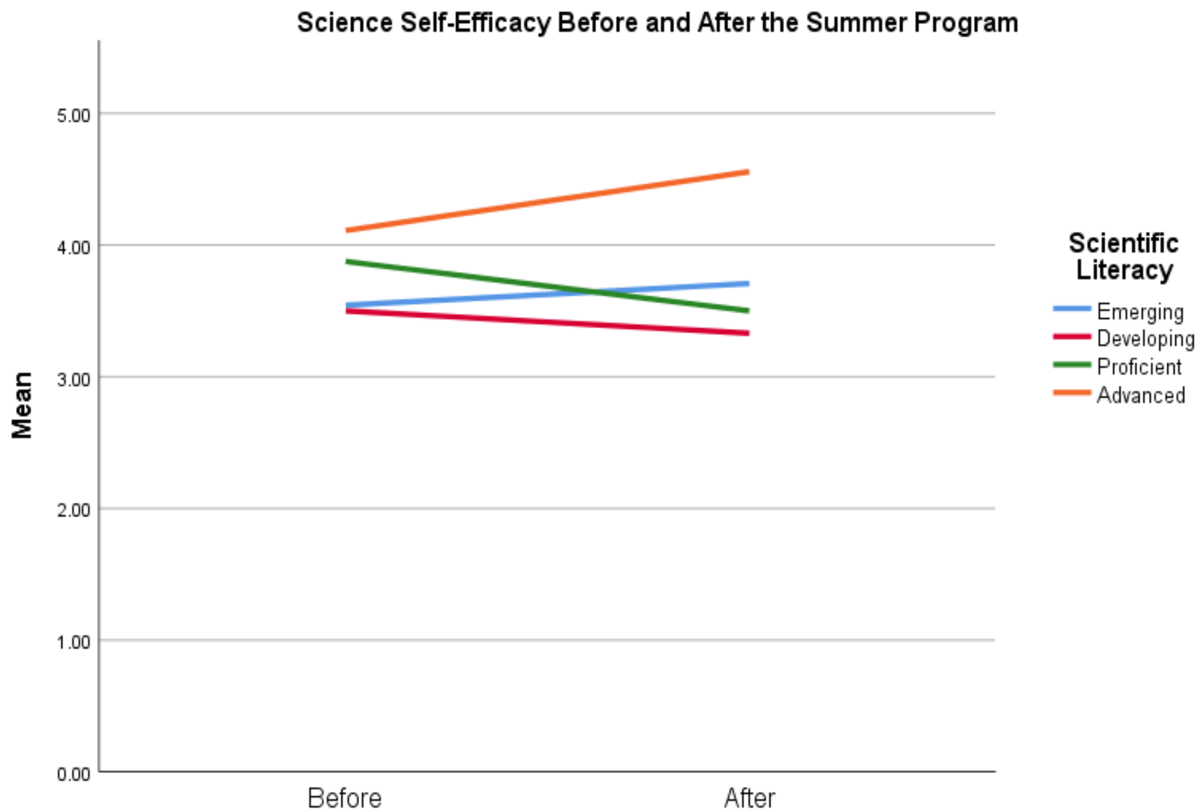

Figure 2.9 Science self-efficacy by scientific literacy.

Identity

Most students increased in science identity from before to after the program. Here again, however, important patterns emerged when demographic variables were considered. Students who were both low-income and first-generation began the program with a lower level of science identity, however they experienced an increase in science identity on par with students who were only low-income or first-generation (Figure 2.10). Despite starting the summer program with relatively similar levels of science identity, students with medium and low GPAs showed differences after the program, with low GPA students drastically declining and medium GPA students maintaining a high level of science identity even six months after the program (Figure 2.11). Science identity also did not increase uniformly across ethnicity: the Asian/White group had only one student and saw a drastic decline (Figure 2.12). Males increased more than females in science identity from before to after the program (Figure 2.13). Lastly, students who scored highest on the scientific literacy scale also had high levels of science identity at the end of the program (Figure 2.14).

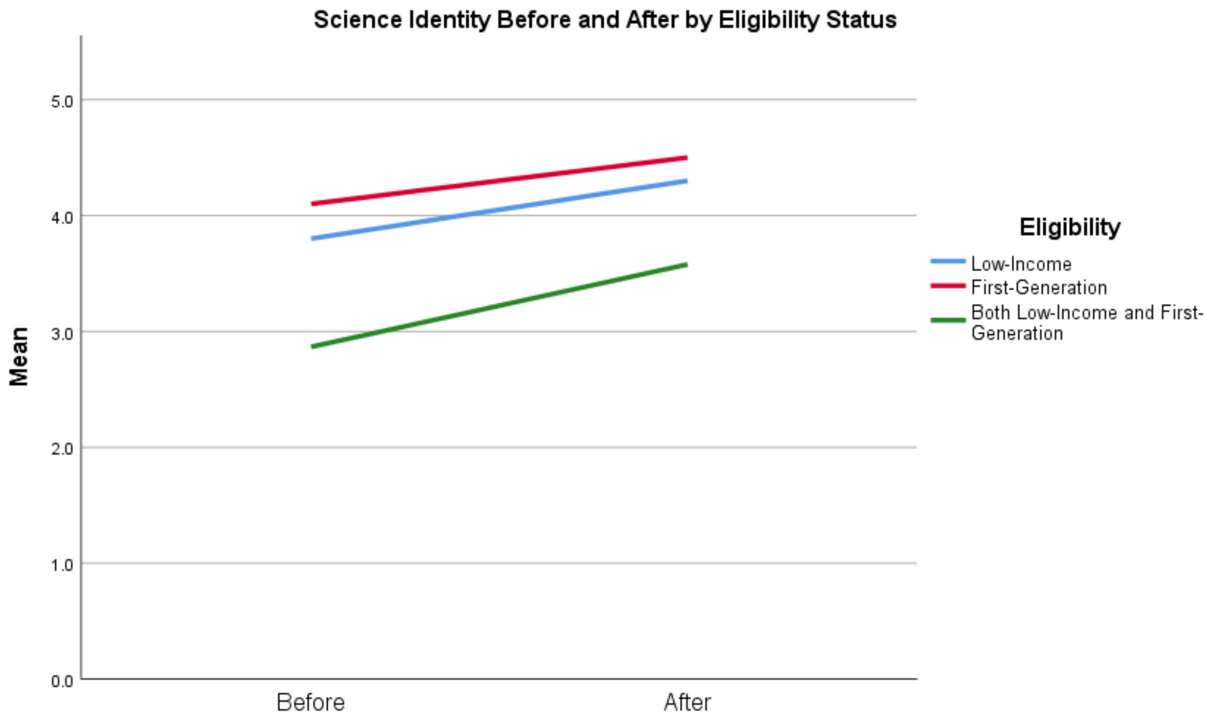

Figure 2.10 Science identity by eligibility status.

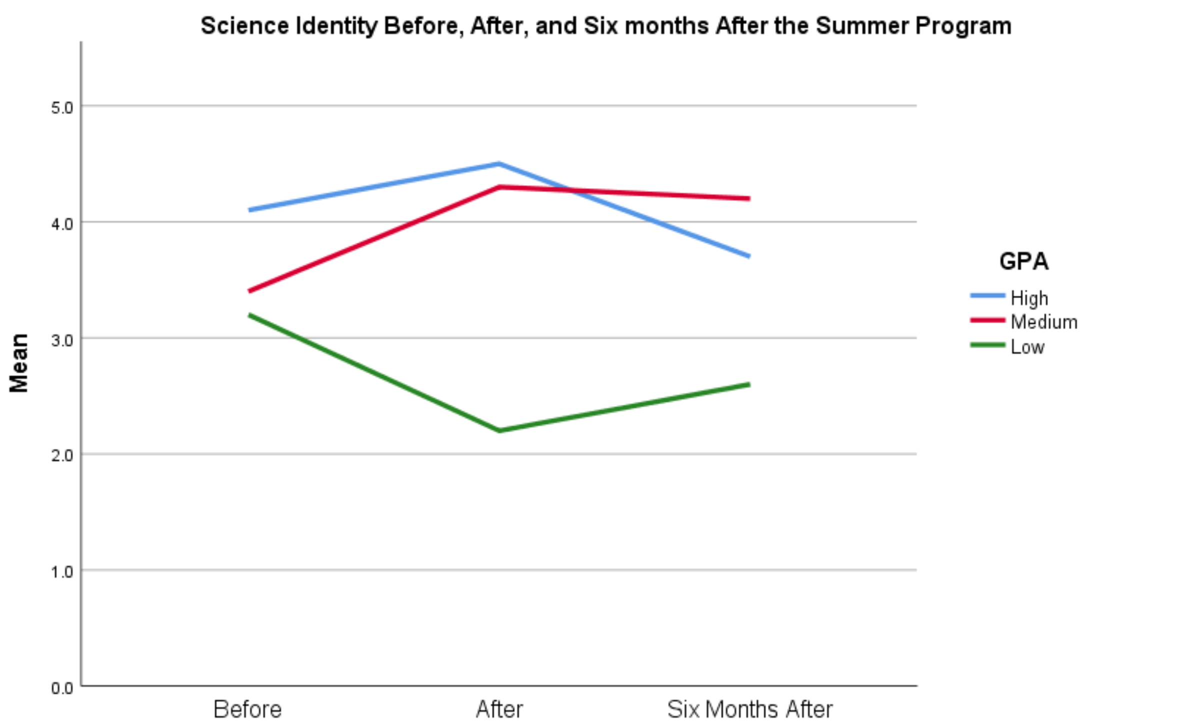

Figure 2.11 Science identity by GPA.

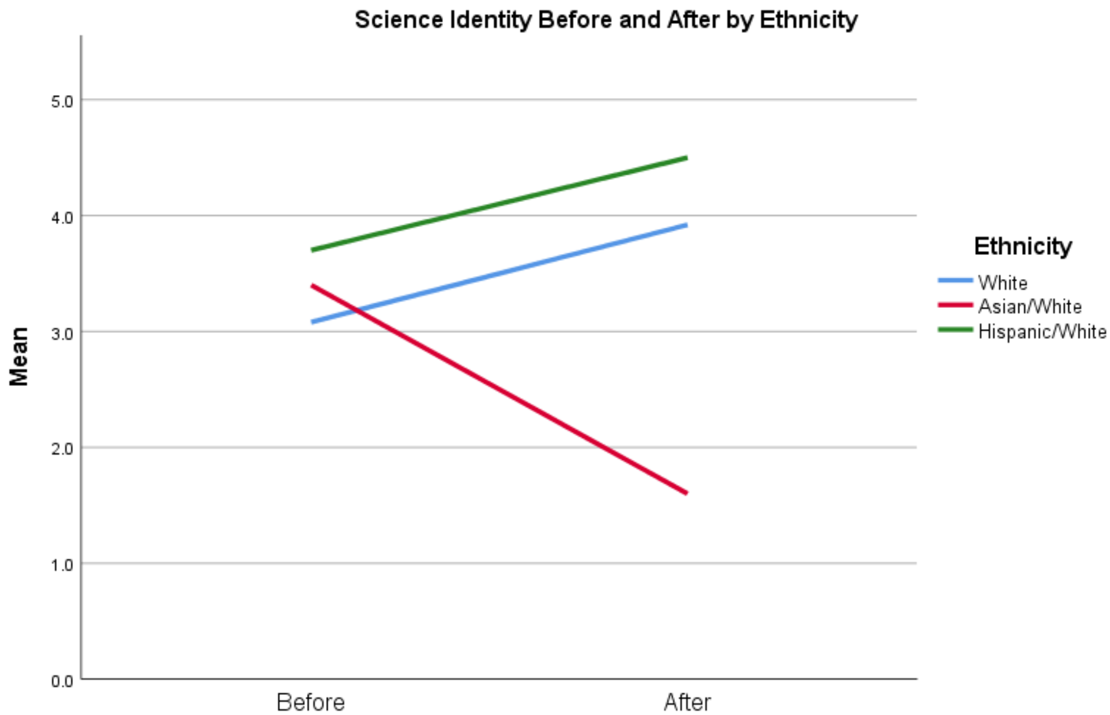

Figure 2.12 Science Identity by ethnicity.

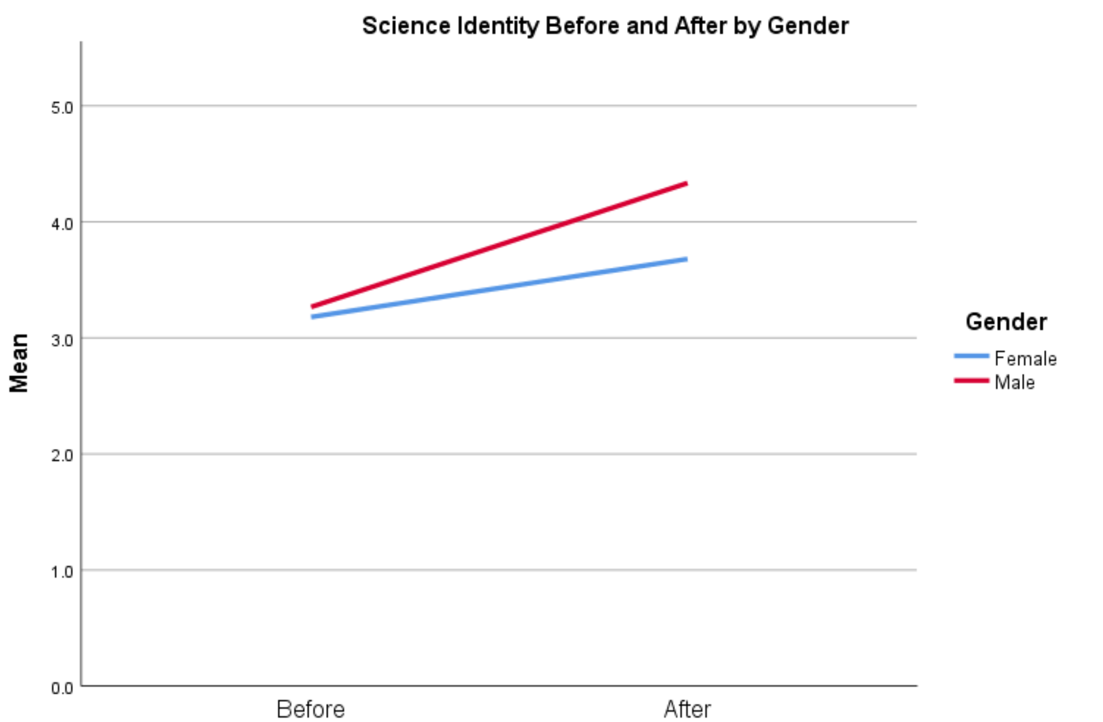

Figure 2.13 Science identity by gender.

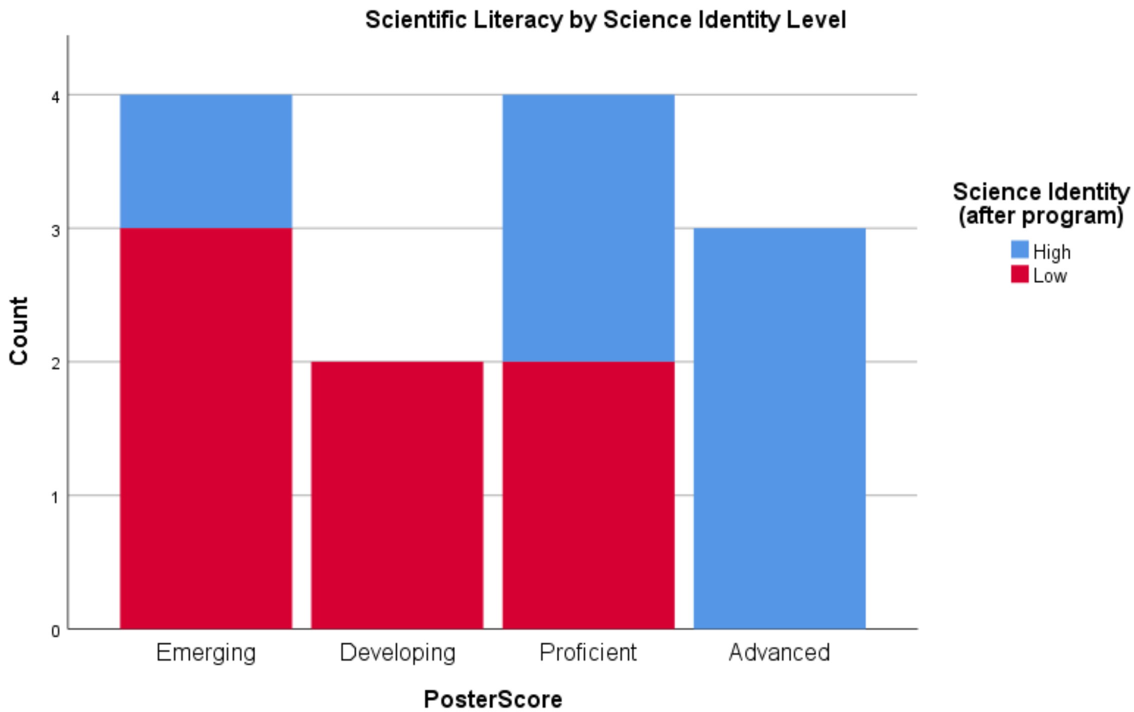

Figure 2.14 Histogram of science literacy levels by science identity level.

Science community values

While change in science community values from before to after the program was statistically insignificant, important patterns again emerged when demographic variables were considered. While students with medium and high GPAs saw no change or only a slight decline from before to after the program, low GPA students saw a more drastic decline (Figure 2.15). Gender was not distinguishing: Males and females both saw a slight decrease (Figure 2.16), however females had higher levels of science community values.

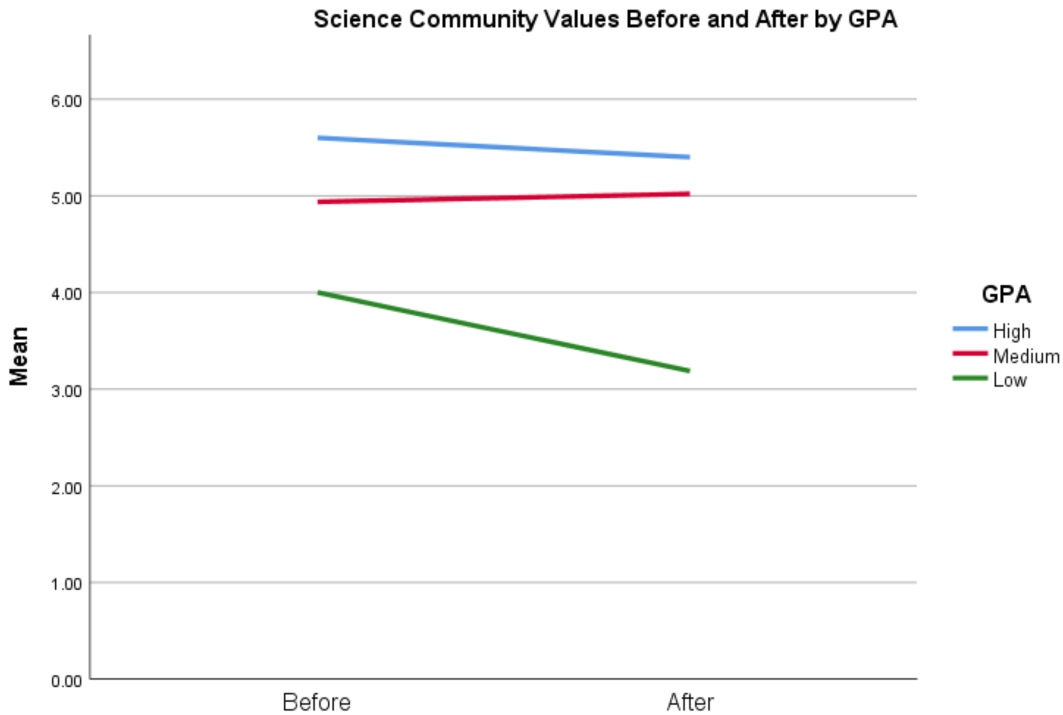

Figure 2.15 Science community values by GPA.

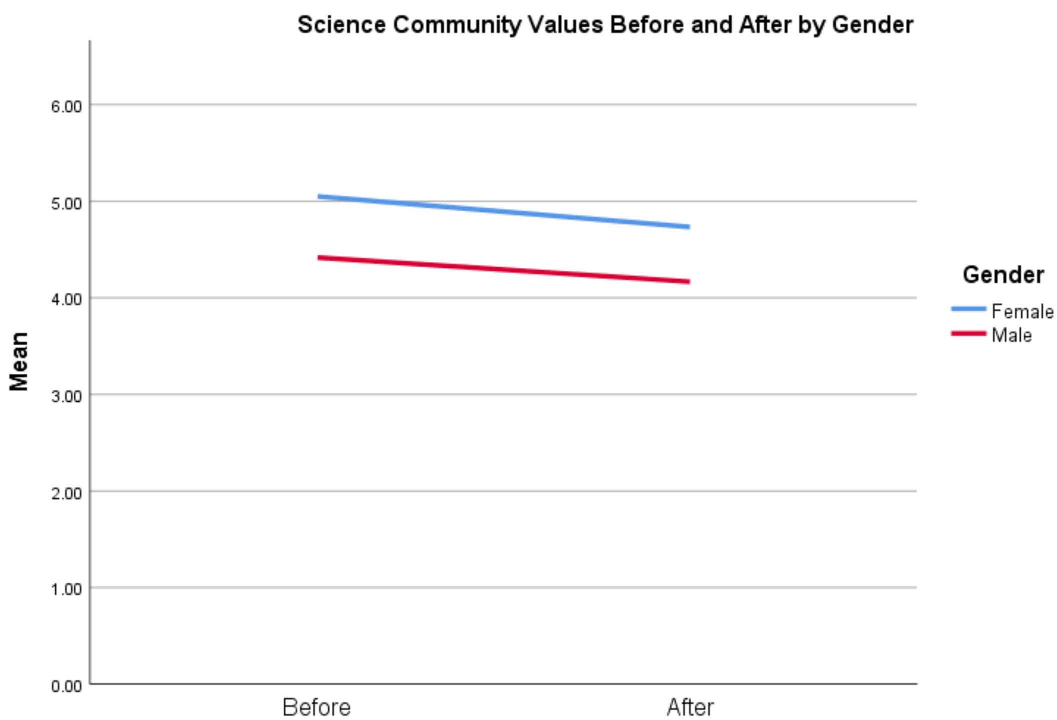

Figure 2.16 Science community values by gender.

Intention

Most students increased in intention to pursue STEM from before to after the program. Here again, however, important patterns emerged when demographic variables were considered. Students who were both low-income and first-generation began the program with a lower level of intention, however they experienced an increase in intention on par with students who were only low-income or first-generation (Figure 2.17). Although males began the program with lower intention to pursue STEM than females, they increased more than females from before to after the program (Figure 2.18). There was also a pattern between intention and identity. Students with lower levels of science identity before the program also had lower intentions at the start of the program, however they saw greater increases from before to after the program (Figure 2.19). Students with lower intention levels at the end of the program saw a dramatic decrease in science identity from before to after the program (Figure 2.20).

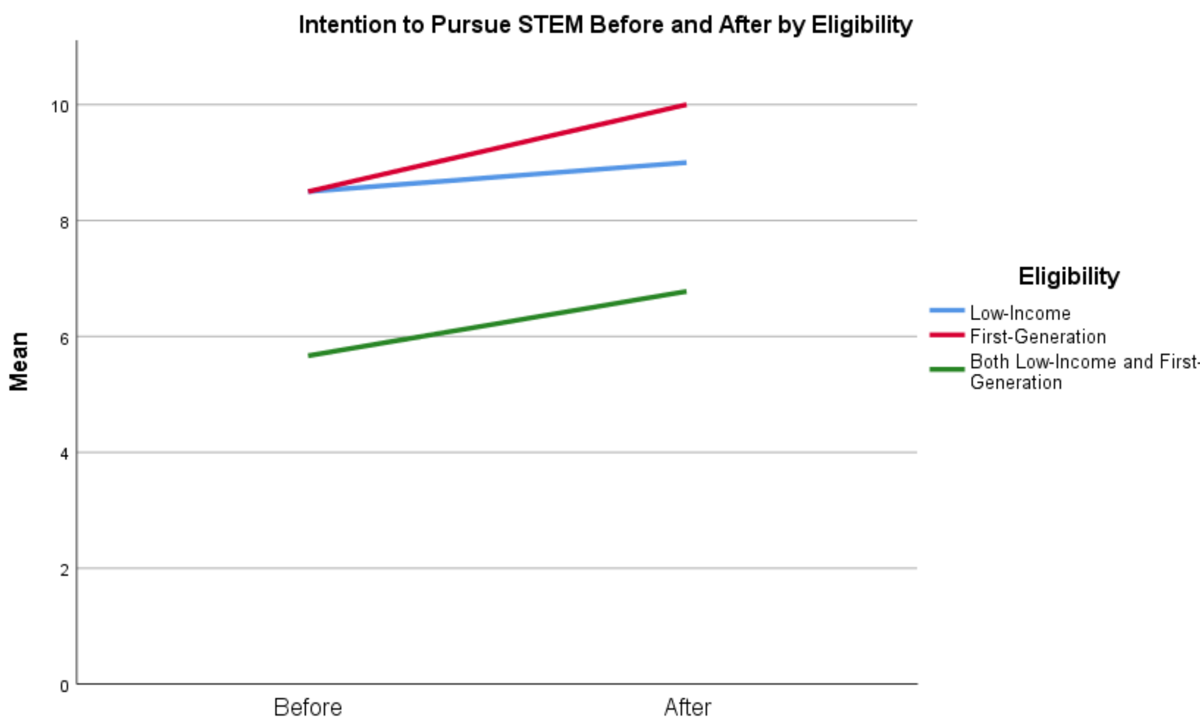

Figure 2.17 Intention to pursue STEM by eligibility.

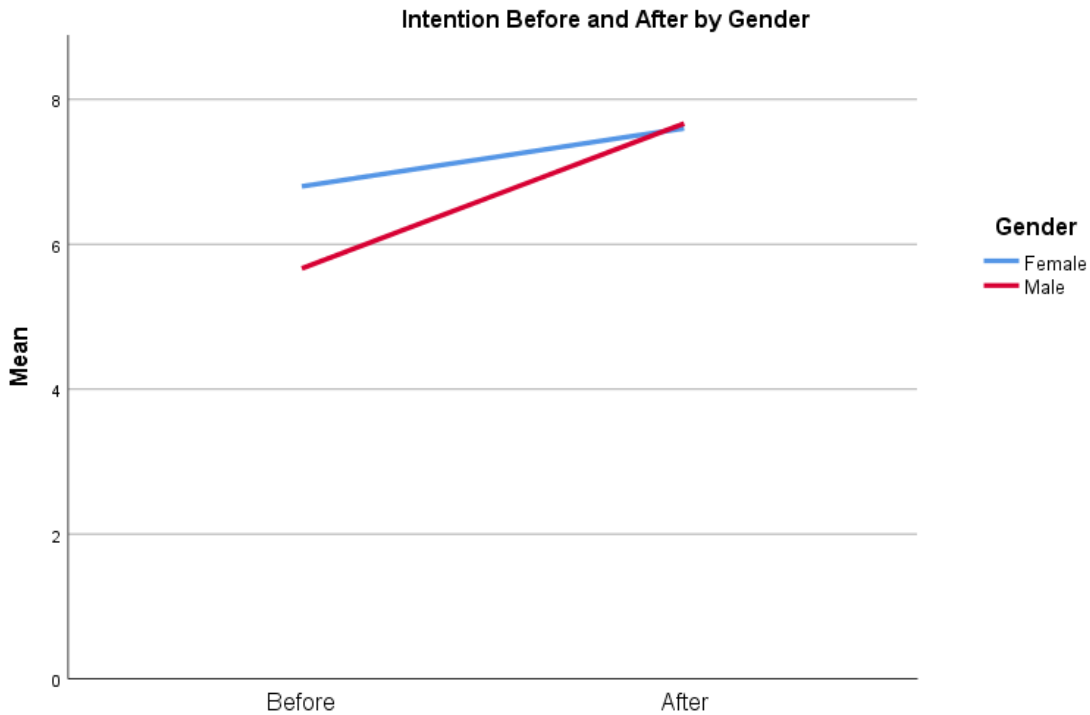

Figure 2.18 Intention to pursue STEM by gender.

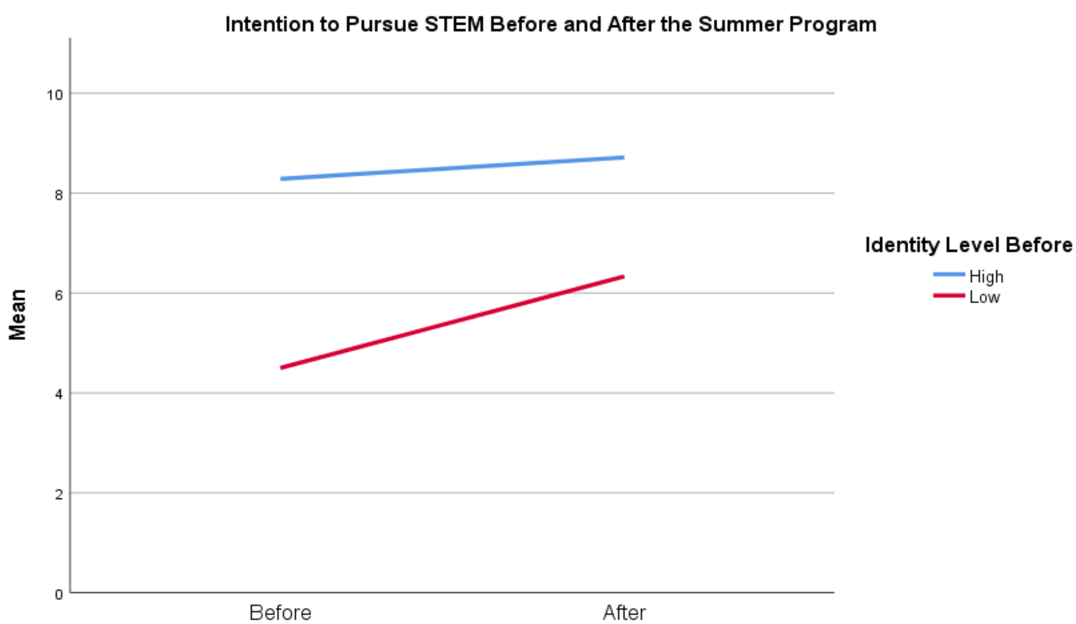

Figure 2.19 Intention to pursue stem by science identity level.

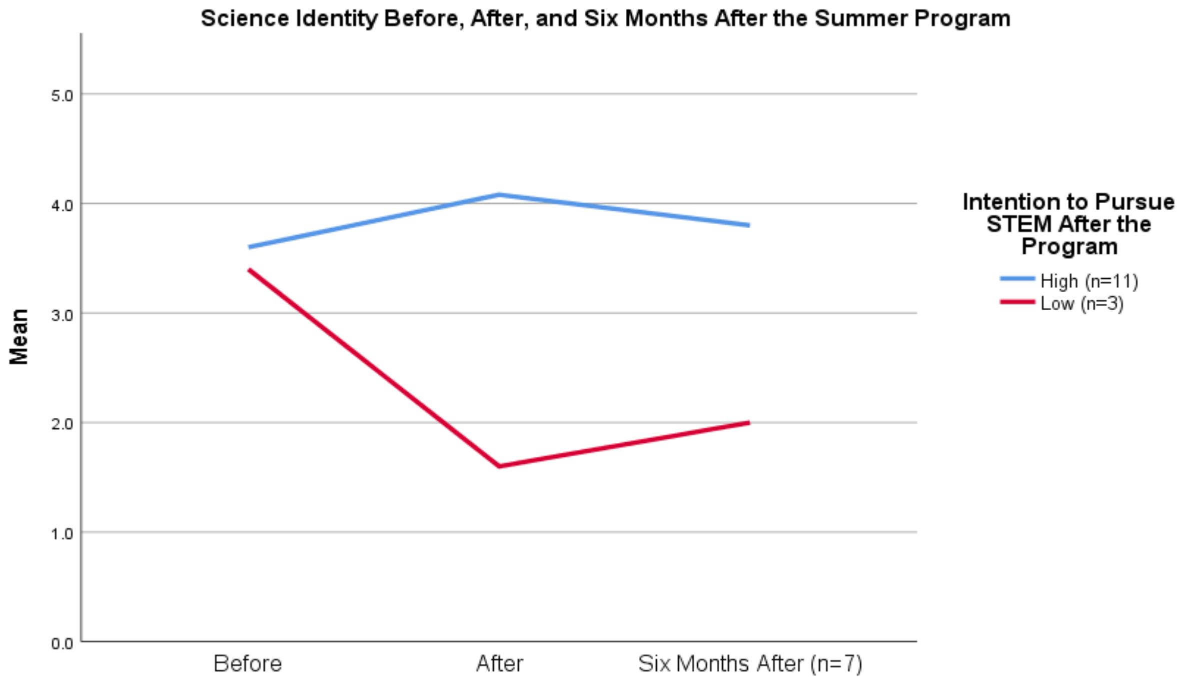

Figure 2.20 Science identity level by intention level.

Scientific literacy

Students with lower scientific literacy scores were also both low-income, first-generation (Figure 2.21). However, low-income, first-generation students were present in every scientific literacy category.

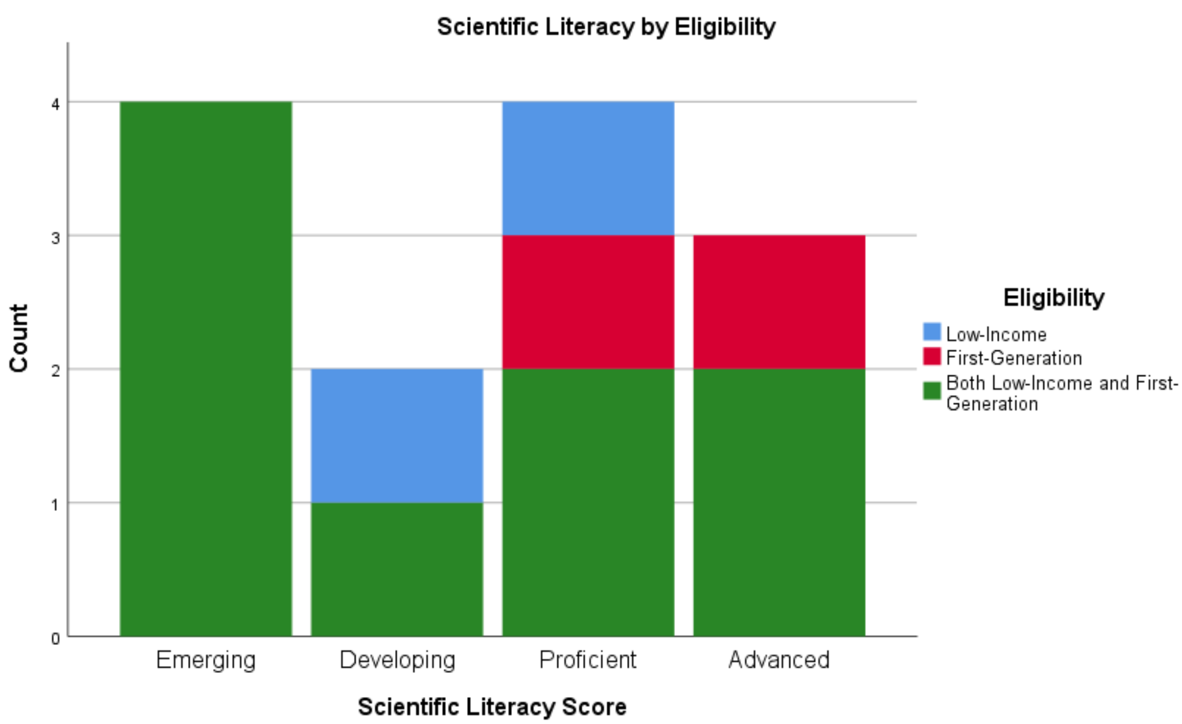

Figure 2.21 Scientific literacy by eligibility status.

Student scientific literacy scores as measured through the posters were highly variable (Figure 2.21). Students investigated research questions of their own design, ranging from “What can we do about the potholes in our community?” to “How can we address the impacts of cyberbullying at our school?” to “What are cost-effective solutions for safe drinking water in developing countries?” They used a research poster template to guide their project development, but it was primarily self-directed with formative feedback provided through small group discussions and mentoring by graduate students. Students were directed in the initial prompt to choose a community-based issue of relevance to them, and each work session focused on a different stage of the project. Students chose issues related to bullying, school and community infrastructure, homelessness, water quality, and access to high-quality education. Students experienced the challenge of narrowing a complex issue through a particular research focus. While not all students investigated a scientific topic, their use of scientific methods was made explicit through comparison to scientific inquiry. There were differences in levels of dedication to the research projects. Some students were invested, while others were easily distracted. More scaffolding may have helped these students stay focused, while more self-directed learners were able to maintain their focus without prompting. Students presented their research twice, once in Idaho and once in Utah. Students demonstrated ownership and pride in their projects, confidently fielding questions and relaying their expertise to the audience.

Qualitative Findings

Performing science in authentic setting key to science identity

The first theme to emerge from initial coding of the data was the relationship of performing science and science identity. When asked when they felt like a science person and when others saw them as a science person, students responded by describing what they were doing, primarily during field-based activities. These were coded “performing” and “being recognized by others.” When students described the science skills they had gained during the summer, they named skills developed from participating in field activities as well as their personal research projects, coded “Self-efficacy.” These three codes all result from field-based science experiences and authentic research experiences, which led to the theme of “Performing science in an authentic setting key to science identity.”

Performing. Students identified as a science person when they were performing science skills or practices in an authentic context. Although there were several classroom-based science activities, no student mentioned these activities in the interviews when describing times they felt like a science person. Instead, their examples came from field-based experiences when they were actively engaging in science practices. When describing what they were doing when they felt like a science person, students mentioned a range of science practices such as making and writing down observations, investigating, sharing ideas, and performing water quality tests. Table 2.5 lists the frequency of instances students felt like a science person, with an illustrative quote, and Figure 2.23 shows the programmatic activities students were engaged in when they felt like a science person.

Table 2.5 Frequency of instances of science identity.

When students felt like a science person	Frequency	Example quote
When testing water quality	6	"I felt like a science person when we were in the field on the river and we got to do different things to test the quality of the river like the oxygen level and the current…"
When snorkeling	2	"We got to do a little [snorkeling] in the pool and look at the life-forms down there, I felt like a scientist then."
When identifying, making and writing observations	2	"We had to try and identify all these plants...that was really scientific especially with writing everything down…"
When going on a field expedition	1	"I felt like a scientist going on a trip…"
When comparing water quality tests	1	"We tested different places and different times… and it felt sciency"
When sharing ideas	1	"I felt like a science person when we did that project… I really liked that because I was able to share my ideas and get feedback from it which is more sciency than I thought"
When investigating and comparing	1	"One of the big [moments when I felt like a science person] was when… I was looking at different fossils and comparing them to other ones."

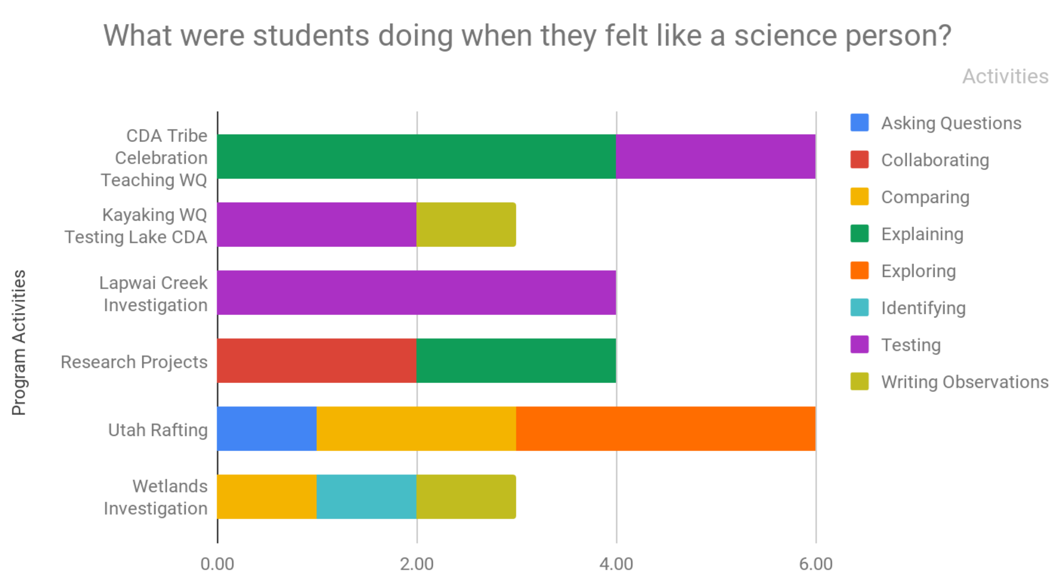

Figure 2.22 Frequency bar chart showing distributions of science practices by program activity.

Water quality testing came up in six of the 10 interviews, unsurprising considering it was a main focus of the summer program. During the first two weeks of the program, students tested water quality three times in three different water bodies, including one time when they were teaching younger students how to perform water quality tests. By learning water quality testing skills and then collecting data in different locations they were able to compare samples and interpret the findings. One student specifically mentioned comparing water quality tests as a time when she felt like a scientist.

A majority of students felt like a science person when they were doing water quality testing, however some students provided examples of other experiences that made them feel like a science person. For example, one student felt more "sciency" when sharing ideas with others while collaborating. This student's experience highlights an authentic aspect of the student research projects, where students were encouraged to collaborate, brainstorm in groups, and provide each other feedback. Modern science depends on collaboration, often interdisciplinary, and providing students this opportunity helped to facilitate science identity in an authentic way.

Two students described snorkeling as a time when they felt like a science person. During this field experience, the scientist shared with the students why and how she collects data on steelhead populations, and then students had the opportunity to do their own snorkel survey. Students were able to step into the everyday life of a scientist through a scaffolded experience (see example quotes in Table 6).

Being recognized by others. Four students mentioned feeling recognized as a science person when they taught younger students (Table 2.6). The teaching experience gave participants a new perspective on their learning: "I had felt like a scientist before but it was in school, so it was like I had to, but this was like I was kind of doing it on my own and I was leading other people on how to do it which I've never done before." The experience of teaching others was new to this student and led her to feel both independent and empowered. Although their water quality testing skills were newly acquired, students had the opportunity to see themselves as competent when put in a position of teaching younger students. Some students felt that even just participating in the program made them feel like a science person because friends or family recognized them as such.

> I talked about it with my friends or my cousins and they'd be like 'oh that's really cool' and they'd know I was doing it for educational purposes, so I felt like they looked at me like I was doing really educational-based things and I was pretty smart in that way.

Students felt smart and sciency just for deciding to participate in the program and recognized each other as such. When asked when he felt recognized as a science person, one student responded, "Didn't everyone view each other as a science person?" These examples point to the importance of teaching others and participating in an out-of-school, science-specific program for students to feel recognized as a science person.

Table 2.6 Frequency of instances of science identity recognition.

When students felt recognized as a science person	Frequency	Example Quote
When teaching or leading others	4	"...And when we were teaching water quality to kids that was really cool because it made you question what you knew because you're teaching these little kids, and they don't know anything so you got to be the teacher. You really need to think like, 'what do I know?' and you realize you know a lot more than you think."
When recognized by friends or family	2	" I talked about it with my friends or my cousins and they'd… know I was doing it for educational purposes so I felt like they would look at me… like I was really smart…"
When collaborating	1	"I think collaborating ... we talked about issues and what they thought as well as me and so we had more data on that and so it just gave everyone a better understanding and felt more sciency and I think they see me as more sciency in that way."
When water quality testing	1	"When we were doing water quality testing and we were out doing the kayaking too, and we were all testing water and stuff."
While participating in the program	1	"Didn't everyone view each other as a science person?"

Self-Efficacy

In terms of new skills acquired during the program, students primarily mentioned water quality testing, research skills, and some general science practices (Table 2.7). When students discussed research skills they described a new ability to narrow a research focus and develop a project around a specific question:

> With our research posters that we were doing that really made us think and narrow down a thesis and question and a hypothesis...so instead of looking at this really broad topic you're looking at this really specific question and just researching that.

One student identified science skills such as being able to make observations as useful because it "helps you know what to ask and think." In that sense, there was some evidence of a feeling of empowerment from developing science skills. Another student felt that participating in the field experiences gave her a better understanding of how to develop a research project: "they made us have a question and then we had to figure it out and so I felt that helped me figure out ways to research on a problem with information that I had and make a project out of it." Similarly, another student felt the research project helped her to develop collaboration skills: "I think I learned how to do a science project kind of as a group. I haven't done that before really so it taught me how to work as a team in science."

Table 2.7 Frequency of skills described by category.

General Science Practices	Frequency	Water Quality Testing	Frequency	Research Skills	Frequency
Making observations Investigating Exploring Comparing	4	Performing tests Snorkeling	6	Narrowing the research focus Organizing Ideas Creating a project from a question	3
Writing Observations Identifying	1	Comparing tests between sites	1	Communicating/sharing ideas with others/Collaborating	3
		Teaching others about WQ testing Leading Others	4	Asking for help	1

Upward Bound environment supports students to "try on" a science identity

Students expressed that the Upward Bound program felt like a safe space to share ideas, collaborate on projects, and not be judged. It also allowed them to broaden their perception of what science is. These data showed how students felt safe during the program to explore science, leading to the theme "Upward Bound Environment Supports Students to "try on" Science Identity."

Belonging. Students felt that the summer program was an environment that supported the free expression of ideas, which they felt was a feature of the culture of science. They expressed that all ideas in science are valid and worthy of exploration. They claimed that they felt no judgement from peers in expressing their ideas during the program, and that the enthusiasm among the group differed from the typical classroom environment:

> It's just really cool to be around a really nice group of people because if you're kind of stuck in a really non-interactive group than you don't get much out of it and so I really like that aspect of year-round people who are actually interested in it and you're not like at school where people are like 'oh I don't want to be here.' They signed up to go and so it's like a learning process.

Choosing to be a part of Upward Bound helped students to feel like it was a different kind of group dynamic which in turn created a different type of learning environment - one that was less judgmental and more open-minded. Students specifically felt that the environment of the program differed from other learning environments:

> I know sometimes people hold back about saying some things cuz they think ‘oh I’ll sound dumb’ or something like that. And so if you're put in an environment where all ideas are treated equally... then it really helps to branch out and share more ideas that you have.

The safe learning environment facilitated student learning by allowing them to stretch themselves in new ways without judgement.

Broadening perceptions of science. One of the goals of Upward Bound is to expose students to a wide variety of experiences and careers that they would otherwise not have access to. For this reason, field days were spent with different scientists and experiencing different aspects of science. This new exposure was impactful for some students: “I think this helped me looked more on the side of science careers that is fun and the good opportunities you have in it.” This student also began to look at science careers in a more positive light as a result. By interacting with scientists who didn’t reflect the stereotypical scientist, students were also able to have a new perception of the scientists themselves:

> It made me have a different outlook on it cuz before I thought I kind of thought science was for the real Geeks or (laughter) I don't know those who are just in the books, but you really have to spend some time just outside and looking at different things.

This student found that people who pursue science may just be regular people who have spent the time pursuing their interests.

Valuing science in everyday life

Students made connections between what they experienced and learned in the course and their everyday lived experience, as well as human impacts on the environment. They were able to make these connections when describing the importance of the science research they encountered during the program. They were also able to identify ways that science integrates into their lives.

Science Values. Students felt that the work of the scientists they met during the program was valuable, for example because “... they make sure that our water is safe, and that our environment is being taken care of thoroughly.” In this example, the students connected science to the local environment and drinking water, which the student valued. Other students felt the work of the scientists they met during the program was especially important because of “all these environmental problems” - making them worthwhile careers. The majority of students (eight) connected the importance of the work of the scientists they met to implications for environmental health. Students also identified ways they had integrated science into their lives. For example, by seeing environmental impacts in a new light, by identifying water issues, or connecting science learned in school to real world examples:

> I remember doing pH in elementary school I think a little bit but I hadn't gone that in-depth with water testing ... And so I think it helped me realize because people usually talk about Flint and water or things that can harm you and so it made me realize ‘Oh there can be really bad things in our water’ and so it's good to test them when you can.

This student was able to contextualize the science she was learning about in the summer program with current events, as well as prior knowledge. In particular, students found environmental science to be relevant to daily life: “...if you don't know anything about environmental science you could be doing damage in just the regular things you do.” This student identified the relevance of environmental science, as well as implications of understanding to prevent negative human impact on the environment.

Career intentions. Half of the students interviewed specified a STEM career they intended to pursue: three students wanted to pursue a career in medicine, one student wanted to be an astronaut and one student wanted to research animals. One student specified a non-STEM career (massage therapy), while the remainder had far less certainty in what they wanted to do for a career.

Barriers to science

Students were asked two questions about barriers to science: “What do you think keeps others from pursuing science?” and “What barriers might keep you from pursuing science?” Students identified barriers such as seeing science as abstract and inaccessible, feeling that there are certain inherent qualities one must possess to be a scientist, or concern that they wouldn’t enjoy the work or lacked the passion to pursue it.

Science as vague and abstract. When asked what keeps people from pursuing science one student said, “I think they get overwhelmed.” Other students echoed the sentiment that science is too abstract and vague to be accessible: “it’s so broad that they don’t know what to look at at first, and usually what they look at first is lab coats, and they think well I don’t want to be in a lab...” Similarly, another student said, “‘scientist’ is so broad that it's kind of hard to choose the kind of scientist you want to be and so I think they get overwhelmed maybe at the name of ‘scientist’.” Students also perceived that stereotypes of science as sterile, difficult, and lab-based seem to get in the way of finding access points into science.

Fixed qualities of a scientist. When asked if they thought they would make a good scientist, there were mixed responses. Some students described their own qualities, and then compared them to the qualities they thought a scientist possesses. The qualities students identified as necessary to be a good scientist were being hard-working, curious, good at working in teams and having a good memory. While some students described qualities they had in common with scientists, other students pointed to differences. When asked if she would make a good scientist, one student responded, “I think in some ways I could because I get really into a certain topic once it's brought up, but being able to remember all of the data that I've collected, I have a hard time memorizing everything so I would be very forgetful.” While she identified that her ability to focus would help her as a scientist, she also felt that she lacked a necessary characteristic, a potential barrier to becoming a successful scientist. Students’ fixed representations of their own characteristics as well as those of scientists suggest that a fixed idea of characteristics of scientists is a potential barrier to pursuing a science career.

Needing to enjoy the day to day work. Students felt that if they did not feel particularly drawn to a certain science subject then it was not the right fit for them. Students universally felt that it is most important to be very interested in the scientific topic of choice. When asked what factors into their own decisions to pursue science, one student said, “It would be something I wouldn't get tired of because I don't want to hate my job. I'd rather have a fun job that I wake up and be like ‘oh yeah I get to be a scientist’, or ‘I get to do this’ and I think that a big aspect of it would be that I enjoy it.” Not enjoying doing the daily work of a particular field came up as a barrier for some students:

> Me personally I wouldn't want to do any of those jobs just because I don't have a super interest in it. I did like the water test people. Their job is to test the water and figure out how to fix it and they’re able to be out on the water every day and have science and fun at the same time. To be able to work and have fun at the same time is my priority I think.

While students could see the value of many of the STEM careers they were exposed to, some students expressed concern that they did not have enough interest or passion to find enough daily enjoyment in the work. One student noted that what stands in the way of pursuing science for her was, “passion probably because I have a passion for massage therapy instead of maybe testing water although it does look fun.” Another student was concerned with “losing interest” in a science career, suggesting that specializing in a particular topic may be viewed as a risky investment. This suggests that some students may feel that an amount of certainty in their interest or passion for a particular subject is necessary to pursue a STEM career due to the high level of investment of work and schooling required. This suggests that some students view interest and passion as fixed rather than something that may build over time or through experience.

Discussion: Converging Quantitative and Qualitative Results

The research questions of the present study were: (1) How did the summer program impact students’ science identity, self-efficacy, science values, and intention to pursue science? and (2) What barriers keep students from developing an orientation toward science? We also wanted to understand whether demographic variables accounted for any differences in how students were impacted by the program. In merging the quantitative and qualitative data, it is possible to see areas of agreement as well as disagreement which suggest a more complex picture than either data set is capable of seeing the entirety of on its own.

Science Identity

Both sets of findings found evidence supporting an increase in science identity during the program. The qualitative data also pointed to the parts of the program that most supported the development of science identity: field experiences where students were actively engaged in science practices such as water quality testing, the opportunity to teach newly acquired skills to younger students, and the intellectually and emotionally safe environment of the program which allowed students to share ideas without fear of judgement. These findings support previous findings emphasizing the importance of practicing science in authentic contexts for developing science identity (Ballard, Dixon, & Harris, 2017; Buxton, 2006), as well as meaningful opportunities to teach others (Olitsky et al., 2018). The importance of the learning environment is also well supported in the literature: The ‘chilly culture’ of undergraduate science classes has long been attributed to student attrition from science majors (Seymour & Hewitt, 1997; Tinto, 1987). An emotionally safe space creates a positive learning environment where students feel safe to make mistakes without being made fun of (Izard, 2016). However, proponents of supplementary science learning experiences have paid less attention to the importance of the culture of the environment, with more focus on the authenticity of the context and opportunity for skill development (Chemers et al., 2010; Chinn & Malhotra, 2002; Estrada et al., 2011, Estrada et al., 2018). While research suggests that underrepresented students succeed in science when the curriculum incorporates aspects of their everyday and cultural experiences (Buxton, 2006; Lee & Luykx, 2006), the findings of this study suggest that the culture of the science learning environment may be as important as the degree of authenticity and warrant further investigation into the role of culture in supplementary science experiences for supporting student success in science.

While 77% of students saw an increase in science identity from before to after the program, there were differences according to demographic variables in the quantitative results. For example, males’ science identity increased more than females, an unsurprising result given the well-documented “gender gap” whereby women reported lower confidence levels in math and science achievement (Blickenstaff, 2005). However, research suggests that women’s self-concepts in STEM are enhanced by exposure to female STEM experts (Stout, Dasgupta, Hunsinger, & McManus, 2011). The program investigated here featured primarily female STEM professionals. One must consider whether the gap between males and females may have been larger if not for the STEM experts being majority female.

Other demographic differences relate to ethnicity. While students identifying as White and Hispanic/White saw increases in science identity from before to after the program, a student from a non-majority ethnic background saw a dramatic decrease in science identity. Robinson et al. (2018) found that students from underrepresented groups were more likely to show a similar pattern of initially lower science identity which decreases throughout college, with women and underrepresented students least likely to be in the highest levels of science identity. However, Kang et al. (2018) found no significant differences among racial/ethnic groups in relation to STEM identities.

Students with medium and high GPAs saw increases in science identity, while those with low GPAs saw a decrease. The apparently polarizing impact of the summer program on students' science identities when considering GPA was unexpected, however subsequent investigation finds some support in the literature. While the data collected in the current study does not provide direct explanations for why students with lower GPAs saw a decrease in science identity, qualitative data suggests that students' whose science identities decreased had fixed mindsets. Qualitative data from interviews with these interviews suggests that they felt they lacked the qualities they thought scientists possessed. Researchers have found that students with fixed mindsets who perceive their present ability to be low may lose motivation when challenged by setbacks and certain types of ability-based goals (Grant & Dweck, 2003). The main implication of this finding is that students entering the program with histories of lower academic achievement need additional support, perhaps through guidance in developing a growth mindset.

Science Self-efficacy

While quantitative data showed some increases and some decreases in science self-efficacy among students, qualitative data pointed only to gains. Every student interviewed felt they had acquired science skills during the program. One possible explanation for this discrepancy could be due to the phenomenon of learning whereby increased knowledge makes one more aware of gaps in knowledge or put another way by American physicist J.A. Wheeler: "As our island of knowledge grows, so does the shore of our ignorance" (cited by Horgan, 1992, p. 20). Another explanation could be that the self-efficacy questions related most to science research skills, while the skills developed in the program were more general science practices. This is one of the challenges of aligning research instruments with the realities of programming and is a limitation of the study.

Interestingly, student poster scores on the scientific literacy scale were only somewhat related to self-efficacy. Unsurprisingly, students who scored highest on the poster (advanced) began the program with the highest levels of self-efficacy, and also increased the most during the program. The next highest scoring group (proficient) had the next highest level of self-efficacy, however this group saw a decrease in self-efficacy during the program. The lowest and fourth highest scoring group (emerging) began the program with the next highest level of self-efficacy and increased slightly during the program. The third highest scoring group (developing) started with self-efficacy slightly below the “emerging” group, however they decreased slightly during the program. Findings suggest that while students with higher scientific literacy perceived increases in their skills during the program, those with lower scores had a more complex experience. The differences in self-efficacy patterns among scientific literacy scores may be due to the increased effect of variability in the small sample size, however it may also point to differences in program experiences among students with differing abilities and knowledge in STEM.

Demographic differences in patterns for self-efficacy were similar to those for science identity when looking at gender, GPA, and program eligibility status. Self-efficacy decreased slightly for females, whereas for males it increased. This supports previous findings that women tend to undervalue their skills and abilities in science compared to males (Blickenstaff, 2005), and suggests that more explicit discussion of women in STEM may be needed. Students with lower GPAs decreased in self-efficacy, and those with medium and high GPAs saw increases. Considering that students with lower levels of science self-efficacy were also more likely to have lower GPAs, this finding suggests that students’ self-perceptions may relate to their engagement in the program and subsequent perceptions of skills gained during the program. The main implication of this finding is that students with lower levels of science self-efficacy are also more likely to have had less academic success, and therefore may need more scaffolding and support to facilitate successful and positive experiences during the program. Similarly, students with both low-income and first-generation status saw decreases in self-efficacy in comparison to those with only one or the other, suggesting that these students need additional supports.

Science Community Values

A striking result of the quantitative data was the decline in science community values for all students except for those who started the program with a high level of science community values. Qualitative findings showed an increase in students’ value of science in relation to their everyday lives, and especially in relation to environmental health. The only question on the science community values scale that saw a slight increase in mean response was related to the value of building the world’s scientific knowledge base. Surprisingly, the question related to the value of science for solving world issues saw a decrease in mean response. This could in part be due to the focus of the program on local issues rather than global issues. Students may have gained an understanding of how science is useful for local environmental issues, but not in the context of contributing to larger global issues. Perhaps students saw the highly specific nature of the scientists' work as being unrelated to larger global issues, suggesting that future programming make connections to the larger scientific community more explicit.

Quantitative data suggests that some students were turned off to science community values as a result of the program, while qualitative data suggests students came to value local science in the context of their community. This finding suggests that the program did less to integrate students into the community of science, and more to facilitate students' integration of science into their own lived experience apart from the science community. Perhaps science values are difficult to acquire in a short-term program which emphasized breadth of STEM careers and experiences over depth of one science experience. The more recent research by Estrada et al. (2018) supports this finding in that longer-term mentored STEM experiences had greater impacts on students' persistence in science. The qualitative findings support the notion that students who are not planning to go into STEM fields may still benefit from STEM programming in that it may help them to find connections between science and their everyday lives. The concept of science for everyday life has been termed *science for citizenship* and is an important outcome of science education to support the public engagement with science, and a society capable of making decisions related to complex social-scientific issues (Davies, 2004; Jenkins, 1999; Kolstø, 2001; and informal science education literature e.g. National Research Council, 2009). This last point brings up an issue that programs like UBMS may be grappling with - whether the program serves to recruit students who have dropped out of the STEM pipeline into STEM careers or at least science citizenship, or to support already interested students in achieving their dreams. The UBMS goal of making STEM careers more accessible for underserved students does not necessarily preclude science for citizenship as a desired program outcome, and it may be an area for future investigation given the findings supporting this outcome presented here.

Intention to Pursue STEM

While quantitative data showed an increase in intention to pursue STEM for 69% of students, there was mixed support for this in the qualitative data. According to qualitative findings, only half of students specified a STEM career they were interested in pursuing (predominantly a pre-existing interest in the medical field), and some students felt they lacked the passion or interest to pursue a particular STEM research career. So, while general intention to pursue STEM may have increased overall, qualitative data did not support an increase in interest in any specific STEM careers encountered during the program. One possible explanation is the fixed theory of interest described below (under Barriers) for preventing students from considering specific careers if they feel they lack enough present interest or passion. Another possible explanation is that students' expectations of the likelihood they would pursue STEM increased due to other factors besides development of interest in pursuing a STEM career. There was, for instance, a high correlation between intention and science identity. Interest, however, also plays an important role in identity development. The four-phase model of interest suggests that interest begins with an external spark and develops through increased valuation, positive affect, and knowledge acquisition before it becomes internalized as part of one's identity (Hidi & Renninger, 2006). This connection between identity and intention was supported in the quantitative findings - students with lower intentions to pursue STEM at the end of the program saw decreases in science identity during the program. More investigation of the role of interest and identity development in relation to intention may clarify the mixed findings of general vs specific intentions to pursue STEM.

Relationships Between Variables

Survey findings suggest that the summer program was most impactful for developing science identity and intention to pursue science careers but did not increase student's science self-efficacy or values related to science significantly. These findings are partially in agreement with Estrada et al. (2011) who found identification to be a stronger indicator of integration into the sciences than self-efficacy for graduate students. The authors postulated that graduate students' long-term intention is more influenced by their identity than their abilities. However, much of the literature points to self-efficacy as an important indicator of whether or not a student will continue in science. Robinson et al. (2019) found that higher perceived competence correlated with higher science identity. Wang (2013) found math self-efficacy beliefs were positively and significantly correlated with intent to pursue STEM. And occupational self-efficacy is the determining factor of career choice (Bandura & Locke, 2003). However, in the present study, self-efficacy was less correlated with intention than identity and values were. These findings could be due to the nature of the program (perhaps not providing sufficient mastery experiences for increases in self-efficacy) or the participants (ceiling effect), and the extent to which a three-week program can impact each of the constructs measured. Patterns in demographic variables were consistent across most variables, suggesting that science identity, self-efficacy, intention, and values are equally affected by demographic-related threats. This supports findings by Aschbacher, Li, and Roth (2010) that student science identity, self-confidence, perceived ability in science and acknowledgement by others are important mediators of whether students continued in science.

Barriers

A fixed mindset

Qualitative data found evidence of fixed mindsets among some students. Students' fixed representations of their own characteristics as well as those of scientists suggest that a fixed mindset is a potential barrier to pursuing a science career. Students in poverty are especially prone to a fixed mindset, or the belief that intelligence cannot be changed (Dweck, 2008). The belief that intelligence is malleable and can be increased through work is a growth mindset (Dweck, 2008). Claro, Paunesku, & Dweck (2016) found that students from lower-income families were twice as likely to hold a fixed mindset. However, they found that low-income students who held a growth mindset were higher achievers, demonstrating that a growth mindset is protective against the barriers to success that poverty presents. Research shows that achievement gaps decrease for female and minority students when a growth mindset framework is used to inform them that they can do as well as others (Dweck, 2008). Strategies for promoting a growth mindset in students includes explicit discussion of brain plasticity, valuing challenge, effort and struggle, and giving process praise and feedback (Dweck, 2008).

A fixed implicit theory of interest

Findings suggest that some students view interest and passion as inborn or fixed rather than something that may build over time or through experience. The notion that fixed and growth mindsets apply to career interests is supported by recent research (Chen, Ellsworth, & Schwarz, 2015; O'Keefe, Dweck, & Walton, 2018). Similar to a fixed or growth mindset in relation to learning, one can have a fixed or growth theory of interest. Those with fixed (also called 'fit' by Chen et al., 2015) theories view interests and passions as somewhat predetermined - e.g. "find your (pre-existing) passion", judge fit of a profession by how enjoyable it is right from the start. Those with a growth (also called by 'develop' by Chen et al., 2015) theory view passion as something that develops over time through mastery of the work. Research by O'Keefe, Dweck, and Walton (2018) found that holding a fixed theory meant dampened interest in areas outside of existing interests, as well as naive assumptions of boundless motivation once a passion has been found. Importantly, their research found that those with a fixed theory were more likely to lose interest when difficulties in engaging in the new interest arose. The authors caution that "urging people to find their passion may lead them to put all their eggs in one basket but then to drop that basket when it becomes difficult to carry" (O'Keefe, Dweck, & Walton, 2018, p. 1653).

Given the evidence of fixed theory among student participants described above, it is highly probable that students holding fixed theories may have been inhibited from developing an interest in the STEM careers they were exposed to during the program. It may also help to explain why some students felt that passion and interest was a prerequisite of STEM careers, and thus a barrier in some cases. Notably absent from students' discussion of science as a career choice was their perceived ability to successfully attain and perform a science career, although some students mentioned the fixed qualities described previously such as memory as something which may keep them from pursuing science careers.

Students' implicit theories of interest may impact their ability to not only develop an interest in STEM careers during the program, but also to developing a STEM identity, science community values, and self-efficacy given the interconnections of these variables. Considering the importance students placed on finding a career based on their interests, passions, and whether or not the work would be enjoyable, these findings suggest further investigation into the implicit theories of interest held by low-income and first-generation status students, and the extent to which implicit theories of interest may be inhibiting the pursuit of STEM careers for these students. The main implication here is that in order to guide students into STEM careers, programs must provide explicit guidance in how interests can be developed, and through persistence and investment, eventually lead to a STEM career.

Demographic factors

Findings suggest that women, minority ethnicities, students who are both low-income and first-generation, and lower academic achievers may face additional barriers in developing an orientation toward science than their peers. The detectable effect of demographic variables on science identity and self-efficacy lend support to previous research that finds that external social forces can influence the extent to which a student feels like a science person (Carlone, Scott, & Lowder, 2014). In addition, these groups had lower levels of self-efficacy, which has important implications for success in STEM. Students who have higher self-efficacy are more likely to persist in the face of difficulty (Zimmerman, 2000; Usher and Pajares, 2008), and research has shown that for college students, perceived competence in STEM predicts achievement in a STEM course and lessened intention to leave their STEM major, especially for underrepresented students (Hilts, Part & Bernacki, 2018).

There is also evidence that the demographic factors identified here may have compounding effects on orientation toward science. For example, students who are both low-income and first-generation were more likely to be lower academic achievers. Factors affecting potential first-generation college students like little active parental involvement may be amplified by the negative impacts of poverty (Gibbons & Shoffner, 2004). Parental educational involvement is strongly related to student educational success (Benner, Boyle, & Sadler, 2016). Not receiving additional support can be a barrier for students, especially those without parental encouragement and support. Related to this, there may be demographic variables which were not investigated here which could also play a role. In particular, findings of Mihelich et al. (2015) that more politically and religiously conservative Idahoans are less supportive of STEM education measures, which may also affect their students' engagement with STEM.

Another barrier, stereotype threat, or the disruptive anxiety that one's performance will confirm negative stereotypes, hinders performance as well as career aspirations for underrepresented groups in science (Shapiro & Williams, 2012). Stereotype threat is largely driven by environmental cues, including the academic environment which can encompass parent and teacher behavior as well as being a numerical minority (Shapiro & Williams, 2012). Stereotype threat can impact underrepresented students in a number of ways, including disengagement from a particular domain and its relation to their self-concept (Beasely & Fischer, 2012). This prompts consideration of the representation among STEM experts in the program for each of the student groups identified here. For example, research suggests that interventions such as self-affirmation activities, and direct and indirect interaction with role models may reduce perceptions of identity threat in Latino students (Hernandez, Rana, Rao, & Usselman, 2017; Schinske, Perkins, Snyder, & Wyer, 2016). Stereotype threat should be considered as a possible barrier for each of the groups mentioned here, and programming should be designed to address specific barriers for each group. For example, although STEM experts for this program were majority female, they were also majority White - which may have contributed to stereotype threat for non-White students.

Conclusion and Implications

The purpose of this research was to improve our understanding of the impacts of authentic science experiences for low-income and potential first-generation college students. Specifically, by examining science identity, self-efficacy, values, and demographic variables, I sought to better understand how authentic science experiences may influence the psychosocial variables which have been demonstrated to facilitate persistence in STEM (Ballen et al., 2017; Chemers et al., 2010; Chemers et al., 2011; Eccles & Barber, 1999; Estrada et al., 2011; Hernandez et al., 2013; Hurtado et al., 2009). Relationships among these factors as well as demographic variables were examined to better understand how to support low-income and first-generation students. This research fills a gap in our understanding of how demographic variables impact authentic science learning experiences and will aid in the development of evaluation tools and adaptation of theoretical models appropriate for the Upward Bound STEM Access program. In addition, this research contributes to a greater body of literature which seeks to understand the types of educational experiences that can prepare students of all backgrounds to succeed in science (Aschbacher, Li, & Roth, 2010; Lewis, Menzies, Nájera & Page, 2009). Findings of this study will be useful for the design, development, implementation and evaluation of authentic science experiences.

Findings from this study support the notion that supplementary science experiences students can facilitate the development of science identity. Specific program elements which most contributed to students' science identity development included a supportive environment, and opportunities to engage in science practices and to teach others. Findings suggest that the learning environment is important for students to feel safe in 'trying on' a science identity. When students feel like they are not being judged and they can express themselves freely, it helps them to feel accepted and like a contributing member of a science community. Such an environment creates space for students to practice participating in a science community, but without the pressure and identity threats that can otherwise present themselves in traditional, 'chilly' science learning environments. Supplemental science experiences therefore play a critical role for students of nondominant backgrounds who may feel culturally isolated in traditional science classroom environments.

This research also suggests that science identity, performance, values, recognition, and self-efficacy are interwoven, supporting the investigation of those variables in tandem. For example, in this research students only discussed their science identity in terms of performance and recognition. Activities that attend to multiple variables are therefore especially impactful, as in the teaching experience that students had which allowed them to feel recognized and identify as someone capable of teaching science to others. Not only were students actively applying new skills in a different context, but by teaching younger students they were able to see themselves as leaders and science people. This type of experience has a cascading impact and should be prioritized when possible, especially for those students who may have lower self-concepts in relation to science.

There were patterns in the findings among demographic variables which have implications for program design. There was some evidence pointing to fixed mindsets among students, which was linked to fixed perceptions of scientists and identified as a barrier to science for some students. Therefore, supplementary science interventions serving low-income, first-generation students should consider explicit guidance in developing growth mindsets, especially in regard to STEM career trajectories. In addition, programs may want to consider scaffolding authentic science experiences, recognizing that GPA, eligibility status, and initial levels of science identities and skills can affect student preparedness and propensity to develop science identity and self-efficacy during the program. Future research might investigate the impacts of scaffolded approaches to authentic science experiences. Future investigations may also want to consider duration of participation as a variable, as some studies have found that the longer students participate in Upward Bound, the more improved their education outcomes (Myers, Olsen, Seftor, Young, & Tuttle, 2004).

Overall, agreements in the data point to positive effects of the program on science identity and intention to pursue STEM careers for most students. Discrepancies in the quantitative and qualitative data point to the importance of mixed methods for understanding complex human experience. Differences among demographic variables suggest important external mediators to engagement with science such as race/ethnicity, eligibility status, gender, and academic performance. This study suggests that not all students experience authentic science programming in the same way and prompts further investigation into how and why students of different backgrounds may succeed in science.

Caveats and Limitations

The current study focuses on one Upward Bound Math Science summer program at the University of Idaho. This study focuses on the experience of a small group of low-income, first-generation students in regard to the phenomena of interest - integration into the sciences facilitated by an intervention. Findings provide insight into the effectiveness of the program for some students, but the non-experimental study design limits our ability to attribute causality between program elements and impacts. Through qualitative findings, however, a plausible explanation of program impacts is presented. This narrative of student experience adds depth and description to our understanding of the phenomena, but broader generalizations from the data are not possible due to the nature of the data such as the small sample size, and lack of control group or randomization.

The self-selecting sample is a limitation because students with already high levels of science identity, academic success in science, etc., would introduce a 'ceiling effect.' The small sample size also introduces randomness, which may lead one to assume a cause and effect relationship when none exists. Comparison groups and larger sample sizes would help to distinguish program impacts from noise in the data. In addition, interpretation of the qualitative data is subjective. Although peer-debriefing was used to enhance validity of the findings, I was undoubtedly influenced by my prior experiences, biases, and worldview. Students likely filtered their responses during interviews to be more socially acceptable simply due to human nature and power dynamics, despite efforts to encourage their honest responses. Lastly, there may be a gap in alignment between what the instruments and interview questions asked about and the actual experience of the program for participants. Identity work related to developing a relationship with science may not be a one-way, linear process which can be detected in the limited timeframe of this study. Understanding whether any changes are long lasting requires long-term follow-up outside of the scope of this research.

Therefore, this study provides just a glimpse into the experience of student participants in the program.

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Chapter 3: A Case Study Evaluation of an Upward Bound Summer Program

Introduction

Presented here is a summative evaluation of the Summer 2018 watershed science summer course for STEM Access Upward Bound at the University of Idaho. The case study evaluation approach included mixed methods to understand program effectiveness and implications for practice. I served as an internal evaluator as well as program designer and instructor of the course. This evaluation focuses on the Upward Bound Math Science program at the University of Idaho and specifically how findings presented here can inform programmatic learning and practice.

Evaluation is essential for understanding what is and is not effective and serves as an important decision-making tool for making programs better. Evaluation is a systematic process that can be used for different purposes, for example to improve a program based on participant feedback, or to identify staff training needs. When quality is important, and resources are scarce, evaluations can help determine the most effective ways to accomplish intended goals. Evaluation also helps us to answer questions of whether or not people's lives are being improved. For STEM Access, evaluation questions can help to understand program effectiveness, and identify areas for program improvement

Evaluation reports are written for an intended audience. In this case, the primary audience is the STEM Access Upward Bound program at the University of Idaho. This report was written to be most useful for the staff members of the program who may use the results for making decisions about programming. Secondary audiences may include stakeholders of STEM Access Upward Bound. Tertiary audiences may include those not directly connected to the program, but for whom the report may be relevant. For example, other Upward Bound Math Science programs may be interested in hearing about the summer program and the results of the evaluation. The field of informal science learning (e.g. Center for Advancing Informal Science Education) may also be interested in the evaluation in relation to informal science learning.

This report strives to meet the standards of quality program evaluations, including utility, feasibility, propriety, accuracy, and evaluation accountability (Yarbrough, Shulha, Hopson, & Caruthers, 2011) as well as the Guiding Principles for Evaluators (AEA, 2004). The case-study evaluation model was used to guide the evaluation, as well as the Framework for Summative Evaluation in Informal Science Education (Fu, Peterson, Kannan, Shavelson, & Kurpius, 2015). Essential elements of the evaluation process included stakeholder involvement, developing a program theory, and a focus on the practical application of the evaluation. IRB approval was obtained and is included in Appendix 2.1. Because I had a dual role as program staff and evaluator, I describe how my roles existed and how it was handled in terms of potential bias or conflict of interest. One of the core competencies of evaluators identified by the American Evaluation Association (2018) is building evaluative capacity of the host program. To this end, materials developed to aid the STEM Access program in future evaluations are included in the appendix and touched on briefly in the report.

STEM Access Watershed Science Summer Program Evaluation Final Report

The purpose of this report is to provide an evaluative summary of the 2018 STEM Access summer program by reporting on program effectiveness for enhancing student orientation toward science and discussing possible implications for future STEM Access Upward Bound program improvement. Funding for this evaluation was provided by the STEM Access Upward Bound program at the University of Idaho, and the Interdisciplinary Graduate Education Research Traineeship (IGERT) program in Water Resources at the University of Idaho. This study was approved by the Internal Review Board of the University of Idaho and certified as exempt under category 1 at 45 CFR 46.101(b)(1) (IRB #18-802).

Executive Summary

Economically disadvantaged students in Idaho are almost 20% less likely to complete high school than their better-resourced peers (ISDE, 2018). Nationally, economically-disadvantaged students who graduate high school are 15% less likely to receive a bachelor's degree (McFarland et al., 2018). This disparity in educational access has led to underrepresentation in math and science college majors and careers for disadvantaged students and comes at a cost to those individuals whose educational attainment is unrealized as well as society (Mau, 2016). Upward Bound Math Science (UBMS) is a federal program working to address the gaps in math and science for disadvantaged populations. The goal of Upward Bound Math Science is to improve education outcomes for participants by providing coaching and academic enrichment experiences that make math and science college degrees and careers more accessible. Evidence suggests the program is effective at increasing the likelihood that participants will pursue and complete a four-year degree in math or science (Olsen, et al., 2007).

This exploratory case study evaluation examines the impacts of a place-based, authentic science summer program for Upward Bound participants. The three-week summer program involved youth in a variety of activities designed to develop their science skills, science identity, and feeling of inclusion in the science community. Demographic baseline data was collected, as well as outcome data (indicators) collected through surveys and interviews. By focusing on an individual summer program, this descriptive evaluation provides in-depth description of participant experience through mixed methods. Findings are suitable for insight into programmatic learning, but do not attribute causality and are therefore generalizable.

This evaluation report provides an evaluative summary of the 2018 STEM Access summer program in two parts: (1) a report on program effectiveness for enhancing student orientation toward science examining the impact of the summer program on orientation toward science as measured by science identity, science self-efficacy, science community values, and intention to pursue a STEM degree/career; and (2) a discussion of possible implications for future STEM Access Upward Bound program improvement. Outcomes suggest that participation in the summer program (1) increased science identity, (2) affected science self-efficacy and community values differently for different students, and (3) increased participant intention of pursuing a STEM degree/career.

Evaluation Highlights

The extent to which the summer program facilitated accessibility of STEM degrees/careers:

- Science identity increased during the program for most students.
    - 77% of students saw an increase in science identity from before to after the program.

  - Students felt like a science person when actively engaged in science practices in authentic settings.
- Although students described skills they developed during the program, science self-efficacy did not increase for most students.
  - 38% of students showed an increase in science self-efficacy, 31% showed no change, and 31% showed a decrease.
  - Students could name water quality testing, general science, and research skills they developed during the program.
- Although students contextualized science in their everyday lives, science community values did not increase for most students.
  - 31% of students showed an increase in their internalized values of science, 31% showed no change, and 38% showed a decrease.
  - Students described the value of science in relation to their everyday lives, and especially in relation to environmental health.
- Intention to pursue STEM increased during the program for most students, but most students did not develop specific interest in STEM careers during the program.
  - Intention to pursue STEM increased for 69% of students.
  - Only half of students interviewed identified a specific STEM career of interest.

The most important reasons for the program's successes:

- Field experiences provided meaningful opportunities for students to actively engage in science practices in authentic settings.
- The opportunity to lead through service learning helped students to feel recognized as a science person and to reflect on their learning.
- The social norms of the summer program created a safe environment that valued students' ideas, thoughts, and opinions and bridged the culture of science.

The most unresolved issues for SAUB summer program success:

- Barriers to STEM such as a fixed mindset and fixed theory of interest are present among students.
- Integration into science was variable across demographics. Women, minority ethnicities, students who are both low-income and first-generation, and lower academic achievers may face additional barriers in developing an orientation toward science than their peers.

Introduction

Overview of Project and its Goals

Presented here is a summative evaluation of a watershed science summer course for STEM Access Upward Bound (SAUB) at the University of Idaho which took place during the summer of 2018. The three-week summer program involved youth in a variety of activities designed to develop their science skills, science identity, and feeling of inclusion in the science community. The goal of the program was to engage Upward Bound student participants in authentic science experiences to make STEM degrees and careers more accessible for them. A more detailed description of the program can be found in the appendix.

Key Stakeholders and Target Audience

Key stakeholders of this evaluation are SAUB staff and high school student participants of the program. This report was written to be most useful for the staff members of the program who may use the results presented here for making decisions about programming. Secondary audiences may include stakeholders of STEM Access Upward Bound interested in hearing about the results of the evaluation. Tertiary audiences may include those not directly connected to the program, but for whom the report may be relevant. For example, other Upward Bound Math Science programs may be interested in hearing about the summer program and the results of the evaluation. The field of informal science learning (e.g. CAISE) may also be interested in the evaluation in relation to informal science learning.

Program Logic

Authentic science experiences through Upward Bound summer programming provide disadvantaged students the opportunity to engage in science in a relevant and meaningful way, increasing their confidence in their science skills and ability to see themselves as a science person. The logic of the program draws on the Tripartite Integration Model of Social Influence (TIMSI) developed by Estrada et al. (2011) to understand how a program engaging students in authentic science learning experiences can support their integration into the science by developing students' science identity (seeing oneself as a science person); science self-efficacy (feeling confident in science abilities), and science community values (believing in principles of science). Figure 3.1 shows the program theory of change including elements of the TIMSI model in the context of the SAUB program. The accessibility of STEM degrees/careers for student participants was investigated through students' integration into science, using mediator variables of science identity, science self-efficacy, science community values, and intention to pursue science as identified in the literature on persistence in science for underrepresented populations. Table 3.1 shows program activities aligned with anticipated outcomes.

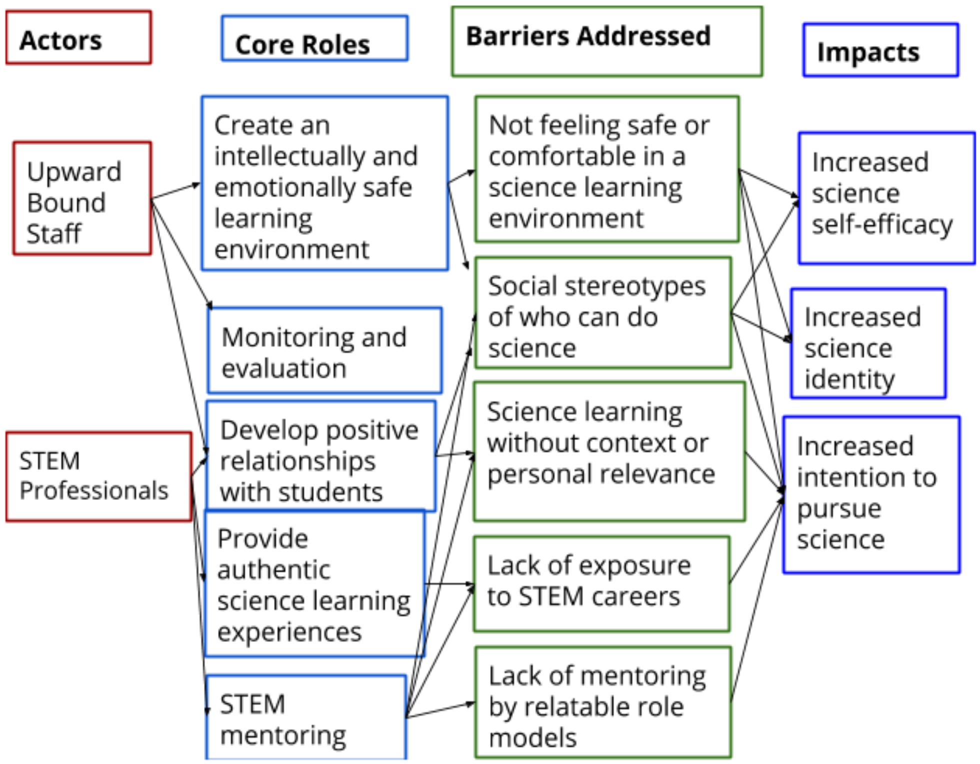

Figure 3.1 The theory of change of the summer program.

Table 3.1 Program activities supporting integration into STEM in summer program aligned with outcome indicators.

Program Activities	Outcome Indicator
Students participate in scientific research through authentic field experiences including water quality testing, analysis, sampling, comparison, and reporting.	Self-Efficacy Science Identity
Authentic science field experiences take place in the local community and are connected to local social issues	Science Community Values
Team building, attention to emotional and intellectual safety, small group work, and opportunities to get to know scientists both personally and professionally	Science Identity Science Community Values
Students design their own community-based research project (mastery experience), receive mentoring (process feedback), no summative evaluation	Science Identity Self-Efficacy
Students teach younger students at a service learning event, students share their research projects with a larger audience.	Self-Efficacy Science Identity

Evaluation Framework

Purpose of the Evaluation

The purpose of this report is to provide an evaluative summary of the 2018 STEM Access summer program, focusing on the effectiveness of the program in increasing accessibility of science for program participants. This report is intended primarily for the STEM Access Upward Bound staff for the purposes of programmatic learning and decision making.

Key Evaluation Questions

1. To what extent did the summer program effectively facilitate accessibility of STEM degrees/careers for student participants as measured by science identity, science self-efficacy, and science community values?
2. What were the most important reasons for the program's successes?
3. What are the most unresolved issues for SAUB summer program success?

Role of the Evaluator

I was approached by the director of SAUB to help in the design and instruction of a three-week summer program. My research interest in authentic science learning experiences aligned with the program's goals and previous summer program designs. Planning for the goals of the program was a collaborative effort between STEM Access staff and myself, but program curriculum design was primarily my own effort contingent on approval by the SAUB director. For this evaluation, I served as the primary investigator and was responsible for all data collection and analysis. Being both the lead instructor for the course and the evaluator presents some challenges but is not uncommon in education research. The principle concern is bias, or a preconception that restricts a researchers' consideration of possibilities during a study (Savin-Baden & Major, 2013). A more detailed description of my positionality can be found in the Appendix 3.1.

Evaluation Method: A Case Study Approach Using Mixed Methods

Evaluations concerned with effectiveness and insight into aspects of programming thatcontribute to outcomes must seek a full understanding of what participants' experiences entail. Such a design must allow for the emergence of unexpected findings, while also justifying the links between evaluation questions, design, and methods (Fu, Peterson, Kannan, Shavelson, & Kurpius, 2015). A case study approach was appropriate for the evaluation because it can address the question of effectiveness by providing tacit knowledge into what is happening and why in a real-life context (Yin, 2011). By examining a program's internal workings and how they produce outcomes, an evaluative case study can provide in-depth explication of a program (Stufflebeam, 2001). Evaluative case studies do not require controls of treatments, as they investigate programs as they naturally occur, often through triangulation of methods (Stufflebeam, 2001).

This evaluation uses results from a quasi-experimental mixed methods study to investigate the impacts of the Upward Bound summer program using variables predictive of participants' persistence in STEM. To understand aspects of participant experience as complex as identity, deep and descriptive data is needed, making qualitative methods an appropriate fit. To measure the effect of an intervention, a quasi-experimental design was used to compare measurements from before to after the program using a standardized instrument, which can also be used to compare across programs and years. A mixed-methods investigation gathers both quantitative and qualitative data and integrates the data to draw interpretations based on the strengths of each to understand the research problems (Creswell, 2014). A broad overview of methods can be found in Table 3.2, and a more detailed explanation of the methods can be found in the appendix.

Table 3.2 An overview of methods.

Evaluation Question	Method(s)	Data Source(s)
To what extent did the summer program effectively facilitate accessibility of STEM degrees/careers for student participants as measured by science identity, science self-efficacy, and science community values?	Mixed Methods	Ethnographic-style semi-structured interviews Pre-post and six-month follow-up questionnaire
What were the most important reasons for the program's successes and failures?	Qualitative	Ethnographic-style semi-structured interviews
What are the most unresolved issues for SAUB summer program success?	Qualitative	Ethnographic-style semi-structured interviews

Methodological steps taken to control for bias and threats to validity include using previously validated scales for measurement and standard statistical methods for analysis. Peer debriefing of qualitative findings was used to ensure that external others supported the conclusions of the research. In many aspects, this evaluation was participatory, in that SAUB staff contributed to evaluation questions, development of the interview guide, and peer debriefing, which ensured multiple perspectives throughout the evaluation process. Some methods to check my potentially biased interpretations include using mixed methods, utilizing theory and experimentation, triangulating the data, and peer debriefing. I used reflective journaling throughout the analysis process and peer discussions to create distance and deconstruct the familiar as strategies to avoid bias and assumptions (Van Heugten, 2004). I also authentically and centrally embedded participants' voices in the findings and conclusions of the evaluation (Tolbert, Schindel, & Rodriguez, 2018).

Limitations

The self-selecting sample is a limitation because students with already high levels of science identity, academic success in science, etc., introduce a 'ceiling effect.' The small sample size also introduces randomness, which may lead one to assume a cause and effect relationship when none exists. Comparison groups and larger sample sizes would help to distinguish program impacts from noise in the data. In addition, interpretation of the qualitative data is subjective. Although peer-debriefing was used to enhance validity of the findings, I was undoubtedly influenced by my prior experiences, biases, and worldview. Students likely filtered their responses during interviews to be more socially acceptable simply due to human nature and power dynamics, despite efforts to encourage their honest responses. Lastly, there may be a gap in alignment between what the instruments and interview questions asked about and the actual experience of the program for participants. Identity work related to developing a relationship with science may not be a one-way, linear process which can be detected in the limited timeframe of this study. Understanding whether any changes are long lasting requires long-term follow-up outside of the scope of this evaluation. Therefore, this study provides just a glimpse into the experience of student participants in the program. More discussion of limitations of the study design is included in Appendix 3.4.

Participants

A self-selected population of 16 high school students enrolled in a three-week summer STEM Upward Bound experience were asked to participate in this research study. Their participation in the present study was entirely voluntary and contingent on parental approval. In total, 14 students participated in the survey and 10 students participated in the interviews. The researcher made every attempt to limit the 'burden' of research felt by students by keeping surveys and interviews short, and prioritizing quality instruction over data collection needs.

Demographic Description of Survey Respondents (*n*=14)

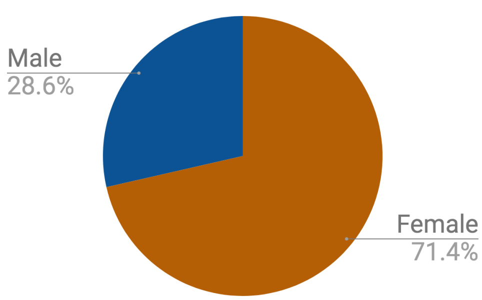

Figure 3.2 Gender Identity

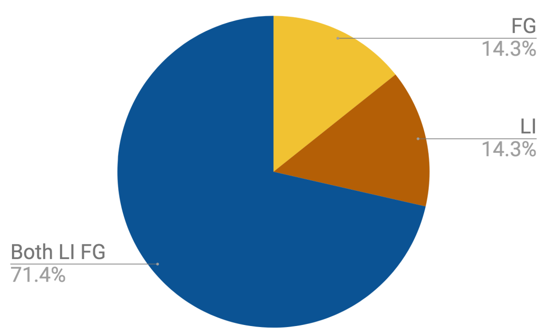

Figure 3.3 Eligibility Status

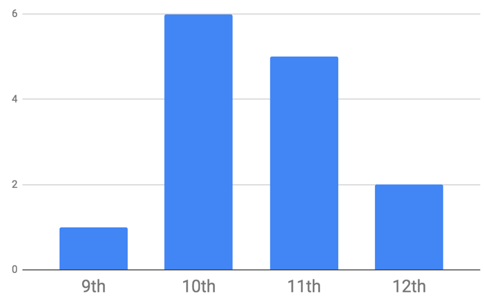

Figure 3.4 Grade level distribution

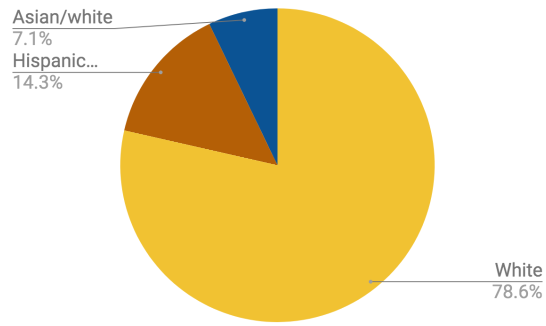

Figure 3.5 Racial and Ethnic Identity

Table 3.3 Overview of summer program impacts.

	Quantitative Data				Qualitative Data	
	Positive Change	Negative Change	No Change	Significant?	Main Finding	Student Quote
Science Identity	77%	15%	8%	Yes	Students felt like a science person when engaged in science practices	*I felt like a science person when we were in the field on the river and we got to do different things to test the quality of the river like the oxygen level, the current, and how we got to do a little snorkeling in the pool and look at the life-forms down there.*
Science Self-Efficacy	38%	31%	31%	No	Students identified water quality testing and research skills developed during the program	*I didn't know how to test water before but I learned how to do that and so now I know what tools to use to test water.*
Science Community Values	31%	38%	31%	No	Students contextualized science in their everyday lives	*I'm more into environmental science now because I liked learning about the different things that were in the water that people don't usually think about... and how the nature surrounding water really affects what the water quality is like.*
Intention to Pursue STEM	69%	8%	23%	Yes	Half of students identified a specific STEM career of interest	*I could see myself being in a science career. I think this helped me look more on the side of science careers that is fun and the good opportunities you have in it.*

Note. STEM Access Upward Bound summer programming strives to make STEM careers more accessible for students. The chosen indicators have been identified as important factors for integration into science and STEM fields for underrepresented students. Quantitative data came from surveys students took before and after the program (n=13). Qualitative data came from interviews with students three months after the program (n=10). The survey instrument and interview guide can be found in Appendix 2.3.

Key Findings

The key findings are presented in relation to the evaluation questions. More detailed description of the findings can be found in the appendix.

Key Evaluation Question 1: To what extent did the summer program effectively facilitate accessibility of STEM degrees/careers for student participants as measured by science identity, science self-efficacy, and science community values?

An overview of findings related to evaluation question one can be found in Table 3.3 on the previous page. Specific findings for each outcome indicator are discussed below.

Science identity increased during the program for most students.

Both sets of findings found evidence supporting an increase in science identity during the program:

- 77% of students saw an increase in science identity from before to after the program (Table 3.3, Figure 3.6).
- Students felt like a science person when actively engaged in science practices in authentic settings (Table 3.3).

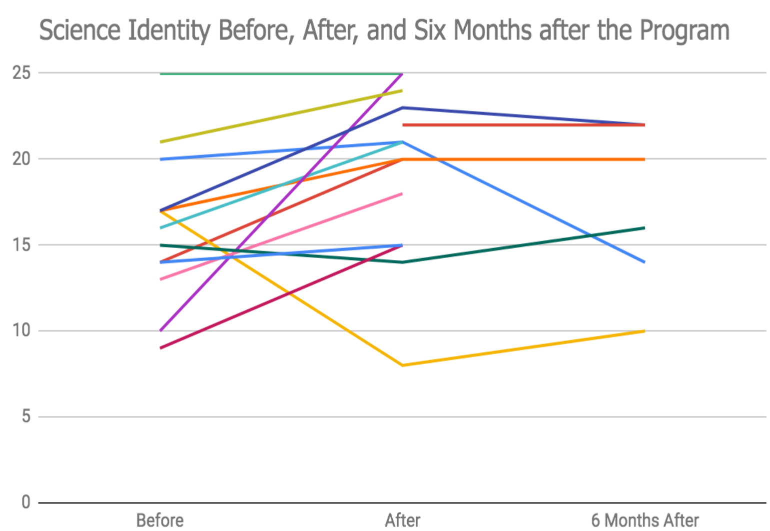

Figure 3.6 Line graph for science identity measured before, after, and six months after the program. Note. Each line represents one student. The Y axis represents the student's aggregate score for each of the items in the scale.

A science identity increases the likelihood a student will pursue a science degree or career (Chemers et al., 2011; Estrada et al., 2011; Estrada et al., 2016; Hernandez et al., 2013; Robinson et al., 2018). Science identities are strengthened when students have science experiences that are engaging and satisfying (Bell et al., 2019). Students without science identity are more likely to leave the sciences. While 77% of students saw an increase in science identity from before to after the program, there were differences according to demographic variables in the quantitative results. For example, males' science identity increased more than females, an unsurprising result given the well-documented "gender gap" whereby women report lower confidence levels in math and science achievement (Blickenstaff, 2005). However, research suggests that women's self-concepts in STEM are enhanced by exposure to female STEM experts (Stout, Dasgupta, Hunsinger, & McManus, 2011). The program investigated here featured primarily female STEM professionals. One must consider whether the gap between males and females may have been larger if not for the STEM experts being majority female. More on demographic differences is included below.

The qualitative data also pointed to the parts of the program which most supported the development of science identity: Field experiences where students were actively engaged in science practices such as water quality testing, the opportunity to teach newly acquired skills to younger students, and the intellectually and emotionally safe environment of the program which allowed students to share ideas without fear of judgement. Each of these is discussed in more detail in subsequent findings.

Implications for programming:

- Direct participation in science practices can increase science identity.
- The development of science identity is also situational, so attention to meaningful context is critical.

Although students described skills they developed during the program, science self-efficacy did not increase for most students.

Qualitative and quantitative findings were not in agreement:

- 38% of students showed an increase in science self-efficacy, 31% showed no change, and 31% showed a decrease (Table 3.3, Figure 3.7).
- Students could name water quality testing, general science, and research skills they developed during the program (Table 3.3).

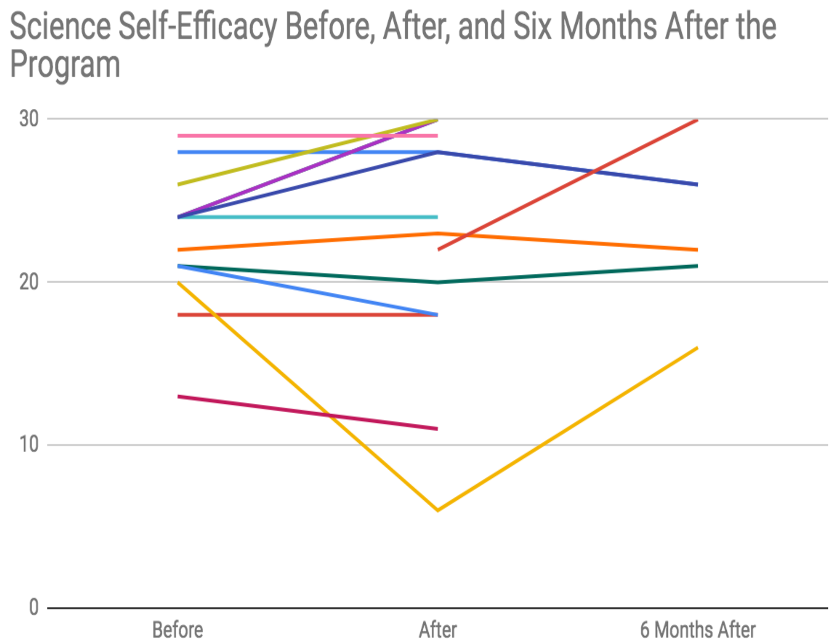

Figure 3.7 Line graph for science self-efficacy measured before, after, and six months after the program. Note. Each line represents one student. The Y axis represents the student's aggregate score for each of the items in the scale.

Survey findings did not show a significant increase in student's science self-efficacy. These findings could be due to the nature of the program (perhaps not impacting science skills) or the participants (ceiling effect), the instrument, or the extent to which a three-week program can impact self-efficacy for an entire domain, in this case science. While much of the literature describes self-efficacy as an important indicator of whether or not a student will continue in science, Estrada et al. (2011) found identification to be a stronger indicator of integration into the sciences than self-efficacy. The authors postulated that long-term intention is more influenced by identification than perceived abilities.

In terms of new skills acquired during the program, students primarily mentioned water quality testing, research skills, and some general science practices. When students discussed research skills they described a new ability to narrow a research focus and develop a project around a specific question: "With our research posters that we were doing that really made us think and narrow down a thesis and question and a hypothesis...so instead of looking at this really broad topic you're looking at this really specific question and just researching that." One student identified science skills such as being able to make observations as useful because it "helps you know what to ask and think." In that sense, there was some evidence of a feeling of empowerment from developing science skills. Another student felt that participating in the field experiences gave her a better understanding of how to develop a research project: "they made us have a question and then we had to figure it out and so I felt that helped me figure out ways to research on a problem with information that I had and make a project out of it." Similarly, another student felt the research project helped her to develop collaboration skills: "I think I learned how to do a science project kind of as a group. I haven't done that before really so it taught me how to work as a team in science."

While quantitative data showed some increases and some decreases in science self-efficacy among students, qualitative data pointed only to gains. Every student interviewed felt they had acquired science skills during the program. One possible explanation for this discrepancy could be due to the phenomenon of learning whereby increased knowledge makes one more aware of gaps in knowledge or put another way: "As our island of knowledge grows, so does the shore of our ignorance" (John Archibald Wheeler, American theoretical physicist). In other words, students were not aware of their actual skills and abilities until they enacted them during the program, at which time they re-evaluated their skills in a way to more closely match reality, resulting in a lower self-assessment of skills as measured by the instrument. Another explanation could be that the self-efficacy questions related most to science research skills, while the skills developed in the program were more general science practices. This is one of the challenges of aligning research instruments with the realities of programming and is a limitation of the study.

Implications for programming:

- Students with differing abilities and knowledge in STEM may experience the program differently.
- Some students may need more scaffolding and support to facilitate successful and positive experiences during the program, for example students with lower levels of science self-efficacy were also more likely to have had less academic success. Similarly, students with both low-income and first-generation status saw decreases in self-efficacy in comparison to those with only one or the other, suggesting that these students need additional supports.

Although students contextualized science in their everyday lives, science community values did not increase for most students.

Qualitative and quantitative findings were not in agreement:

- 31% of students showed an increase in their internalized values of science, 31% showed no change, and 38% showed a decrease (Table 3.3, Figure 3.8).
- Students described the value of science in relation to their everyday lives, and especially in relation to environmental health (Table 3.3).

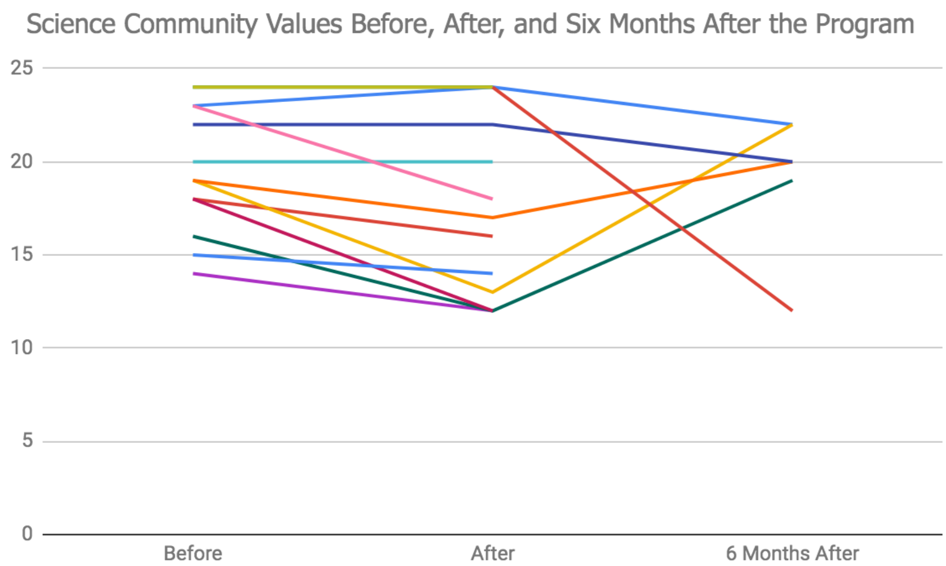

Figure 3.8 Line graph for science community values measured before, after, and six months after the program. Note. Each line represents one student. The Y axis represents the student's aggregate score for each of the items in the scale.

A striking result of the quantitative data was the decline in science community values for all students except for those who started the program with a high level of science community values. Qualitative findings showed an increase in students' value of science in relation to their everyday lives, and especially in relation to environmental health. The only question on the science community values scale which saw a slight increase in mean response was related to the value of building the world's scientific knowledge base. Surprisingly, the question related to the value of science for solving world issues saw a decrease in mean response. This could in part be due to the focus of the program on local issues rather than global issues. Students may have gained an understanding of how science is useful for local environmental issues, but not in the context of contributing to larger global issues. Perhaps students saw the highly specific nature of the scientists' work as being unrelated to larger global issues, suggesting that future programming make connections to the larger scientific community more explicit.

Quantitative data suggests that some students were turned off to science community values as a result of the program, while qualitative data suggests students came to value local science in the context of their community. This finding suggests that the program did less to integrate students into the community of science, and more to facilitate students' integration of science into their own lived experience apart from the science community. Perhaps science values are difficult to acquire in a short-term program which emphasized breadth of STEM careers and experiences over depth of one science experience. The more recent research by Estrada et al. (2018) supports this finding in that longer-term mentored STEM experiences had greater impacts on students' persistence in science.

The qualitative findings support the notion that students who are not planning to go into STEM fields may still benefit from STEM programming in that it may help them to find connections between science and their everyday lives. The concept of science for everyday life has been termed *science for citizenship* and is an important outcome of science education to support the public engagement with science, and a society capable of making decisions related to complex social-scientific issues (sSee Davies, 2004; Jenkins, 1999; Kolstø, 2001; and informal science education literature e.g. National Research Council, 2009). This last point brings up an issue that programs like UBMS may be grappling with - whether the program serves to recruit students who have dropped out of the STEM pipeline into STEM careers or at least science citizenship, or to support already interested students in achieving their dreams. The UBMS goal of making STEM careers more accessible for underserved students does not necessarily preclude science for citizenship as a desired program outcome, and it may be an area for future investigation given the findings supporting this outcome presented here.

Implications for programming:

- Students may have gained an understanding of how science is useful for local environmental issues, but not in the context of contributing to larger global issues.
- Perhaps students saw the highly specific nature of the scientists' work as being unrelated to the larger community of science, suggesting that future programming make connections to the values of the broader scientific community more explicit.

Intention to pursue STEM increased during the program for most students, but most students did not develop specific interest in STEM careers during the program. Qualitative and quantitative findings were not in agreement:

- Intention to pursue STEM increased for 69% of students (Table 3.3, Figure 3.9).
- Only half of students interviewed identified a specific STEM career of interest (Table 3.3).

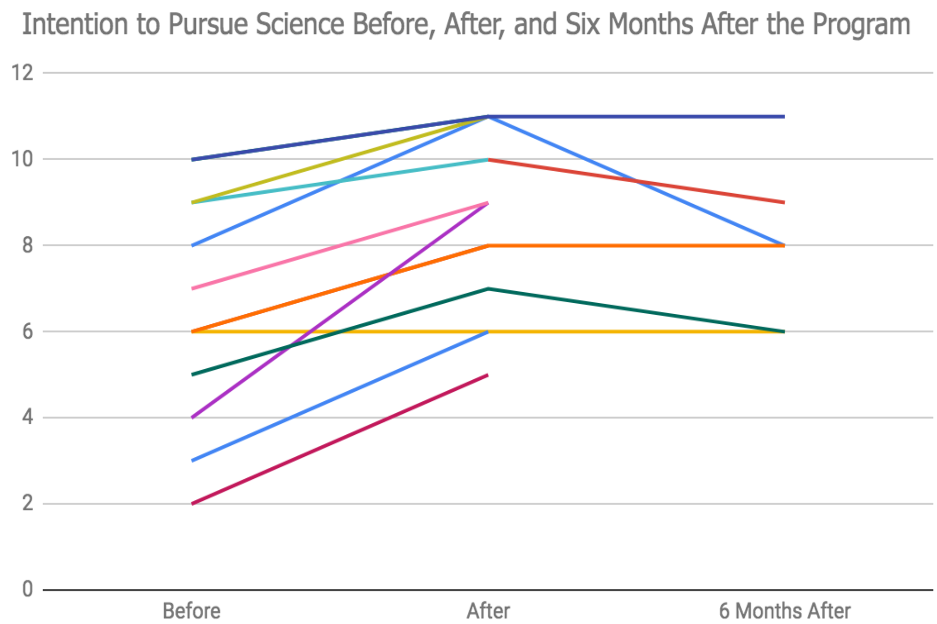

Figure 3.9 Line graph for intention measured before, after, and six months after the program.
Note. Each line represents one student.

While quantitative data showed an increase in intention to pursue STEM for 69% of students, there was mixed support for this in the qualitative data. According to qualitative findings, only half of students specified a STEM career they were interested in pursuing (predominantly a pre-existing interest in the medical field), and some students felt they lacked the passion or interest to pursue a particular STEM research career. So, while general intention to pursue STEM may have increased overall, qualitative data did not support an increase in interest in any specific STEM careers encountered during the program. One possible explanation is the fixed theory of interest (described below) for preventing students from considering specific careers if they feel they lack enough present interest or passion. Another possible explanation is that students' expectations of the likelihood they would pursue STEM increased due to other factors besides development of interest in pursuing a STEM career. There was, for instance, a high correlation between intention and science identity. Interest, however, also plays an important role in identity development. The four-phase model of interest suggests that interest begins with an external spark and develops through increased valuation, positive affect, and knowledge acquisition before it becomes internalized as part of one's identity (Hidi & Renninger, 2006). More investigation of the role of interest and identity development in relation to intention may clarify the mixed findings of general vs specific intentions to pursue STEM.

Implications for Programming:

- A fixed theory of interest is a current barrier for some participants.
- Future evaluations should further investigate the role of student interest in intention.
- Future programming should be developed based on student interest to ensure they are developing skills and interests that can help them to develop towards a career of interest to them.

Key Evaluation Question 2: What were the most important reasons for the program's successes and failures?

Field experiences provided meaningful opportunities for students to actively engage in science practices in authentic settings.

Students identified as a science person when they were performing science skills or practices in an authentic context. Although there were several classroom-based science activities, and one field experience in which students were not actively engaging in science practices, no student mentioned these activities in the interviews when describing times they felt like a science person. Instead, their examples came from field-based experiences when they were actively engaging in science practices. When describing what they were doing when they felt like a science person, students mentioned a range of science practices such as making and writing down observations, investigating, sharing ideas, and performing water quality tests.

The most frequently mentioned science practice students described when asked about times they felt like a science person was water quality testing: "I felt like a science person when we were in the field on the river and we got to do different things to test the quality of the river like the oxygen level and the current…" Figure 3.10 shows the programmatic activities students were engaged in when they felt like a science person.

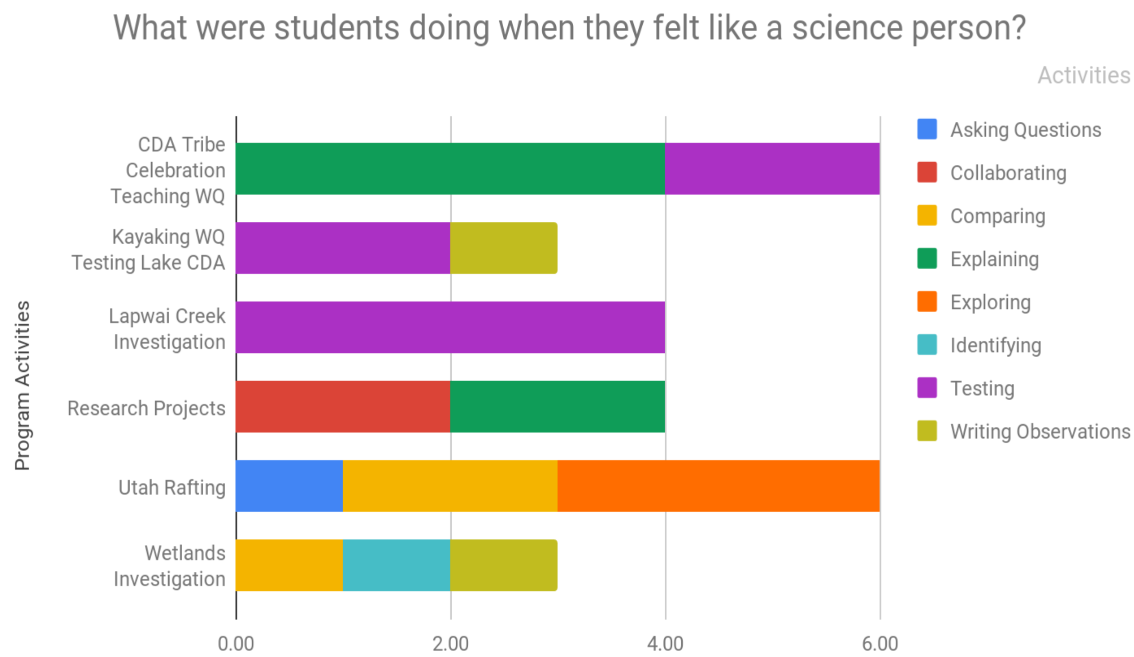

Figure 3.10 Frequency bar chart showing distributions of science practices by program activity.

These findings support previous research which emphasizes the importance of practicing science in authentic contexts for developing science identity (Ballard, Dixon, & Harris, 2017; Buxton, 2006), where students were actively engaged in science practices such as water quality testing.

The opportunity to lead through service learning helped students to feel recognized as a science person and to reflect on their learning.

Students mentioned feeling recognized as a science person when they taught younger students: “I had felt like a scientist before but it was in school, so it was like I had to, but this was like I was kind of doing it on my own and I was leading other people on how to do it which I've never done before.” The experience of teaching others was new to this student and led her to feel both independent and empowered. Although their water quality testing skills were newly acquired, students had the opportunity to see themselves as competent when put in a position of teaching younger students. The importance of meaningful opportunities to teach others is supported in the literature (Olitsky et al., 2018).

Implication for programming:

- Opportunities to teach and lead may have a cascading positive impact and should be prioritized when possible, especially for those students who may have lower self-concepts in relation to science.

The social norms of the summer program created a safe environment that valued students' ideas, thoughts, and opinions and bridged the culture of science.

There was a strong connection between students' perceptions of group norms and belonging and their feelings of safety in expressing their ideas without judgement. Students felt that the summer program environment supported the free expression of ideas, which they also felt was a feature of the culture of science. They expressed that all ideas in science are valid and worthy of exploration. They claimed that they felt no judgement from peers in expressing their ideas during the program, and that the enthusiasm among the group differed from the typical classroom environment:

> It's just really cool to be around a really nice group of people because if you're kind of stuck in a really non-interactive group than you don't get much out of it and so I really like that aspect of year-round people who are actually interested in it and you're not like at school where people are like 'oh I don't want to be here.' They signed up to go and so it's like a learning process.

Choosing to be a part of Upward Bound helped students to feel like it was a different kind of group dynamic which in turn created a different type of learning environment - one that was less judgmental and more open-minded. Students specifically felt that the environment of the program differed from other learning environments:

> I know sometimes people hold back about saying some things cuz they think 'oh I'll sound dumb' or something like that. And so if you're put in an environment where all ideas are treated equally... then it really helps to branch out and share more ideas that you have.

The safe learning environment facilitated student learning by allowing them to stretch themselves in new ways without judgement. The importance of social norms and and belonging for youth development is reflected in a comprehensive report on programming to promote youth development, which identified eight components of successful youth programming based on research on family, schools, and community supports:

1. Structure and limits that are developmentally appropriate and that recognize adolescents' increasing social maturity and expertise;
2. Physical and psychological safety and security;
3. Opportunities to experience supportive relationships and to have good emotional and moral support;
4. Opportunities to feel a sense of belonging;

5. Opportunities to be exposed to positive morals, values, and positive social norms; Opportunities to be efficacious, to do things that make a real difference and to play an active role in the organizations themselves;
6. Opportunities for skill building, including learning how to form close, durable human relations with peers that support and reinforce healthy behaviors, as well as to acquire the skills necessary for school success and successful transition into adulthood; and
7. Strong links between families, schools, and broader community resources (NRC, 2002, p. 135).

The importance of the learning environment is also well supported in the science education literature: The 'chilly culture' of undergraduate science classes has long been attributed to student attrition from science majors (Seymour & Hewitt, 1997; Tinto, 1987). An emotionally safe space creates a positive learning environment where students feel safe to make mistakes without being made fun of (Izard, 2016). However, proponents of supplementary science learning experiences have paid less attention to the importance of the culture of the environment, with more focus on the authenticity of the context and opportunity for skill development (Chemers et al., 2010; Chinn & Malhotra, 2002; Estrada et al., 2011, Estrada et al., 2018). While research suggests that underrepresented students succeed in science when the curriculum incorporates aspects of their everyday and cultural experiences (Buxton, 2006; Lee & Luykx, 2006), the findings of this study suggest that the culture of the science learning environment may be as important as the degree of authenticity and warrant further investigation into the role of culture in supplementary science experiences for supporting student success in science.

Implications for programming:

- Time spent developing positive group dynamics has positive impacts on students' development of science identity and feelings of belonging.
- It is important to continue to facilitate positive social norms to build comfortable, friendly environments for students to experience science, develop as learners, and try on a science identity in an intellectually and emotionally safe space.

Key Evaluation Question 3: What are the most unresolved issues for SAUB summer program success?

Barriers to STEM such as a fixed mindset and fixed theory of interest are present among students.

Qualitative data found evidence of fixed mindsets among some students. Students' fixed representations of their own characteristics as well as those of scientists suggest that a fixed mindset is a potential barrier to pursuing a science career. Students in poverty are especially prone to a fixed mindset, or the belief that intelligence cannot be changed (Dweck, 2008). The belief that intelligence is malleable and can be increased through work is a growth mindset (Dweck, 2008). Claro, Paunesku, & Dweck (2016) found that students from lower-income families were twice as likely to hold a fixed mindset. However, they found that low-income students who held a growth mindset were higher achievers, demonstrating that a growth mindset is protective against the barriers to success that poverty presents. Research shows that achievement gaps decrease for female and minority students when a growth mindset framework is used to inform them that they can do as well as others (Dweck, 2008). Strategies for promoting a growth mindset in students includes explicit discussion of brain plasticity, valuing challenge, effort and struggle, and giving process praise and feedback (Dweck, 2008).

There was also evidence suggesting that some students view interest and passion as inborn or fixed rather than something that may build over time or through experience. The notion that fixed and growth mindsets apply to career interests is supported by recent research (Chen, Ellsworth, & Schwarz, 2015; O'Keefe, Dweck, & Walton, 2018). Similar to a fixed or growth mindset in relation to learning, one can have a fixed or growth theory of interest. Those with fixed (also called 'fit' by Chen et al., 2015) theories view interests and passions as somewhat predetermined - e.g. "find your (pre-existing) passion", judge fit of a profession by how enjoyable it is right from the start. Those with a growth (also called by 'develop' by Chen et al., 2015) theory view passion as something that develops over time through mastery of the work. Research by O'Keefe, Dweck, and Walton (2018) found that holding a fixed theory meant dampened interest in areas outside of existing interests, as well as naive assumptions of boundless motivation once a passion has been found. Importantly, their research found that those with a fixed theory were more likely to lose interest when difficulties in engaging in the new interest arose. The authors caution that "urging people to find their passion may lead them to put all their eggs in one basket but then to drop that basket when it becomes difficult to carry" (O'Keefe, Dweck, & Walton, 2018, p. 1653).

Given the evidence of fixed theory among student participants described above, it is highly probable that students holding fixed theories may have been inhibited from developing an interest in the STEM careers they were exposed to during the program. It may also help to explain why some students felt that passion and interest was a prerequisite of a STEM careers, and thus a barrier in some cases. Students' implicit theories of interest may impact their ability to not only develop an interest in STEM careers during the program, but also to developing a STEM identity, science community values, and self-efficacy given the interconnections of these variables. Considering the importance students placed on finding a career based on their interests, passions, and whether or not the work would be enjoyable, these findings suggest further investigation into the implicit theories of interest held by low-income and first-generation status students, and the extent to which implicit theories of interest may be inhibiting the pursuit of STEM careers for these students. The main implication here is that in order to guide students into STEM careers, programs must provide explicit guidance in how interests can be developed, and through persistence and investment, eventually lead to a STEM career.

Implications for programming:

- Develop an action plan for addressing fixed theories of growth and interest in programming, staff training, and preparing scientists to work with youth.
- Strategies for promoting a growth mindset in students includes explicit discussion of brain plasticity, valuing challenge, effort and struggle, giving process praise and feedback, and informing students that they can do as well as others (Dweck, 2008).
- In order to guide students into STEM careers, programs must provide explicit guidance in how interests can be developed, and through persistence and investment, can eventually lead to a STEM career.

Integration into science was variable across demographics. Women, minority ethnicities, students who are both low-income and first-generation, and lower academic achievers may face additional barriers in developing an orientation toward science than their peers.

Findings suggest that women, minority ethnicities, students who are both low-income and first-generation, and lower academic achievers may face additional barriers in developing an orientation toward science than their peers. The detectable effect of demographic variables on science identity and self-efficacy lend support to previous research that finds that external social forces can influence the extent to which a student feels like a science person (Carlone, Scott, & Lowder, 2014). In addition, these groups had lower levels of self-efficacy, which has important implications for success in STEM. Students who have higher self-efficacy are more likely to persist in the face of difficulty (Zimmerman, 2000; Usher and Pajares, 2008), and research has shown that for college students, perceived competence in STEM predicts achievement in a STEM course and lessened intention to leave their STEM major, especially for underrepresented students (Hilts, Part & Bernacki, 2018).

There is also evidence that the demographic factors identified here may have compounding effects on orientation toward science. For example, students who are both low-income and first-generation were more likely to be lower academic achievers. Factors affecting potential first-generation college students like little active parental involvement may be amplified by the negative impacts of poverty (Gibbons & Shoffner, 2004). Parental educational involvement is strongly related to student educational success (Benner, Boyle, & Sadler, 2016). Not receiving additional support can be a barrier for students, especially those without parental encouragement and support. Related to this, there may be demographic variables which were not investigated here which could also play a role. In particular, findings of Mihelich et al. (2015) that more politically and religiously conservative Idahoans are less supportive of STEM education measures, which may also affect their students' engagement with STEM.

Another barrier, stereotype threat, or the disruptive anxiety that one's performance will confirm negative stereotypes, hinders performance as well as career aspirations for underrepresented groups in science (Shapiro & Williams, 2012). Stereotype threat is largely driven by environmental cues, including the academic environment which can encompass parent and teacher behavior as well as being a numerical minority (Shapiro & Williams, 2012). Stereotype threat can impact underrepresented students in a number of ways, including disengagement from a particular domain and its relation to their self-concept (Beasely & Fischer, 2012). This prompts consideration of the representation among STEM experts in the program for each of the student groups identified here. For example, research suggests that interventions such as self-affirmation activities, and direct and indirect interaction with role models may reduce perceptions of identity threat in Latino students (Hernandez, Rana, Rao, & Usselman, 2017; Schinske, Perkins, Snyder, & Wyer, 2016). Stereotype threat should be considered as a possible barrier for each of the groups mentioned here, and programming should be designed to address specific barriers for each group. For example, although STEM experts for this program were majority female, they were also majority White - which may have contributed to stereotype threat for non-White students.

Implications for programming:

- External mediators to engagement with science such as race/ethnicity, eligibility status, gender, and academic performance must be considered and addressed in programming.
- In particular, stereotype threat should be considered as a possible barrier. For example, although STEM experts for this program were majority female, they were also majority White - which may have contributed to stereotype threat for non-White students.
- In addition, programs may want to consider scaffolding authentic science experiences, recognizing that GPA, eligibility status, and initial levels of science identities and skills can affect student preparedness and propensity to develop science identity and self-efficacy during the program.

Conclusions and Recommendations

The purpose of this evaluation was to provide an evaluative summary of the 2018 STEM Access summer program, focusing on the effectiveness of the program in increasing accessibility of science for program participants. Specifically, by examining science identity, self-efficacy, values, and demographic variables, as well as demographic variables, we sought to better understand how to support low-income and first-generation students. This report is intended primarily for the STEM Access Upward Bound staff for the purposes of programmatic learning and decision making.

Findings from this evaluation support the notion that supplementary science experiences students can facilitate the development of science identity. Specific program elements which most contributed to students' science identity development included a supportive environment, and opportunities to engage in science practices and to teach others. Findings suggest that the learning environment is important for students to feel safe in 'trying on' a science identity. When students feel like they are not being judged and they can express themselves freely, it helps them to feel accepted and like a contributing member of a science community. Such an environment creates space for students to practice participating in a science community, but without the pressure and identity threats that can otherwise present themselves in traditional, 'chilly' science learning environments. Supplemental science experiences therefore play a critical role for students of nondominant backgrounds who may feel culturally isolated in traditional science classroom environments.

This evaluation also suggests that science identity, performance, values, recognition, and self-efficacy are interwoven, supporting the investigation of those variables in tandem. For example, in this research students only discussed their science identity in terms of performance and recognition. Activities that attend to multiple variables are therefore especially impactful, as in the teaching experience that students had which allowed them to feel recognized and identify as someone capable of teaching science to others. Not only were students actively applying new skills in a different context, but by teaching younger students they were able to see themselves as leaders and science people. This type of experience has a cascading impact and should be prioritized when possible, especially for those students who may have lower self-concepts in relation to science.

There were patterns in the findings among demographic variables which have implications for program design. There was some evidence pointing to fixed mindsets among students, which was linked to fixed perceptions of scientists and identified as a barrier to science for some students. Therefore, supplementary science interventions serving low-income, first-generation students should consider explicit guidance in developing growth mindsets, especially in regard to STEM career trajectories. In addition, programs may want to consider scaffolding authentic science experiences, recognizing that GPA, eligibility status, and initial levels of science identities and skills can affect student preparedness and propensity to develop science identity and self-efficacy during the program. Future evaluation might investigate the impacts of scaffolded approaches to authentic science experiences.

Overall, agreements in the data point to positive effects of the program on science identity and intention to pursue STEM careers for most students. Discrepancies in the quantitative and qualitative data point to the importance of mixed methods for understanding complex human experience. Differences among demographic variables suggest important external mediators to engagement with science such as race/ethnicity, eligibility status, gender, and academic performance. This study suggests that not all students experience authentic science programming in the same way and prompts further investigation into how and why students of different backgrounds may succeed in science, and how best to support them.

Key Recommendations for the Program

- Building positive social norms is a program strength. Continue the work of building positive, comfortable, friendly environments for students to experience science and try on a science identity in an intellectually and emotionally safe space. It's not just the curriculum or programming, social interactions are important. Preventing exclusionary behaviors and bullying behaviors is critical. Continue to develop skills in a culture of support and building upon strengths to succeed rather than deficit-based approaches.
- Develop an action strategy to address growth and fixed mindsets. Consider opportunities to address these barriers through embedded curriculum.
- Develop an action strategy to address demographic threats. Continued investigation into barriers and threats for participants can help inform future programming. Recruit scientists/grad students whose life experience/background matches with participants (perhaps have criteria for programming e.g. 70% both low income and first-generation). Given the evidence that students of different backgrounds experienced the program differently, SAUB may want to consider scaffolding programming, so that student needs, level of interest, and level of development are in courses or programming specifically designed to support their needs.
- The mentorship component showed promise and could be developed further. For example, having mentors present whenever students are working on their projects may help them feel more consistently supported.
- Opportunities for leadership and responsibility in programming serves to empower students and recognize them as capable and contributing people.

Recommendations for Future Evaluations

- Conduct surveys or interviews with students prior to developing the summer programs to find out what skills and interests students would like to develop. This will ensure they are building skills of interest to them that may support them in college and career goals. Consider incorporating youth in evaluation efforts, whereby youth are trained in planning and evaluating and participate in data collection, analysis, and interpretation.
- Comparison between programs - Consider partnerships with other UBMS programs to coordinate measurement to generate larger sample sizes. Short term assessment has challenges, so matching indicators to reasonable time periods is important.
- This evaluation suggests that not all students experienced the programming in the same way and prompts further investigation into why students of non-dominant had less positive outcomes. A lens of critical pedagogy may thus be appropriate for future evaluations, given its concern with empowering non-dominant students through analysis that involves the "interactive context between individual and society with theory and practice as coexistent" (Ryoo, Crawford, Moreno, & Mclaren, 2009, p. 134).

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Chapter 4: Conclusion

Non-formal science education programs are often limited in the amount of time and resources they can devote to program design, research, and evaluation. While understandable, a lack of reference materials of this kind has negative implications for programmatic learning and development. This body of work contributes a program design case, research, and evaluation of a summer program designed for STEM Access Upward Bound at the University of Idaho. To my knowledge, a comprehensive account of this kind has never been done for the STEM Access program, and has the potential to build the capacity for similar future endeavors, and the potential for programmatic learning leading to more impactful programming. In particular, principle contributions of this work include:

Article 1: Design Case of an Out-of-School Summer Program for Underserved Youth

- The application of an instructional design model to the development of a summer program and explication of each element.
- The identification of research and practice-based instructional strategies best suited to program instructional goals and student population.
- In-depth characterization of STEM Access participants and analysis of context.

Article 2: Understanding the Impacts of Authentic Science Experiences Through Social Influence Theory

- I expand upon the work of Estrada et al. (2011, 2018) by applying a model of social influence theory to understanding student integration into science at the program level.
- The mixed methods case study suggests positive impacts of authentic learning experiences on science identity above any other variable investigated.
- I identify barriers to integration into STEM including a fixed mindset, fixed theory of interest, and possible demographic-related factors.

Article 3: Evaluation of a 2018 STEM Access Upward Bound Summer Program for Low-Income and First-Generation High School Students

- Summative case study evaluation of the summer program
- Findings with implications for programming
- Program recommendations based on important findings

Article one is a design case which describes the development of an Upward Bound summer program for low-income and first-generation youth using the Morrison, Ross, Kalman and Kemp (2013) model of instructional design. The Morrison, Ross, Kalman and Kemp (2013) model is flexible and non-sequential, and a good option for student-centered instruction in both formal and non-formal education contexts. This design case demonstrates a process for developing a program in consideration of student needs, program objectives, contextual factors, and the application of an appropriate learning model. It can serve as inspiration or guidance for other program designs, as well as clarify important program elements and decision-making for research and evaluation purposes.

Article two investigates the impacts of the summer program using quasi-experimental mixed methods from the perspective of social influence theory, with science identity, self-efficacy, community values, and intention as outcome variables. While qualitative and quantitative data suggest the program positively influenced students' science identities, there was not agreement between the data sets on the impact of the program on students' science self-efficacy, science community values, and intention to pursue STEM. Patterns in student responses of the pre and post survey suggest demographic differences in student experience of the program. Although there are limitations of the study design that prevent generalization of the findings, they provide insight into the types of learning experiences that can lead to the development of science identity. Specific program elements that most contributed to students' science identity development included a supportive environment, and opportunities to engage in science practices and to teach others. The demographic differences suggest the need for further investigation to understand whether and how this type of program may be equally beneficial for all students.

Article three is a summative evaluation of the summer program for STEM Access Upward Bound at the University of Idaho. While Chapter Three focused on the impacts of authentic science experiences, this chapter focuses on how findings presented here can inform programmatic learning and practice for the STEM Access program. This kind of evaluation can help the program understand its effectiveness for achieving the goal of Upward Bound Math Science - to improve education outcomes for participants by making math and science college degrees and careers more accessible. The evaluation identified the extent to which the summer program effectively facilitated accessibility of STEM for participants, with overall mixed findings. It also identified reasons for the program's successes, as well as unresolved issues for success. Recommendations for future programming included continued attention to creating positive social norms during programming and developing a plan for addressing fixed mindsets and theories of interest in programming as this was identified as a significant barrier to STEM for students.

Recommendations

All three articles have implications for the field of non-formal science education. Articles 1 and 3 have particular practical implications for STEM Access, in that they can serve as reference materials for developing future programs and evaluations. They may also be insightful for other Upward Bound programs with similar contexts or instructional goals. Article 2 has implications for a broader audience, including other programs with similar goals who may be interested in using the model of social influence theory to understand the impacts of authentic science experiences. Specific recommendations for each of these contexts include:

For STEM Access Upward Bound:

- Use of an instructional design model like the Morrison, Ross, Kalman and Kemp (2013) model can help to clarify and align program objectives, context, and learner needs.
- Continue the work of building positive, comfortable, friendly environments for students to experience science and try on a science identity in an intellectually and emotionally safe space.
- Develop an action strategy to address fixed mindsets and theories of interest.
- Develop an action strategy to address demographic threats.
- Continue to provide students opportunities for leadership and responsibility in programming because there is evidence that it serves to empower students and help them feel recognized as a science person.

For non-formal STEM education programs:

- Programs promoting persistence in science degrees or careers for students who have already embarked on such a trajectory are an appropriate fit for the Tripartite Integration Model of Social Influence (TIMSI). However, programs serving high school students with less developed degree or career goals may consider modifying the model to include interest in STEM degrees/careers.
- A programmatic goal of STEM for citizenship may be a more appropriate fit for programs serving students with mixed levels of interest in STEM degrees or careers, given the measurement problems presented in Chapter Three.
- This research finds a stronger correlation between science identity and intention than between self-efficacy and intention and suggesting the importance of science identity as a variable of interest for understanding student integration in science.
- It is important to investigate how students of different demographic backgrounds are

impacted by programming, to identify needs for specific supports and to address possible threats.

Opportunities for Future Investigation

Although this work provides insight into program design, research, and evaluation of an authentic science summer program for underserved youth, there are many opportunities for further investigation. For example, there is opportunity for future investigation to replicate this work but with different study designs which strengthen external validity and make findings generalizable to broader audiences. In particular, comparison groups and randomization should be considered, however such designs are still fraught with challenges (see Rowan-Kenyon, Cahalan, & Yamashita, 2018). Future research may investigate the impact of specific program elements in order to prioritize programming efforts. For example, comparison of the impacts of developing a research project with and without mentoring. As described previously, identifying measurable variables best suited to the program and participants also requires future investigation, and may consider student interest. In addition, better understanding of how demographic factors influence student program experience are needed. In particular, low academic achievement prior to programming had a significant negative impact on science identity and self-efficacy. Other opportunities for future evaluations include:

- Conducting surveys or interviews with students ahead of program planning to incorporate their interests and support them toward their college and career goals.
- Incorporating youth in evaluation efforts, whereby youth are trained in planning and evaluating and participate in data collection, analysis, and interpretation.
- Utilizing a lens of critical pedagogy, given the concern for demographic inequality in program impacts presented in chapters 3 and 4 and the alignment of critical pedagogy with empowering students of non-dominant backgrounds.

Reference

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Appendix 1: Supplementary Material for Chapter 1

Appendix 1.1: Program Schedule

June 11 - June 21, 2018

Monday June 11, 10 am - 4 pm
LCSC, Sacajawea hall Rm. 144
10:00 - 10:30 Introduction name game (name tags - Draw a picture of yourself achieving your greatest goal). PollEv.com/solsen214 . Draw a scientist, share with a partner.
10:30 - 11:00 Inside/Outside Activity - Team contract (John)
11:00 - 11:15 Agenda for the week, program goals, intro to research projects (Sarah)
11:15 - 11:30 Science notebooks and decoration (Sarah)
11:30 - 12:00 Pack Lunch and get ready for field (water bottles)
12:00 - 12:30 Leave LCSC Travel to field
Garden Gulch Road Nature Trail
12:30 - 1:00 Lunch with Rue Hoover
1:00 - 3:00 Field Activities guided hike, plant ID, watershed management
Activity 1: I notice..., I wonder..., it reminds me of…
Activity 2: Plant observations. Pick a plant. Write down 10 observations that are not immediately obvious. Come up with questions for the plant that you do not know the answer to.
Nez Perce Historic Park
3:00 - 4:00 Drive to park, use bathrooms, reflection and wrap up. End with spotlighting.

Tuesday June 12, 9 am - 4 pm
LCSC, Sacajawea hall Rm. 144
9:00 - 9:30 Team Building (Kurt/John) Birthday line-up. Two truths and a lie.
9:30 - 10:30 Science Activity

Number Patterns activity - Were you doing science? Use science flowchart. What are science skills? Relate this to the activity from yesterday where they wrote down how they saw STEM being used by Rue Hoover.

Brainstorm questions for science professionals.

Dream catcher activity (TRIO Works) - making goals SMART

10:30 - 11:30 Research Projects
11:30 - 12:00 Travel to field (30 minutes)
Mission Creek
12:30 - 1:00 Lunch with Natasha
1:00 - 3:00 Field Activities - Snorkeling, water quality monitoring, macros
Nez Perce Historic Park
3:00 - 4:00 Drive to park, use bathrooms, reflection and wrap up

Wednesday June 13, 9 am - 4 pm
LCSC, Sacajawea hall Rm. 144
9:00 - 9:30 Team Building (Kurt/John)
9:30 - 10:30 Science Activity (blackout poetry)
10:30 - 12:00 Research Projects
12:00 - 12:30 Travel to field (30 minutes)
Canoe Project Site
12:30 - 1:00 Lunch with Julian
1:00 - 3:00 Service activities - planting, weeding, etc.
Nez Perce Historic Park
3:00 - 4:00 Drive to park, use bathrooms, reflection and wrap up

Thursday June 14, 9 am - 4 pm

LCSC, Sacajawea hall Rm. 144
9:00 - 9:30 Team Building (Kurt/John)
9:30 - 10:30 Mentoring for Research Projects
10:30 - 11:30 Working on Research Projects
11:30 - 12:00 Travel to Nez Perce Tribal Fish Hatchery
Nez Perce Tribal Fish Hatchery
12:00 - 1:00 Lunch
1:00 - 2:00 Hatchery Tour
2:00 - 3:00 Dams discussion
3:00 - 4:00 Reflection and wrap up

<u>Monday June 18, 10:30 am - 4 pm</u>
Bring water kits and swimsuits
CDA Resort
9:00 - 9:30 Check in
9:30 - 10:00 Drive to camp Larsen
Meet in Harrison at City Park/Trailhead
10:00 - 10:30 Introduction and orientation to Lake Celebration
10:30 - 11:30 Water Quality Testing with Success Center Students
12:00 - 1:00 Lunch and speeches
1:00 - 3:00 Field activities rotation: field sketching, water activities, bioblitz
3:00 - 4:00 Reflection activities
4:00 Travel

<u>Tuesday June 19, 9 am - 4 pm</u>
CDA Resort
9:00 - 9:30 Check in
9:30 - 10:30 Travel to Harrison
Meet in Harrison at City Park/Trailhead
10:30 - 11:30 Team Building
11:30 - 12:00 Lunch
12:00 - 1:00 Get bikes, safety talk, bike to end of Anderson lake
1:00 - 3:00 Kathleen leads discussions of heavy metal contamination
3:00 - 4:00 Arrive in Harrison, ice cream, reflection

<u>Wednesday June 20 9 am - 4 pm</u>
CDA Resort
9:00 - 11:30 Team Building + Research Projects
11:30 - 12:00 Travel to NIC
Harbor Center/Lake CDA
12:00 - 1:00 Lunch with Marie
1:00 - 2:00 Kayak around Blackwell Island, water quality testing in 4 locations, collect plankton samples
2:00 - 3:00 Compare water samples + look at plankton
3:00 - 4:00 Reflection activities

<u>Thursday June 21, 9 am - 4 pm</u>
CDA Resort
9:00 - 10:30 Team Building + Research Projects
10:30 - 12:00 Research Project Presentations
12:00 - 1:00 Lunch
1:00 - 1:30 Travel to Hayburn Park (30 mins Drive)
1:30 - 2:30 End of Program Debrief; Rafting Discussion;
2:30 - 4:00 Ice Cream Social; Free Activities

Program Materials List

Water Jugs (2)
Ice Chests (2)
Ice (daily)
Lunch materials
Snacks
Pencils
Ipads (24)
Water quality kits
Macroinvertebrate kits
Field guides
Science notebooks

Appendix 1.2 - Program Curriculum

1.2.1 Research Poster Lesson Plan

TRIO INSPIRE

STEM ACCESS science technology engineering math

Research Posters

Rationale

Students will develop a community-based research project of their choosing. The final product will be a completed poster which students will present to a broader audience. Students will be introduced to and then have time to work on one section of the poster per day. They will receive support from staff and mentors throughout the work time.

Objectives

1) Student will be able to identify a community-based research question of interest to them.

2) Student will be able to cite credible sources in their literature review and use the information to inform their project.

2) Student will be able to articulate why the project is of importance to them and the methods for their project.

Steps

Opening: Discuss the scope of research projects, posters, and expectations. Tell students they will be developing a community-based research question of their choosing, and designing a project to investigate that question. Pass out research poster assignment. Encourage students to choose a project related to water resources. Inform students that they will be working on one aspect of the project per day. They are allowed to work individually or in groups up to three. Pass out Ipads and ensure they have access to the research poster template (either via google docs or preloaded onto ipads).

Main: After introducing the section of the poster that students will be working on that day (see inquiry prompts below), students will spend 45 minutes to one hour working on ipads individually or in groups. Instructor, staff, and mentors (on day 6) will assist students during work time.

Closing: Check in with student progress during work time, ask for clarification questions, and see if further time is needed for that section.

Inquiry Prompts for Research Posters

Day 1 Introduction: *"The world as we have created it is a process of our thinking. It cannot be changed without changing our thinking."* -Albert Einstein
"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has." -Margaret Mead

Brainstorm for a few minutes some aspects of your community that need addressing or could be improved using science in some way. Now, take a look at those ideas and see if there is one you are especially interested in or drawn to - perhaps it is close to your heart, or you think it would be really fun or interesting to try to do something about.

Day 2 Need for Research: *"Don't underestimate the power of your vision to change the world. Whether that world is your office, your community, an industry or a global movement, you need to have a core belief that what you contribute can fundamentally change the paradigm or way of thinking about problems." -Leroy Hood.*

What potential impacts do you anticipate for the community or society? Why do you think this is an important issue and that something needs to be done?

Day 3 Research Question: *"It is not the answer that enlightens, but the question."* – Eugene Ionesco *"A wise man can learn more from a foolish question than a fool can learn from a wise answer."* – Bruce Lee

Think back to the issue in your community that needs addressing. In order to address that issue, what question needs to be asked? What do you want to know? Make a list of all the questions you have related to that issue.

Day 4 Literature Review: *"We learn more by looking for the answer to a question and not finding it than we do from learning the answer itself."* – Lloyd Alexander

What do you need to know in order to understand your research topic area better? Make a list of things you'd like to learn more about in relation to your topic.

References: Create citations for each of the references you used. Show students how to create references using Citation Machine.

Day 5 Hypothesis: Some types of scientific research involve hypotheses -usually when you are testing an idea. Usually, scientists already have an idea of how the test will go - this is the hypothesis. Often, the hypothesis takes an "IF______ THEN_____" form. What might the hypothesis be for your research?

Day 6 Methods: Imagine you had everything you needed to make your project happen - time, resources, etc. What are the steps needed to actually complete the proposed research? This of this as the 'instruction manual' of your research project. It should be detailed enough that someone else could pick up the manual and actually be able to make it happen.

Day 7 Budget: Bill Gates is interested in your project but wants to know what it would cost to make it happen. Think of everything it would take to make the project happen. Supplies? Pay for time of you (and others)? How many hours per week will it take to complete the project?

Day 8 Visual: Choose an image that represents your research. It could be a photo, a drawing, or another image. This should not just be a selfie!

Day 9 Conclusion: "Science, my boy, is made up of mistakes, but they are mistakes which it is useful to make, because they lead little by little to the truth." **Jules Verne**, **Journey to the Center of the Earth**. What reflections do you have after completing the research proposal?
What potential impacts do you anticipate for the community or society?

Day 10 Stem Careers: What kinds of STEM professions relate to this work? [For an optional activity to facilitate this see the Candy Factory Activity from TRIO WORKS]

Standards

Idaho Content Standards

List 1-3 Idaho Standards applicable http://sde.idaho.gov/academic/standards, may include Common Core Standards http://www.corestandards.org/read-the-standards/

LS4.D: Biodiversity and Humans • Sustaining ecosystem health and biodiversity is essential to support and enhance life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational, cultural, or inspirational value. Humans depend on the living world for the resources and other benefits provided by biodiversity. Impacts on biodiversity can be mitigated through actions such as habitat conservation, reclamation practices, wildlife management, and invasive species control. Understanding the effects of population growth, wildfire, pollution, and climate variability on changes in biodiversity could help maintain the integrity of biological systems. (LS2-HS-7, LS4-HS-6.

ETS1.B: Developing Possible Solutions • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (LS4-HS-6)

ESS3-MS-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. • Further Explanation: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).

Three Dimensions of Next Generation Science Standards (NGSS)

List elements of the Three Dimensions included https://www.nap.edu/read/13165/chapter/2#3, may include NGSS standards https://www.nextgenscience.org/search-standards

Scientific and Engineering Practices:
1. Asking questions (for science) and defining problems (for engineering)
3. Planning and carrying out investigations
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

P21 Framework for 21st Century learning

List elements of P21 Framework for 21st Century Learning included http://www.p21.org/our-work/p21-framework

Key Subjects and 21st Century Themes - Science and Civics, Civic Literacy and Environmental Literacy
Learning and Innovation Skills - Creativity and innovation
Information, Media, and Technology Skills - Information Literacy
Life and Career Skills - Initiative and self-direction

Materials:

1. Ipads
2. Research Poster Template
3. Research Poster Assignment

Timeline

Students will need 45 minutes to one hour per day for two weeks to complete their projects.

Modifications

Students can pair up or form groups of three to discuss their ideas, troubleshoot, and give each other feedback. The timing can be adjusted to fit the available time.

Prior

Students should have discussed and agreed to a code of conduct for behavior, participation, and interacting with other students.

Assessment

Student progress should be monitored to ensure they are on track to complete their projects by the end of the second week. Students should complete their posters and be able to present on them by the final day. Students should be prepared to answer questions during their presentations.

Rubric

See the scientific literacy rubric developed by the Stanford Center for Assessment, Learning, and Equity.

Post-Program Evaluation of Lesson by Instructor

Overall students were able to develop community-based research projects of importance to them and develop and present a poster. Based on the rubric, projects ranged from "Emerging" in most of the scoring domains of the rubric to a few examples of "Advanced." Overall, most students were "Developing" for most of the scoring domains. Students struggled to articulate the science-related issue in some cases, and most students did not evaluate an argument, which was not an explicit section of the research poster. Given the limited timeframe, student projects and presentations allowed them to develop research skills but did not allow them sufficient time to develop “Proficient/Advanced” projects according to the rubric. So while learning objectives were met, the research poster project quality varied among students, and therefore was an inconsistent mastery learning experience.

Students were most engaged when the mentors were present. Students demonstrated ownership of their research projects, and were coached on how to develop their methods. I think the mentorship component played a key role in student development of research skills, and mentoring is best timed to take place on the day students are developing their methods section.

The scaffolded approach to the research projects worked out well. Students who were working faster could move ahead, and students who needed more time could finish up during free time, which a few students did. Overall, the allotted time was sufficient for most students to complete the projects. Ensuring that all staff are working with students during the work time will help to ensure that students are getting the help they need when they need it.

Students benefited from working at table groups and providing each other feedback and help. Allowing time at the end of each work period for students to present to their table groups what they accomplished that day may help students to reflect on their progress and learning, and may be another opportunity for assessment.

Common themes among student research projects included bullying and school-related problems. Only a few students chose water-related research projects. Perhaps narrowing the scope of the assignment and providing more examples of possible water-related projects would help students to come up with water-related projects.

The Ipads were adequate and most students were able to use them easily. A few students struggled with the Ipads, so having laptops available for use would be helpful. Using google drive was easy for most students, however a few struggled with this and so perhaps an app based tool on the Ipad should be considered, rather than web-based google drive.

1.2.2 Research Poster Assignment

STEM Access

Research Proposal Poster Composition Guide

Summer 2018
Instructor: Sarah Olsen
E-Mail: saraho@uidaho.edu

STEM Access Phone:
208-885-5819
www.uidaho.edu/stemaccess

Overview

"Research is formalized curiosity. It is poking and prying with a purpose. " -*Zora Neale Hurston*

This program will provide you with the tools and resources needed to complete a research proposal poster. Work will be completed during the program with guidance. You will choose a STEM-related question of interest to you that connects to community.

Research Poster Elements:

- Introduction
- Need for Research
- Research Question
- Literature Review
- Hypothesis (if applicable)
- Methods
- Visual
- Budget
- Conclusion
- STEM Careers
- References

Program Structure:

This is an activity-based program. You will be applying the field-based learning experiences to your research project.

Although the process of science is not always linear, at the core it involves testing ideas with evidence.

1. Observe and Wonder

Investigations begin with observations. You may have noticed things that sparked your curiosity. You can use these observations as the foundation for your own research. This observation phase of the research is key; scientists focus their attention on the world around them and use their senses to experience what's there. They may compare what they see to what they already know or to other things they see.

2. Develop a Question

One of the hardest things about the process of science is to ask questions in a way that makes them suitable for an investigation. If a question is not testable, that doesn't mean it's not a good question. It just isn't something you'll be able to study. Testable questions ask about objects, organisms, and events in the natural world. They can be answered through experiments, observations, or surveys by collecting and analyzing evidence that is measurable.

3. Literature Review

Although observation and questioning are essential to the process of science, they are not enough to launch a scientific investigation on their own. Scientists also need background knowledge which can include everything they've picked up from school or experience, supplemented with reviews of the scientific literature. Understanding what other scientists have already figured out about a particular topic is crucial to the process. This background knowledge allows scientists to make connections between ideas and observations.

4. Create a Hypothesis

Hypotheses are possible answers to your research question. Be sure to list all possible outcomes, including the possibility that you will observe no differences or relationships in your study subjects.

5. Develop your Methods

Your question will help determine the type of investigation you will do. An observational investigation documents the natural world (learning from what you see). An experimental investigation manipulates the independent variable (learning what happens if you change something). You will need to consider the sample size (how much data you need to collect), what you will keep constant (everything but the independent variable if possible), and whether you will need a control (for experimental investigations). How will you record your data - what would the data table look like?

The methods section is important because it allows other scientists to replicate the study and to evaluate its quality.

1.2.3 Research Poster Template

University of Idaho

STEM ACCESS | UPWARD BOUND

Title

Project proposal by

10th grade,Lewiston High School, Lewiston Idaho

Upward Bound Math Science

Introduction

What issue are you interested in investigating through your research project?
How did you get your idea? How does your unique lens (your experiences/personal interests/values) lead you to this research? Introduce us to your vision.

Research Question

1) What science questions need to be asked?

Literature Review

Find at least 3 credible sources that relate to your science research idea. Reference them here and write a sentence or two about what they show or how they inform your idea.

Hypothesis (If applicable)

Drawing from what you learned in your literature review, what results do you expect?

STEM Careers

Describe the STEM careers involved in this research idea.

Need for Research

To develop your vision: how could you use science to help make a difference in your community?

1) What problem are you interested in?
2) Why is this problem important to people or the world?

Methods

What are the steps needed to actually complete the proposed research?

Visual

Include a picture that helps to tell the story of your research.

Budget

Include anticipated costs for this project.

Conclusion

What potential impacts do you anticipate for the community or society?
What reflections do you have after completing the research proposal?

References

Cite your sources here

This poster was produced as part of the STEM Access Project. For information contact stemaccess@uidaho.edu or 208-885-5819.

1.2.4 Daily Reflection Lesson Plan

TRIO INSPIRE

STEM ACCESS science technology engineering math

Daily Reflections

Rationale

Students will learn, notice, and try new things throughout the day, and it is important for them to process these experiences. This activity will stimulate reflection and provide down time for students to think about how they see themselves as people who do science, and ponder their own science ideas.

Objectives

1) Student will be able to reflect on science field experiences.

2) Student will be able to respond to discussion questions based on field experiences.

2) Student will be able to generate questions based on the science field experience.

Steps

Opening: Discuss reflection questions and expectations. Tell students to find a quiet place on their own to think about and write down ideas from the reflection questions. Students should be within ear shot, and know what signal they will hear when time is up. Students should not distract others, and should continue writing until the time is up.

Main: Students will spend 10-15 minutes writing. Signal students to come back as a group when time is up. Students will form a circle and share their ideas (could use talking stick, throw a ball, or another method to take turns sharing). Set the space by describing how students can participate in the sharing circle. Students who agree with another student can snap or wave fingers. Students can add on ideas or present alternatives (come up with signals for these as a group). The facilitator can follow up on ideas that need more developing. For example: How did you come to that idea/conclusion? How has your thinking about that changed? What questions did that bring up for you? What do you need more time to think about? What was confusing?

Closing: Allow students 3-4 minutes to add more ideas to their reflection after the group discussion. Pass out post-it notes and ask students write a science question they have from the day to add to the “Wonder Board” of potential research questions.

Daily Reflection Questions (select 1-3 questions per day):

What happened in the activity today? How did it feel? What can we learn from this activity going forward?

How do you think this research impacts the community?

Who do you think benefits from this research? How?

Could you see yourself doing this kind of science or something similar? Why or why not?

What might be challenging about this work and why is it worth the struggle?

TRIO INSPIRE

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In what ways is this work similar to they way you thought of science before? In what ways is it different?

What questions arose for you about how or why this research is done?

Today I noticed…

Today I learned…

Today I wondered…

What would you like to explore further?

What ideas from today do you think are important and that others should know about?

How would you explain the research you learned about today to your friend's grandmother?

Standards

Idaho Content Standards

CCSS.ELA-LITERACY.SL.9-10.1 - Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.

CCSS.ELA-LITERACY.SL.9-10.1.C - Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions.

CCSS.ELA-LITERACY.SL.9-10.1.D - Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.

Three Dimensions of Next Generation Science Standards (NGSS)

Scientific and Engineering Practices
1. Asking questions (for science) and defining problems (for engineering)
4. Analyzing and interpreting data
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

P21 Framework for 21st Century learning

List elements of P21 Framework for 21st Century Learning included http://www.p21.org/our-work/p21-framework

LEARNING & INNOVATION SKILLS - Critical Thinking and Problem Solving, Communication, Collaboration

TRIO INSPIRE

STEM ACCESS science technology engineering math

Materials:

Student science journals
Pens/Pencils
Talking stick or ball (optional)
"Wonder Board"
Post-its

Timeline

Reflection will occur daily and is related to each of the learning activities of the day. Fifteen to thirty minutes should be sufficient, depending on the time available.

Modifications

Students can pair up or form groups of three to discuss their ideas. The timing can be adjusted to fit the available time.

Prior

Students should have discussed and agreed to a code of conduct for behavior, participation, and interacting with other students.

Assessment

Students will participate in the activity through writing and discussion (see rubric). Students will write on a post-it a question that arose from their reflection. The post-its will be added to the "Wonder Board" which can be used as a clearinghouse of potential research questions.

Rubric

	Beginning 1	Developing 2	Accomplished 3	Exemplary 4
Writing reflections	Student did not answer questions and was distracting other students	Student did not participate	Student was distracted while writing and did not respond to each question	Student is engaged in writing and provides a response for each question
Contributions to group discussions	No participation	Participation was minimal.	Student contributed by sharing observations.	Student added new reflection and actively supported the group's thinking process.

Post-Program Evaluation of Lesson by Instructor

Overall the reflections were an important anchor point of each day. Providing snacks and water and time to sit, think, and discuss was a good way to wrap up each day. Sometimes students had low energy levels and they struggled to focus on the questions. Switching the format may help to maintain student interest. For example, allowing students to choose the question, to work in pairs, or to write on posters in groups. Switching the format may help to maintain student interest and prevent monotony.

The instructor may wish to collect student journals for assessment throughout the program. For this program, journals were not collected so that students would feel safe to reflect openly and honestly in journals as there was some concern expressed by students at the beginning of the program related to this. However, journals can be a powerful assessment tool and making it clear at the beginning that journals will be collected each day may serve to prevent journals from being lost or misplaced, and gauge student engagement and learning.

1.2.5 Lapwai Wetland Investigation Lesson Plan

TRIO INSPIRE

STEM ACCESS science technology engineering math

Lapwai Wetland Investigation

STEM Expert: Rue Hoover, Nez Perce Tribe Water Resources Division

Rationale

Lapwai creek is located 10 miles east of Lewiston, ID and is a tributary of the Clearwater River. Land use activities within the Lapwai watershed like agriculture, logging, road construction, grazing, irrigation diversions, and floodplain development have impacted resident salmonid populations by altering natural hydrology and sedimentation – causing habitat destruction, fragmentation, and degrading water quality. This has led to many ecological problems such as low summer flows, fluctuating stream temperatures, increased flood events, sedimentation, fish migration barriers, riparian degradation, channel/bank instability, introduction of exotic organisms, and loss of salmonid rearing/spawning habitat (Rasmussen, 2007). In the Idaho Department of Environmental Quality's (IDEQ) Clean Water Act biennial water quality report (Section 305b) to the Environmental Protection Agency (EPA) in 2012, Lapwai creek was listed as an impaired stream (Section 303d) (33 U.S.C. § 1315(b)). The Lapwai watershed has been designated as a critical habitat for the Snake River Basin steelhead by the Endangered Species Act. Restoration initiatives have been underway to improve habitat to benefit various resident and anadromous species, and increase the potential of the Lapwai watershed for spawning and rearing in the Lower Clearwater River Subbasin (Richardson & Rasmussen, 2007). Lapwai creek restoration initiatives present an excellent opportunity for students to understand water resource issues, and possible solutions through restoration and water conservation. This field experience will provide an introduction to field skills, observation, and ecology and natural resource management of Lapwai Creek.

Objectives

1) Student will be able to identify socially significant plants

2) Students will be able to discuss the differences between natives and invasives

3) Students will understand what goes into project management for natural resources

Steps

This is where you add your agenda of what happens throughout the lesson.

Opening: Introduction to the history of the area and the importance of the Nez Perce Tribe.

Main: Take a nature hike through the Nature Trail and go over all the native and culturally important plants along the trail. Students will learn about the importance of wetlands for not only water quality but also the huge diversity of plants. We will explore the wetland and look at wetland soils and upland soils so the student can see the difference and see how to identify hydric features. We will look at the hydrology of the area and plant communities.

Students will have the opportunity to choose a plant to sketch in their field journals, make observations about the plant, and identify it using the field guides.

Closing: Review the topics covered during the tour, importance of restoration for Lapwai Creek, and significance of plants for tribal culture. There will be opportunity for students to ask questions.

Standards

Idaho Content Standards

List 1-3 Idaho Standards applicable http://sde.idaho.gov/academic/standards, may include Common Core Standards http://www.corestandards.org/read-the-standards/

LS2.C: Ecosystem Dynamics, Functioning, and Resilience • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (LS2-HS-2, LS2-HS-6) • Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (LS2-HS-7)

LS4.D: Biodiversity and Humans • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (LS2-HS-7) • Sustaining ecosystem health and biodiversity is essential to support and enhance life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational, cultural, or inspirational value. Humans depend on the living world for the resources and other benefits provided by biodiversity. Impacts on biodiversity can be mitigated through actions such as habitat conservation, reclamation practices, wildlife management, and invasive species control. Understanding the effects of population growth, wildfire, pollution, and climate variability on changes in biodiversity could help maintain the integrity of biological systems. (LS2-HS-7, LS4-HS-6.)

ESS2-HS-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. • Further Explanation: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.

Three Dimensions of Next Generation Science Standards (NGSS)

List elements of the Three Dimensions included https://www.nap.edu/read/13165/chapter/2#3, may include NGSS standards https://www.nextgenscience.org/search-standards

Scientific and Engineering Practices
4. Analyzing and interpreting data
8. Obtaining, evaluating, and communicating information

P21 Framework for 21st Century learning

List elements of P21 Framework for 21st Century Learning included http://www.p21.org/our-work/p21-framework

Key Subjects and 21st Century Skills: Environmental Literacy

Materials:

Plant identification field guides
Student journals
Pencils
Magnifying lenses

Timeline

This is the first field investigation of the program, and will introduce students to the Lapwai Watershed and restoration initiatives of the tribe.

Modifications

Students can work in pairs to identify plants.

Prior

Students should have discussed and agreed to a code of conduct for behavior, participation, and interacting with other students.

Assessment

Assessment will take place during the post-program reflection activity.

Rubric

N/A

Evaluation

This field investigation was a great introduction to wetland restoration and the daily work of a watershed restoration specialist. However, apart from the plant identification activity at the end of the investigation, students had little opportunity to engage directly with restoration field activities. The specialist was concerned with having enough time to do the whole hike, and so we moved at a fast pace as she pointed out plants and their importance. Perhaps by providing less of a tour of the wetland trail and more opportunities for students to engage in hands-on field activities would enhance the experience for students. For example, allow students to investigate and compare two different areas of the wetland - one with native plants and one with invasives. Then allow them the opportunity to share their findings and discuss why restoration plays a role in water quality management for Lapwai Creek.

1.2.6 Lapwai Creek Investigation Lesson Plan

TRIO INSPIRE

STEM ACCESS science technology engineering math

Lapwai Creek Investigation

STEM Experts: Natasha Wingerter and Meghan Foard, graduate students in water resources at the University of Idaho

Rationale

Lapwai creek is located 10 miles east of Lewiston, ID and is a tributary of the Clearwater River. Land use activities within the Lapwai watershed like agriculture, logging, road construction, grazing, irrigation diversions, and floodplain development have impacted resident salmonid populations by altering natural hydrology and sedimentation – causing habitat destruction, fragmentation, and degrading water quality. This has led to many ecological problems such as low summer flows, fluctuating stream temperatures, increased flood events, sedimentation, fish migration barriers, riparian degradation, channel/bank instability, introduction of exotic organisms, and loss of salmonid rearing/spawning habitat (Rasmussen, 2007). In the Idaho Department of Environmental Quality's (IDEQ) Clean Water Act biennial water quality report (Section 305b) to the Environmental Protection Agency (EPA) in 2012, Lapwai creek was listed as an impaired stream (Section 303d) (33 U.S.C. § 1315(b)). The Lapwai watershed has been designated as a critical habitat for the Snake River Basin steelhead by the Endangered Species Act. Restoration initiatives have been underway to improve habitat to benefit various resident and anadromous species, and increase the potential of the Lapwai watershed for spawning and rearing in the Lower Clearwater River Subbasin (Richardson & Rasmussen, 2007). Lapwai creek restoration initiatives present an excellent opportunity for students to understand water resource issues, and possible solutions through restoration and water conservation.
Field site Location: Mission Creek (tributary of Lapwai Creek) 46.29130833 -116.7023444

Objectives

List what you want student to be able to do at the end of the lesson.

1) Students will be able to observe how fish behavior changes in response to the environment

2) Students will be able to identify fish in Lapwai Creek

3) Students will be able to collect and assess water quality data

4) Students will be able to collect and identify macroinvertebrates and make assessments of water quality based on the assemblage

Steps

Opening: Introductions -Natasha will answer questions from the STEM Expert Prep Sheet (e.g. what got you into science? Any obstacles?). Introduction to Lapwai creek and purpose of research. Brief description of rotations. Safety Talk - being near water, etc.

Main: Students will be divided into three groups, and rotate through three stations of 40 minutes:

1. Snorkel surveys- Nastasha will explain how and why snorkel surveys are done in the Lapwai Watershed.Then students will gear up and have the chance to do their own snorkel survey.They will write down their observations and make assessments of water quality based on their findings.
2. Water quality testing - Students will test and record water quality parameters including pH, oxygen, turbidity, phosphate, temperature as well as stream velocity and habitat assessment. Each student or pairs of student are given a parameter to measure. They will write down their measurements, share with the group, and make assessments of water quality based on their findings.
3. Macroinvertebrates - Students will learn about macroinvertebrates and their relationship to water quality by collecting and identify macroinvertebrates in the creek. They will write down what they find and make assessments of water quality based on their findings.

Closing: Students will share out their findings and any differences between groups will be discussed. Findings will be debriefed in regards to water quality, how our data is a snapshot in time, and how this data/research makes a difference for management decisions/community/ecology, etc. Specifically, implications for food availability of fish populations will be discussed, as well as discussion of restoration initiatives.

Standards

Idaho Content Standards

List 1-3 Idaho Standards applicable http://sde.idaho.gov/academic/standards, may include Common Core Standards http://www.corestandards.org/read-the-standards/

LS2-HS-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. • Further Explanation: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.

LS2.A: Interdependent Relationships in Ecosystems • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (LS2-HS-1, LS2-HS-2)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (LS2-HS-2, LS2-HS-6) • Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (LS2-HS-7)

Three Dimensions of Next Generation Science Standards (NGSS)

List elements of the Three Dimensions included https://www.nap.edu/read/13165/chapter/2#3, may include NGSS standards https://www.nextgenscience.org/search-standards

Scientific and Engineering Practices

3. Planning and carrying out investigations
4. Analyzing and interpreting data
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

P21 Framework for 21st Century learning

List elements of P21 Framework for 21st Century Learning included http://www.p21.org/our-work/p21-framework

Key Subjects and 21st Century Skills: Environmental Literacy

Materials:

List all materials needed for this lesson.

Students must bring swimsuits and towels!
Snorkels
Masks
Wetsuits
Iodine
Water quality testing kits and explanation guides
Macroinvertebrate collecting supplies - tubs, containers, magnifiers, ID sheets, nets,
Tape
Life jackets

Timeline

This field investigation takes place during the first week of the program, on the second day, and takes approximately two hours.

Modifications

Students who feel uncomfortable with the snorkeling can be given another job (e.g. writing down observations for the group, safety officer, etc.). Students can work in pairs at any of the stations.

Prior

Students should have discussed and agreed to a code of conduct for behavior, participation, and interacting with other students. Students will have learned about some restoration activities taking place in the Lapwai Watershed the day before during the wetlands investigation.

Assessment

Students will share something they learned at the end of the field experience. Assessment will also take place during the post-program reflection activity.

Rubric

N/A

Post-Program Evaluation of Lesson by Instructor

Much of the burden of logistical planning for this day's activity fell on Natasha. Natasha provided some materials she had access to through her lab such as waders and wading boots. I also borrowed materials from CDA water extension office such as water quality testing kits and macroinvertebrate sampling supplies. Meghan volunteering to help was crucial, as we needed a third person for a station rotations (Natasha and I each led a station).

Meghan and Natasha introduced themselves at the beginning, but we had gear to cart and a little bit of a walk so that time was cut short. I would have liked if I had prepped students ahead of time by having them read a blurb on each of their research or quick biography and come prepared with questions for them.

We allowed time for 30 minutes per station. John was put in charge of helping to keep track of time, which was extremely helpful. Kurt was to generally supervise as there were some potential safety concerns (steep bank, etc.). This was important because if anything were to come up with an individual student, he would be available to help.

Small groups are important for this type of activity. Students need to be actively engaged, and the more students in a group the easier it is to disengage and float into the background. Although logistically a little complicated, it was well worth it.

Student Engagement

My observations of student learning were that students were excited to tell me what they did in the previous station, and they were ready to get their feet wet and get hands-on with water quality testing. I had students record the data their group collected and reflect on what their results meant. Did it make sense for the context? It is important to situate the numbers, especially for abstract concepts like pH.

Possible Improvements

If we had more time, it would have been good to have all groups write their results on a whiteboard for everyone to look at and discuss any differences. As it turned out, there was little time for reflection or wrap up. We had time for students to share something they learned during the field activity.

1.2.7 Coeur d'Alene Basin Investigation Lesson Plan

TRIO INSPIRE

STEM ACCESS science technology engineering math

Coeur d'Alene Basin Investigation

STEM Expert: Kathleen Torso, graduate student in water resources at the University of Idaho

Rationale

Toxic metal contamination represents a global water quality issue that requires an interdisciplinary perspective to fully understand the complexity of this environmental stressor. This lesson will introduce students to the history of metal contamination in the Coeur d'Alene (CdA) Basin from a socio-ecological perspective. Specifically, this place-based lesson is intended to broaden the students' awareness of the primary water quality issue facing the CdA Basin from a biophysical, historical, and cultural perspective.

Objectives

Student will be able to...

1) Define toxic metals.
2) Diagram the biogeochemical cycling of metals within riverine and lake systems.
3) Explain (via journal entry and class discussion) the impact of toxic metals on water resources from a socio-ecological perspective.
4) Develop solutions to disseminate the implications of toxic metal exposure from a public health perspective.

Steps

In this activity, students will ride bikes from Harrison on the Coeur d'Alene trail to learn about metal contamination of the CdA basin.

1. Ride to the end of Anderson Lake
2. Ask students to write down their initial observes of the surroundings of the area.
    a. What water quality issues are present in this system?
    b. Do you think this area is impacted by any environmental stressors?
    c. If so, please describe.
3. Introduce the history of mining in the region.
4. Describe the physical system of the CdA Basin and relate the hydrologic, topographic, anthropogenic and climatic influence on metal mobilization.
5. State the amount of contamination present in the lower basin and lake CdA.
6. Travel to the middle of Anderson Lake.
7. Discuss the biogeochemical cycling of metals in the lower basin as related to natural hydrologic (spring flooding and lake turnover) and human induced (Post Falls dam) processes. Have students create a diagram of the cycling of metals in the lower basin.
    a. Riverine: spring flooding, boat traffic, erosion of bed and bank, anoxic deep meandering bends
    b. Lakes: Function of shallow eutrophic lakes (spring, summer, fall, winter)
    c. Human: Lake drawdown in fall

8. Describe macrophyte study at Thompson Lake.
9. Travel to Harrison Slough
10. Describe transport of metals to CdA lake system and role of Harrison Slough
11. Discuss impact of metals on socio-ecological system
    a. Public health.
    b. Cultural impacts to CdA Tribe.
    c. Aquatic and terrestrial food web and ecological function.
    d. Mitigation and remediation efforts by Tribe, State, and Federal agencies
    e. Current issues: recreational/tourism based industry, public health, ecological health, spread of metals into Rathdrum prairie aquifer via lake eutrophication.
12. Travel to Harrison and meet in park, return bikes

Closing: In teams of 3-4, students will create solutions for current signage issues by addressing the question: How can public health officials best reach public recreating in the contaminated lower river basin? Have students share their ideas with the group.

Standards

Idaho Content Standards

List 1-3 Idaho Standards applicable http://sde.idaho.gov/academic/standards, may include Common Core Standards http://www.corestandards.org/read-the-standards/

ESS3.A: Natural Resources • Resource availability has guided the development of human society. (ESS3-HS-1) • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (ESS3-HS-2)

ESS3.C: Human Impacts on Earth Systems • The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (ESS3-HS-3) • Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (ESS3- HS-4) • Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (ESS3-HS-5) • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (ESS3-HS-6)

ETS1.B: Developing Possible Solutions • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, environmental impacts. (ESS3-HS-2, ESS3-HS-4)

Three Dimensions of Next Generation Science Standards (NGSS)

List elements of the Three Dimensions included https://www.nap.edu/read/13165/chapter/2#3, may include NGSS standards https://www.nextgenscience.org/search-standards

Scientific and Engineering Practices
4. Analyzing and interpreting data
8. Obtaining, evaluating, and communicating information

TRIO INSPIRE

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P21 Framework for 21st Century learning

List elements of P21 Framework for 21st Century Learning included http://www.p21.org/our-work/p21-framework

Key Subjects and 21st Century Skills: Environmental Literacy

Materials:

Journals/pens/pencils

Timeline

This lesson takes place during the second week of the program, and requires approximately two hours.

Modifications

Students can work in pairs to create the heavy metal cycling model.

Prior

Students should have discussed and agreed to a code of conduct for behavior, participation, and interacting with other students.

Assessment

Assessment will take place during the post-program reflection activity.

Rubric

N/A

Evaluation

This lesson provided a great introduction to the legacy of mining activities in the CdA Basin and the impact on the chain lake ecosystem and human health hazards. This topic is challenging in that there is less opportunity for active engagement in science practices due to the concern of toxic metal contamination. However, this lesson had students actively engaged in biking, modeling the heavy metal cycle in the lower basin, and creating a solution to communicating human health concerns to the public. Students really enjoyed the biking and would liked to have biked farther. It was difficult for students to maintain engagement during some parts of the tour, so perhaps making the tour into a kind of 'scavenger hunt' or allowing for more opportunity for critical thinking would help students to engage more with the topic.

Appendix 1.3 - STEM Expert Questions

STEM Skills

What STEM skills do you use most often in your work?

Hands-On Learning

Can you share an example in your work that students could engage in hands-on?

Preparing for Life and College

What advice to you have for young people who are interested in this as a career?
What skills do I need for a position like yours?

Building a Professional Network

Please tell us a little about

- how you got to the job you currently do
- What recommendations you have for young people that want to do this kind of job
- Let us know if you would be ok for students to contact you for follow-up questions
- If you may be interested in providing an internship to students?

Financial Aspects

What are the cost and benefits of your work?

Taking on Responsibility

What kind of responsibilities do you have in your work?

Perseverance

Do you have a story of a challenge you have encountered in your work in STEM (science, technology, engineering, math)

Appendix 2: Supplementary Material for Chapter 2

Appendix 2.1 IRB Outcome Letter

University *of* Idaho
Office of Research Assurances
Institutional Review Board
875 Perimeter Drive, MS 3010
Moscow ID 83844-3010
Phone: 208-885-6162
Fax: 208-885-5752
irb@uidaho.edu

To: Brant G. Miller

Cc: Sarah Olsen

From: Jennifer Walker, IRB Coordinator

Approval Date: April 25, 2018

Title: Considering the Impacts of Authentic Science Experiences on Persistence in Science

Project: 18-082
Certified: Certified as exempt under category 1 at 45 CFR 46.101(b)(1).

On behalf of the Institutional Review Board at the University of Idaho, I am pleased to inform you that the protocol for the research project Considering the Impacts of Authentic Science Experiences on Persistence in Science has been certified as exempt under the category and reference number listed above.

This certification is valid only for the study protocol as it was submitted. Studies certified as Exempt are not subject to continuing review and this certification does not expire. However, if changes are made to the study protocol, you must submit the changes through VERAS for review before implementing the changes. Amendments may include but are not limited to, changes in study population, study personnel, study instruments, consent documents, recruitment materials, sites of research, etc. If you have any additional questions, please contact me through the VERAS messaging system by clicking the 'Reply' button.

As Principal Investigator, you are responsible for ensuring compliance with all applicable FERPA regulations, University of Idaho policies, state and federal regulations. Every effort should be made to ensure that the project is conducted in a manner consistent with the three fundamental principles identified in the Belmont Report: respect for persons; beneficence; and justice. The Principal Investigator is responsible for ensuring that all study personnel have completed the online human subjects training requirement.

You are required to timely notify the IRB if any unanticipated or adverse events occur during the study, if you experience and increased risk to the participants, or if you have participants withdraw or register complaints about the study.

Appendix 2.2: Original and Adapted Scales

Science Self-Efficacy Scale

Original	Flesch-Kincaid Grade level	Modified	Flesch-Kincaid Grade level
Please assess your ability to do the following science tasks, on a scale of 1 (not at all confident) to 5 (absolutely confident):	11.8	**Imagine you are doing a science research project. On a scale of 1 (not at all confident) to 5 (absolutely confident), how confident do you feel that you can do the tasks listed below?**	4.8
Use technical science skills (use of tools, instruments, and/or techniques)	5.8	Use science tools, instruments, and techniques	4.4
Generate a research question to answer	8.3	Come up with a research question to answer	4.3
Figure out what data/observations to collect and how to collect them	7.7	Figure out what data or information to collect and how to collect them	4.7
Create explanations for the results of the study	6.7	Explain the results of your study	4.4
Use scientific literature and/or reports to guide research	8.8	Use scientific resources to guide your research	5.6
Develop theories (integrate and coordinate results from multiple studies)	15.4	Compare your results with the results from other studies	6.2

Scientific Identity Scale

Original	Flesch-Kincaid Grade level	Modified	Flesch-Kincaid Grade level
Assess on a scale of 1 (strongly disagree) to 5 (strongly agree) the extent to which each statement is true for you.	9.6	**On a scale of 1 (strongly disagree) to 5 (strongly agree), how true is each of these statements for you?**	2.3
I have a strong sense of belonging to the community of scientists	6.7	I can see myself as a member of a group of people who do science for work or for fun.	5.7
I derive great personal satisfaction from working on a team that is doing	9.9	I like helping scientists do important research	7.3

important research			
I have come to think of myself as a 'scientist'	2.4	I have come to think of myself as a 'scientist'	2.4
I feel like I belong in the field of science	1.2	I feel like I belong in the field of science	1.2
The daily work of a scientist is appealing to me.	4.8	The daily work of a scientist is appealing to me.	4.8

Scientific Community Values Scale

Original	Flesch-Kincaid Grade level	Modified	Flesch-Kincaid Grade level
Rate how much the person in the description is like you for the following descriptions: [Choice options: "not like me at all," "not like me," "a little like me," "somewhat like me," "like me" and "very much like me"]	7.5	**Rate how much the person in the description is like you:** [Choice options: "not like me at all," "not like me," "a little like me," "somewhat like me," "like me" and "very much like me"]	3.7
A person who thinks it is valuable to conduct research that builds the world's scientific knowledge	8.3	A person who thinks it is a good thing to do research that builds the world's scientific knowledge.	6.5
A person who feels discovering something new in the sciences is thrilling	7.7	A person who thinks it would be exciting to discover something new in science.	7.5
A person who thinks discussing new theories and ideas between scientists is important	10.3	A person who thinks that scientists should share and discuss new ideas with others.	5.8
A person who thinks that scientific research can solve many of today's world challenges	8.4	A person who thinks that scientific research can help solve many of the world problems we face today.	7.8

Intention

Original	Flesch-Kincaid Grade level	Modified	Flesch-Kincaid Grade level
On a scale of 0 (definitely will not) to 10 (definitely will)		On a scale of 0 (definitely will not) to 10 (definitely will)	
To what extent do you intend to	7.6	At this point in time, how likely is it	6.3

pursue a science related research career?		that you will pursue a science related career?	

Appendix 2.3 Interview Guide

Time of interview:

Date:

Place:

Interviewee:

Thank you for taking the time to answer some questions for me! I am interested in how you think the first three weeks of the summer program impacted your ideas about science. Your thoughts on the program are very valuable to Upward Bound. Based on your responses (and the responses of others) I will write a report that will inform the Upward Bound program so they can deliver quality programming. I can share the report and/or the typed up version of the interview which is called the transcript with you if you are interested, just let me know.

You can stop the interview at any time and for any reason, and you don't have to answer all the questions if you don't want to. The results of the interview are anonymous, your name and any identifiers will not be used in any reporting, and a pseudonym (fake name) will be applied to the interview data. The interview will take about 15-20 minutes. Is there anything you'd like to ask before we get started?

[Optional] What is science?

When we say science, we can mean a lot of different things. I am going to share with you one definition of science that captures what I mean when I use that word during this interview:

Science is a creative process of investigating the world. Depending on the investigation, science can involve:

- *making observations;*
- *posing questions;*
- *examining sources*
- *planning investigations;*
- *using tools to gather, analyze, and interpret data;*
- *proposing answers, explanations, and predictions;*
- *reviewing what is already known in light of experimental evidence;*
- *and communicating the results. (Based on NRC, 2000, p. 20).*

Identity

1. Please share about times during the summer program when you felt like a science person.

2. Please share about times when others saw you as a science person.

Self-efficacy

3. How did the summer program change your ability to use tools to test water quality?

4. How did the summer program change your ability to investigate a research question?

5. Do you think you would make a good scientist? Why or why not?

6. How do you think the summer program influenced your feelings toward science?

Science Values

7. Which science-related careers that you encountered during the program did you feel were particularly worthwhile? What about them makes them worthwhile to you?

8. In your opinion, how important is the work of the scientists we met during the program?

Belonging

9. During the summer program, how did you feel like your ideas were valued and accepted?

Intention

11. What did you learn in the summer program that you might apply in the future?

12. What do you think prevents some people from pursuing science?

13. What kinds of things factor into your decisions to pursue science in the future?

14. How do you think the summer program influenced your interest in pursuing science in the future?

15. Is there anything else about your experiences with science during the summer program that you would like to share?

Appendix 2.4 Parental Assent Form

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Important Information Regarding the STEM Access Activities Impact Study—Please Read

Dear Parent/Guardian:

The Upward Bound STEM Access summer programs will be part of an important study called *Considering the Impacts of Authentic Science Experiences on Persistence in Science,* led by researchers from the University of Idaho STEM Access project. This study investigates how we can improve activities for youth designed to increase the student's understanding of and preparedness for careers in science, technology, engineering, and math (STEM). As part of the study, students will complete surveys and interviews about the program and science.

What am I being asked to do? Please read this form then decide whether or not your child may participate in the study.

What is my child being asked to do?

- All STEM Access Activity participants complete a pre- and post-survey during the activity to better understand their learning and provide feedback. Your child' survey will only be used for this study IF allowed by you.
- We may ask your child to be interviewed by researchers, IF allowed by you.
- We may ask your child to participate in a group interview (focus group), IF allowed by you.
- Some parts of the activities may be videotaped or pictures taken. The images will only be used for this study, IF allowed by you.

What data was my child asked to provide?

- The survey asks students to provide their birthdate. Keeping this information would allow to assess the project's potential impact onto college participation and degree attainment, by long-term educational tracking, IF allowed by you.
- The survey asks students to provide some demographic information (grade level, gender, race/ethnicity, parents having Bachelor's degrees or not, the student's perception if/if not the family has limited financial resources, and attendance of educational programs by the student. The study will only use demographic data your child provided IF allowed by you.

Is my child's information private? The researcher will remove your child's name from the study's assessments and interviews and replace it with an identification number. All information will be stored with an ID number and not a name. Consent forms and a list that has the students' name and ID number will be kept in a secure location together with the participant's registration and waiver, separate from the assessment data, such as surveys or interviews.

What are the risks to my child? We do not anticipate any risks to your child related to his or her participation in this study. Students may feel shy or self-conscious when staff is taking video footage; staff are instructed to not take video footage or pictures if students voice the preference to not be filmed.

How will this information be used? Student data will be used to evaluate the STEM Access activities—it will NOT be used to evaluate students. Research analysis findings will be included in articles, presentations, or professional development workshops for educators. Your child's name will not be used in any research articles or presentations. The video recordings may be included in

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professional development materials with educators. These curriculum materials may be presented, displayed, and distributed using various media including but not limited to film, still photographs, Internet postings, DVDs, and other electronic media. The University of Idaho will own all copyrights to the videos.

What are the benefits to my child? Your child may not directly benefit from participating in the survey or interview, but the participation in the STEM Access summer program is specifically designed to benefit the participants, geared to provide hands-on learning about various aspects of STEM careers, delivering a range of content and skills knowledge in science, technology, engineering, and math (STEM).

Is this voluntary? YES, your child's participation in the study is completely voluntary. You may withdraw your child from the study at any time. **If you DO NOT want your child to participate in the research study, sign page 2 of this letter and return it in the enclosed self-addressed envelope.**

Who do I call if I have questions? If you have questions about this study, please contact Kirsten LaPaglia at the University of Idaho at (208) 885-5819 or kirsten@uidaho.edu. If you have further questions regarding your child's rights as a participant, or any concerns regarding this project, or any dissatisfaction with any aspect of this study, you may report them—confidentially, if you wish—to the University of Idaho Institutional Review Board at (208) 885-6162.

University of Idaho

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Parents/Guardians: Signing this form means you **DO NOT** give permission for your child to participate in the parts of the research study that you initial below. You can decline some aspects of the study and not others.

If **you would like for your child to participate** you do not need to return the attached form. However, you should keep these materials for your records.

As part of the STEM Access Summer Program study:

☐ My child's activity surveys may **not** be evaluated for research

☐ My child may **not** be interviewed by researchers

☐ My child may **not** appear in the collected pictures or videos

☐ My child's information may **not** be collected for long-term educational tracking to better understand college go-on rates or degree attainment

☐ My child's demographic responses may **not** be used for this study.

Please print clearly.

___________________________	_______________________________	_______
Child's Signature	Child's Printed Name	Date
___________________________	_______________________________	_______
Parent/Guardian's Signature	Parent/Guardian's Printed Name	Date

If you choose not to participate in any aspect of this study, please mail the form with the prepaid envelope was provided.

If you agree that your child may participate in all aspects of the study listed above, you do not need to return this form.

Questions? Contact us at
stemaccess@uidaho.edu | 208-885-5819

Appendix 2.5: Scientific Literacy Rubric

SCALE
Stanford Center for Assessment, Learning, & Equity

PERFORMANCE ASSESSMENT RESOURCE BANK

SCIENTIFIC LITERACY RUBRIC

SCORING DOMAIN	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
ARTICULATE A SCIENCE-RELATED ISSUE *What is the evidence that the student can articulate a clear issue and explain the connection between the issue and science content?*	• The scientific, social or technological significance of the issue is unclear • Science content contains inaccuracies		• The scientific, social or technological significance of the issue is general with major gaps and leads to readily available answers • Science content is accurate and makes general connections to the issue		• The scientific, social or technological significance of the issue is specific with minor gaps and leads to readily available answers • Science content is accurate and discusses specific connections to the issue		• The scientific, social, or technological, significance of the issue is specific and comprehensive and leads to a challenging research project • Science content is accurate and includes a clear, detailed, and relevant discussion of the connection to the issue
MAKE A CLAIM *What is the evidence that the student can develop a claim?*	• Makes an unclear claim or irrelevant claim.		• Makes a general and relevant claim with major lapses throughout the text.		• Makes a clear, specific, and consistent claim with minor lapses throughout the text.		• Makes a clear, specific, consistent, and logical claim throughout the text.
IDENTIFY EVIDENCE *What is the evidence that the student can use evidence (textual, data, and/or multi-media) relevant to the claim?*	• Refers to evidence that is unclear or irrelevant to the claim. • Refers to inconsistent evidence that is irrelevant or unclear.		• Identifies limited or general evidence relevant to claim. • Mentions inconsistent evidence or counterclaims relevant to the claim.		• Identifies (cites) specific evidence relevant to claim. • Identifies (cites) inconsistent evidence or counterclaims relevant to the claim.		• Identifies (cites) and explains comprehensive, detailed evidence relevant to claim. • Identifies (cites) and explains inconsistent evidence and the relevant to the claim.
JUSTIFY THE CLAIM *What is the evidence that the student can analyze evidence to justify their claim and address counterclaims?*	• Analysis of evidence to justify the claim is missing, inaccurate, or unclear. • Analysis of counterclaim evidence to justify the claim is missing, inaccurate, or unclear.		• Analyzes and synthesizes evidence from multiple sources and used to justify the claim with major errors. • Analyzes and synthesizes counterclaim evidence from multiple sources to support or refute the claim with major errors.		• Analyzes and synthesizes evidence from multiple sources and used to justify the claim with minor errors. • Analyzes and synthesizes counterclaim evidence from multiple sources to support or refute the claim with minor errors.		• Analyzes and synthesizes evidence from multiple sources and used to accurately justify the claim. • Analyzes and synthesizes counterclaim evidence from multiple sources to support or refute the claim.

SCORING DOMAIN	EMERGING	E / D	DEVELOPING	D / P	PROFICIENT	P / A	ADVANCED
EVALUATE THE ARGUMENT *What is the evidence that the student can evaluate the argument?*	• Identifies the strengths OR limitations of the argument are unclear or missing.		• Identifies and evaluates the strengths OR limitations of the argument with major errors.		• Identifies and evaluates the strengths AND limitations of the argument with minor errors.		• Identifies and evaluates the strengths AND limitations of the argument.
ORGANIZATION *What is the evidence that the student can clearly communicate their argument to the intended audience?*	• Argument(s) are unclear or missing. • Language and tone are inappropriate to the purpose and audience		• Arguments(s) are disorganized, underdeveloped and/or loosely sequenced with major transition gaps • Language and tone are appropriate to the purpose and audience with major lapses.		• Argument(s) are organized, sufficiently developed and logically sequenced with minor transition gaps. • Language and tone are appropriate to the purpose and audience with minor lapses.		• Argument(s) are organized, well developed, and logically sequenced. • Language and tone are appropriate to the purpose and audience.
CONVENTIONS *What is the evidence that the student can accurately use scientific conventions* to communicate ideas to others?*	• Citations within text and/or list of references or bibliography are missing. • Norms and conventions of scientific writing are missing.		• Citations within text OR list of references/bibliography are incomplete and/or inconsistent in format. • Follows the norms and conventions of scientific writing with major errors.		• Citations within text AND list of references/bibliography are complete and consistent in format with minor errors. • Follows the norms and conventions of scientific writing with minor errors.		• Citations within text AND list of references/bibliography are complete, consistent in format, and accurate. • Follows the norms and conventions of scientific writing accurately.

* Scientific conventions refers to the use of scientific or technical terms, visual representations, or data (qualitative or quantitative)

Appendix 3: Supplementary Material for Chapter 3

Appendix 3.1: Role of the Evaluator

Positionality

The concept of 'insider/outsider' positionality is useful in describing my relative relationships with SAUB staff and participants. Insider research is the study of one's own social group, or a group with which the researcher has past experience. Outsider research is conducted by those who do not have pre-existing knowledge of the community under study, nor its members (Greene, 2014). This positionality, or where one stands in relation to the other, exists on a spectrum and can be related to cultural values, norms, experiences, and can shift through the research process. Insider-leaning research is quite common in education, and is known as practitioner inquiry (Greene, 2014). Insider research can have advantages and disadvantages. Advantages of insider research are contextual knowledge which can allow the researcher to ask more meaningful questions and project a more truthful and authentic understanding of the group under study. In particular, interaction with participants may be more natural if the researcher has developed relationships, and the researcher may be better able to see past biases and stereotypes. In my work with SAUB, my positionality shifted from outsider toward insider as I worked for the program longer and came to know students on a more personal level. Greater understanding of the inner workings of the program, and relationships with students deepen my interpretation and contextual knowledge. However, a critique of insider research is subjectivity, whereby the perceptions of the insider are limited by familiarity, leading to assumptions. Reflective practice (Schon, 1987) and analysis of positionality are important aspects of addressing bias and assumptions, and their influence on data interpretation.

The American Evaluation Association's *Guiding Principles for Evaluators* (2018) urges evaluators to mitigate the bias and potential power imbalances that can occur as a result of the evaluation context, stating that evaluators should "self-assess one's own privilege and positioning within that context." As a White cisgender (identifying with birth gender) woman born in the United States, I have linguistic, racialized, and gendered identities aligned with those of the dominant majority in the field of education, which grants me access, status, and privilege based on my appearance alone. At the same time I experience marginalization as a female researcher in interdisciplinary sciences interested in the "social" side of science, such as science education, outreach, and communication. I must acknowledge the ease in which I came into my position as instructor/evaluator due to my privilege, and the ways in which this is problematic, given that I do not represent the population of students with whom I worked. In particular, this is problematic given the histories of White oppression and othering of groups determined to need 'assistance' and 'help' to meet the norms of the dominant culture. Given my positionality, it is critical that my process avoid the 'deficit' approach which assumes that the student population is 'less than' while disregarding points of strength, as well as an overly cheery narrative which glosses over important socio-cultural issues (Tolbert, Schindel, & Rodriguez, 2018). Critical reflection involves acknowledging my own involvement in perpetuating oppressive practices, rather than taking the position of the enlightened outsider who knows better. Reflexivity through explicit discussion of preconceptions and biases in the context of the research is an important part of the evaluation process.

Situating oneself socially and emotionally in relation to participants is a critical part of reflexivity (Mauthner & Doucet, 2003). Educators inherently have a level of social distance from participants, as well as unequal power dynamics. However, the summer program environment was different from the typical classroom environment in that there was a smaller group of participants who had chosen to be there, it took place during the summer, and students were not being graded or judged by me. I cared deeply about creating a positive experience for students, and so my principle concerns were their safety, happiness, and engagement. I was constantly reading the group and adjusting programming based on their needs. We spent considerable time getting to know each other as a group, building teamwork skills, and playing games. This also contributed to the positive social norms we established, for example we ended every day by revisiting our group values and recognizing individuals who exemplified those values throughout the day. The culture of the program was of positive reinforcement and inclusivity rather than critique, punishment, or othering. My personality and leadership style are relationship-based, and I tend not to dominate any situation unless necessary (e.g. for facilitation, safety, or boundary-setting, purposes for example). I prefer consensus decision-making when possible, therefore, student voice and input were often included. Students also had complete control of their project topics, and their research ideas were respected and refined rather than changed.

In terms of how I was perceived by students, as a White, educated female, I was likely both familiar (in that this represents the norm among teachers) and different (may be dissimilar from their family members). In addition, not having grown up in the area means I was likely perceived as a community outsider to students. Although I invested time during lunch or breaks to get to know students personally, I was not 'one of them' in any sense due to differences in age, background, and position. However, I did become familiar with who they were, their likes and dislikes, their interests and goals, their pastimes, their family life, and their personality characteristics. I developed friendly rapport with most students so that they felt comfortable coming to me to chat, ask questions, or express concerns. This familiarity and relationship building developed throughout the program means my positioning on the insider-outsider spectrum likely shifted from outsider to somewhere in between outsider and insider by the end of the program. As a staff member for SAUB, I experienced a similar movement from outsider to insider. Having worked for and alongside program staff for a year, being present at weekly staff meetings and collaborating on many projects, I am now closer to an 'insider', however the temporary aspect and nature of my position prevented me from becoming a true insider.

Bias

As a white female PhD student passionate about science education, I bring certain biases to this evaluation. My life experience allows me only partial insight into the lives of the student participants who are predominantly low-income and first-generation. My parents both attended college, and despite a low family income, I had access to high quality education and opportunity in the community where I grew up in California. I studied science in college, and was often aware of the gender divide in my classes. The 'weeding out' strategy of the hard sciences felt unjust and exclusive, but through peer mentoring I managed to make it through my program. As an educator I am concerned with student empowerment through learning, and as a researcher I am interested in how students develop confidence, skills, and identity through particular learning contexts. My personal beliefs about how enrichment opportunities, experiences of empowerment, and belongingness help to shape a students' academic trajectory influence what I identify as important. As an evaluator, I must critique my own values, and be aware of my biases. Reflexivity through explicit discussion of preconceptions and biases is common in qualitative research and therefore in evaluation, which inherently involves some social complexity.

My dual roles as instructor and evaluator inherently lead to some degree of bias and conflict of interest which must be acknowledged. I acknowledge that as the instructor I had a vested interest in student success, and that this is both an avenue for bias (in terms of looking for that success rather than issues) as well as insight (in terms of my intimate perspective of how to improve student experience). However, due to the justice-oriented nature of Upward Bound Math Science program (addressing equity in educational opportunity) and the goals of this evaluation, I believe my dual roles to be a strength, while also taking steps to ensure robustness in method, analysis, and interpretation (addressed below). For this type of work, I believe the strengths of relationships I developed with students and staff enhance my ability to find and express a credible truth, rather than cloud it. To be useful, this evaluation cannot depersonalize the student participants for whom the program exists to serve through numbers alone, because the understanding of human experience requires relationships to be trustworthy. However, I don't believe there is a single truth, and my perspective, however biased or credible, is just one interpretation. It is ultimately up to the readers to assess the usefulness of this evaluation for their own purposes and context.

Appendix 3.2: Case Description

A case study approach provides an in-depth description and analysis of a particular aspect of a program to understand what is happening and why (Yin, 2011). A case study goes beyond description and helps explain real life interventions that are too complex for survey research alone to capture. Case studies create tacit knowledge, and as more are contributed, they can be weaved into a theory over time (Yin, 2011). Evaluative case studies don't require controls of treatments, as they investigate programs as they naturally occur, often through triangulation of methods (Stufflebeam, 2001). By examining a program's internal workings and how they produce outcomes, an evaluative case study can provide in-depth explication of a program (Stufflebeam, 2001).

Definition of the 2018 Watershed Science Summer Program

The three-week summer program involved youth in a variety of activities designed to develop their science skills, science identity, and feeling of inclusion in the science community. Activities included: developing a research proposal for a community-based project of their choosing; collecting data with graduate students in STEM fields; being mentored by graduate students in science; service learning; teaching younger students newly acquired science skills; presenting their research proposal to a broader audience; and exploring STEM careers in the local community through field experiences (see Chapter 1 for more description). Students were not evaluated on their performance in the program as in the typical science classroom. Rather, students were invited into science experiences, allowing them to practice science without the pressure to perform or be judged in relation to their peers. This emphasis on trying out new experiences was embedded in the culture of the program and the types of activities chosen (for example kayaking, biking, snorkeling), which also supported a growth mindset toward science skill development. Exposure to STEM careers, research, and training is a critical component the UBMS goal of encouraging students to pursue postsecondary degrees and careers in math and science, and thus a variety of field experiences and STEM professionals were included in the program. For more information about the program participants and the program's underlying logic of operation, see chapter 1.

Background of STEM Access Upward Bound

Upward Bound Math-Science is a federally-funded program created to address the need for specific support in the fields of math and science for low-income and first-generation students, and to encourage students to pursue postsecondary degrees and careers in math and science (U.S. ED, 2009). UBMS works to meet these goals through a variety of programming, including summer programs with intensive math and science training, year-round counseling and advising, exposure to university settings and faculty research, and participant conducted research under the guidance of faculty or graduate students. In addition, the program works to improve financial and economic literacy, enhance college readiness, and otherwise meet the needs of the underserved students in the program. In 2018 there were 213 individual UBMS programs affiliated with institutions of higher learning. Upward Bound Math Science at the University of Idaho is called STEM Access and is the context of for this case.

Educational attainment in Idaho lags behind the rest of the nation in terms of graduation rates for high school and college. Idaho is among the states with the lowest high school graduation rates, with 20% of the students who enter ninth grade failing to graduate (McFarland et al., 2018). Disadvantaged and minority students in Idaho are at higher risk of drop out. For students in poverty the graduation rate was 71.9% in 2016, for Hispanic students it was 73.7%, and for students with disabilities it was 60% (Ed Trends Report, 2018). For those who do graduate high school, less than half go on to higher education. In 2016, only 45% of Idaho teens went to a college, university, or trade school, placing Idaho well below the national go-on rate of 69% (McFarland et al., 2018). Those who do choose to enroll in college may end up leaving empty-handed. A recent National Student Clearinghouse report found that only 50% of Idaho students who enter four-year public institutions graduate within six years, compared with the national rate of 64.5% (Shapiro et al., 2019).

In addition to issues of educational attainment, Idahoan students are presented with education barriers due to the cultural context of the state. Idaho is a religiously and politically conservative rural state which faces economic challenges. Rural youth are less likely to attend college than youth from metropolitan areas (Herzog & Pittman, 1999). High rates of poverty, long distances to colleges, and lack of educational role models present obstacles to education for rural youth (Grimard & Maddaus, 2004). The sociopolitical context of Idaho has implications for K-12 STEM education in particular. Mihelich, Sarathchandra, Hormel, Craig and Storrs (2015) found that more politically and religiously conservative Idahoans were less supportive of STEM education measures, which may also affect their students' engagement with STEM.

The Physical Setting in Which the Case is Bounded.

The summer program took place June 11-30, in North Idaho during the first two weeks and in Southeast Utah for the third week. In North Idaho, programming took place in the Lewiston-Clarkston Valley and in the Coeur d'Alene lake area. The programming locations were chosen for their proximity to the home communities of student participants. STEM Access Upward Bound serves students in the Lewiston-Clarkston Valley, and additional students from the Upward Bound

Benewah Latah County program participated in the 2018 summer program as well. Students came from Lewiston area, Asotin, Potlatch, and Plummer.

The town of Lewiston is situated on the Snake River at the base of the Idaho panhandle and considered North Central Idaho. The population of the Lewiston-Clarkston Valley which includes Nez Perce County in Idaho and Asotin County in Washington was 60,888 in 2010, which classifies it as a Metropolitan Statistical Area, meaning an urbanized area of 50,000 or more with adjacent territory with social and economic ties (United States Census)

Historically, North Central Idaho's economy was driven by forest and agricultural products. The manufacturing sector is growing and includes ammunition, guns, jet boats, lumber, and paper mills. The University of Idaho, Nez Perce Tribe, Forest Service, Lewis-Clark State College, and fish hatcheries are among the largest employers in the region (Idaho Department of Labor). The Port of Lewiston is navigable for barges and is the most inland seaport in the U.S., transporting paper, lumber, and grain up and down the Columbia River. In Nez Perce county - 92% of adults 25 and older had a high school diploma, and 22.7% had a bachelor's degree or higher. The median household income is $51,804 and 12% of the population lives in poverty. 89.9% white, 6% Native American, 3.9% Hispanic or Latino, and 2.6% two or more races, with less than one percent Black or Asian.

Potlatch is located in Latah County, which is characterized as a nonmetropolitan area with a population of 20,000 or more. The population of Potlatch was 804 in 2010. Formerly a company sawmill town, it is now a bedroom community for the University towns of Moscow and Pullman.

Plummer is the largest city within the Coeur d'Alene Tribal Reservation, with a population of 1,044 in the 2010 census. It is 42% Native American and 45.7% white, and 9.8% two or more races. It is a nonmetropolitan area with an urban population between 2,500 and 19,999. In Benewah County, 14% of the adult population over 25 holds a bachelor's degree, the median household income is $43,310 and 16.5% are living in poverty.

Geographically, North Central Idaho is isolated from Southern Idaho, and occupies Nez Perce and Coeur d'Alene tribal land. Politically, North Idaho voted 64% Republican, 26.4% Democratic, and 9.3% third party in the 2016 Presidential election (U.S. Election Atlas).

Appendix 3.3: Key Roles Involved in the Program

Director - The director oversees all aspects of SAUB program activities.

Outreach Coordinators - Outreach coordinators work closely during the school year with students, providing advising and tutoring in their schools. They also plan activities and work during the summer to staff programming.

Program Instructor, Program Evaluator, Research Assistant - I worked closely with the SAUB team to create an intentionally integrated summer learning experience with student-relevant results. My specific responsibilities were to design the course curriculum in coordination with the director, identify and organize the necessary materials for course delivery, construct specific lessons with objectives and goals serving the overall expected course outcomes, identify appropriate locations for lessons, and plan for assessment. I conducted evaluation of the program as part of my dissertation work, and the following academic year I served as a research assistant for the SAUB program.

Scientists - Scientist partners played a key role in co-designing curriculum for field experiences and implementing the curriculum. Together we identified program activities, selected appropriate learning objectives, and planned logistics.

Student Participants - SAUB participants are highly encouraged to participate in summer programming, but it is ultimately optional. They range in age from rising Freshman to Seniors.

Appendix 3.4: Evaluation Design and Methodology

Trustworthiness of the Evaluation

Questions of validity, or trustworthiness of the study must be addressed to ensure transparency, reliability, and ultimately usefulness of the findings. Here I will address the concern the credibility of the research- which relate to the alignment of methods with evaluation questions through an appropriate study design, richness of data through appropriate methods, challenging biases and assumptions, addressing accountability, and issues of validity.

Study Design

Evaluations concerned with effectiveness, and insight into aspects of programming which contribute to outcomes must seek a full understanding of what participants' experiences entail. Such a design must allow for the emergence of unexpected findings, while also justifying the links between evaluation questions, design, and methods (Fu, Peterson, Kannan, Shavelson, & Kurpius, 2015). A case study approach was appropriate for the evaluation because it can address the question of effectiveness by providing tacit knowledge into what is happening and why in a real-life context (Yin, 2011). By examining a program's internal workings and how they produce outcomes, an evaluative case study can provide in-depth explication of a program (Stufflebeam, 2001). Evaluative case studies don't require controls of treatments, as they investigate programs as they naturally occur, often through triangulation of methods (Stufflebeam, 2001).

To understand aspects of participant experience as complex as identity, deep and descriptive data is needed, making qualitative methods an appropriate fit. To measure the effect of an intervention a quasi-experimental design was used to compare measurements from before to after the program using a standardized instrument, which can also be used to compare across programs and years. A mixed-methods investigation gathers both quantitative and qualitative data and integrates the data to draw interpretations based on the strengths of each to understand the research problems (Creswell, 2014). According to the fundamental principle of mixed research, a combination of methods that has complementary strengths and nonoverlapping weaknesses can increase the quality of the research because the strengths and weaknesses of each make it less likely that the researcher will come to false conclusions (Johnson & Christensen, 2008). In addition, mixed methods research can help researchers, "incorporate safeguards into their inquiries in order to minimize confirmation bias and other sources of invalidity (or lack of trustworthiness) that have the potential to exist in every research study" (Johnson & Onwuegbuzie, 2004, p. 15).

This evaluation used social influence theory to understand how students integrate into science and formed the basis of the theory of change. Theory-based evaluation can help to strengthen validity when random assignment is impossible, by examining the mechanisms that mediate between processes and outcomes to understand how programs work (Weiss, 1997). Similarly, Cook (2000) argues that when theory-based evaluation techniques are used together with experiments they "focus needed attention on what the program theory is, what level of program implementation is obtained, which presumed causal mediation processes actually change, and how this variation in implementation quality is related to variation in distal outcomes" (p. 29).

Challenging Bias and Assumptions

Several methodological steps were taken in data collection and analysis to control for bias. For example, previously validated scales were used and analyzed with standard statistical methods. Peer debriefing of qualitative findings was used to ensure that external others supported the conclusions of the research. In many aspects this evaluation was participatory, in that SAUB staff contributed to evaluation questions, development of the interview guide, and peer debriefing, which ensured multiple perspectives throughout the evaluation process. Some methods to check my potentially biased interpretations include using mixed methods, utilizing theory and experimentation, triangulating the data, and peer debriefing. I used reflective journaling throughout the analysis process and peer discussions to create distance and deconstruct the familiar as strategies to avoid bias and assumptions (Van Heugten, 2004). I also authentically and centrally embedded participants' voices in the findings and conclusions of the evaluation (Tolbert, Schindel, & Rodriguez, 2018).

Accountability

The *Guiding Principles for Evaluators* (2018) states that evaluators should "Recognize and balance the interests of the client, other stakeholders, and the common good while also protecting the integrity of the evaluation." Asking how the evaluation benefits all parties is critical for accountability. Working with Upward Bound staff on program design and evaluation questions and processes helped to enhance contextual relevance and appropriateness of the program and evaluation. By undertaking a comprehensive evaluation, SAUB is being responsive to the changing needs and requirements of students. I have a responsibility in my reporting to highlight issues and opportunities to improve programming to ultimately benefit student participants. I must also reflect on whether or not the program was truly beneficial for all participants. Incorporating student voices in the findings helps to ensure accountability in this regard. There is also room for improvement in this respect in that future programming can involve students in the evaluation process to a greater extent, so that it is in relationship with participants, rather than preset by a researcher or program staff. This may also help to create more socially just research relationships and roles (Tolbert, Schindel, & Rodriguez, 2018).

Quantitative Validity/Reliability

In terms of quantitative validity, using previously validated instruments strengthens the measurement validity because it ensures that I measured the concepts I intended to measure. Limitations of the study design are the small sample size, lack of control group, and convenience sampling, which are threats to external validity and prevent the transferability of the findings to other contexts. Nonparametric analysis was the best fit for the data, however the small sample size threatens the statistical conclusion validity, meaning there is a greater chance of coming to false conclusions. Therefore, findings can provide insight into program impacts rather than draw causal conclusions. Additional potential threats to internal validity include testing effects, regression effect, selection effects, and external events/influences. Participants may not have answered the questions honestly or may have felt pressure to provide socially-desirable responses. It is also possible that I did not collect enough or the right kind of data, or in a way that reduces dependability. Internal validity, however, is somewhat enhanced by qualitative findings and triangulation (Weiss, 1997).

Qualitative Validity

In quantitative research, validity presupposes that there is a singular truth one is trying to approximate (Savin-Baden & Major, 2013). Qualitative research often takes a broader view of reality and thus what makes for quality research, and there is no single set of agreed upon criteria by which it is judged. Internal validity (How do my finings match reality?) and external validity (How true are the results for other cases?) are still relevant for some qualitative research, and more recently developed criteria include criticality, reflexivity, honesty, integrity, and verisimilitude (Savin-Baden & Major, 2013). I'll first discuss the limitations of the data and process, and then address the ways I sought to mitigate those threats, drawing upon a mixture of these criteria most relevant to this study.

Limitations of the qualitative side of this research are the natural subjectivity involved in interviewing. For example, since one's identity is not fixed, we may talk about it in different ways from one day to another. This limits the reliability, or reproducibility of the data. Another limitation is the power imbalance between me and students, which may have made students feel less comfortable telling the truth, for example students may have provided responses they felt would be more socially desirable. In addition, students may not have given accurate responses for many other reasons, including their own confusion on a topic given that they are young and still very much developing their sense of who they are how they think about the world. Three months passed between and the program and when I interviewed students, which presents a maturation threat. While 10 out of 14 students were interviewed, this may not have been sufficient to capture all possible perspectives or may provide an incomplete picture of student experience. My interpretation of the data is subjective, and my ultimate findings and conclusions are influenced by my worldview, life experience, interests, and other eccentricities.

Data Collection

I employed practices such as standardizing how I described the interview process to students, how I asked questions, following an interview protocol, and trying not to influence student responses. I also recorded the interviews and transcribed them. Before interviewing students, I made it clear that the purpose was not to judge them but rather to better understand the program, and that their responses would be anonymous. I encouraged students feel comfortable sharing critical reflections, and to answer openly and honestly. I interviewed a majority of participants in order to capture a wide range of perspectives.

Analysis

In the coding process, I attended to both a priori (concepts identified through the literature, enhancing theoretical validity) and in vivo codes (participant-derived concepts), and went through two rounds of coding. I journaled throughout the analysis and interpretation process to record thought development, which served as an audit trail and record of the process. I engaged peers with some knowledge of science education in peer debriefing (also known as dialogic engagement) to ensure that my findings were plausible based on the data. I utilized external auditing with program staff who were present during the summer program to ensure my findings were reasonable from their perspectives, enhancing confirmability.

Communication

I provide a positionality statement and adequate description of the context, study, and findings to provide transparency and allow others to develop meaning. I triangulated findings with quantitative data to enhance my conclusions. In my conclusions I paid particular attention to relevance to emphasize the importance of the research in context (Savin-Baden & Major, 2013).

Measurement

Previously developed scales by Estrada et al. (2011) measuring scientific self-efficacy, scientific identity, scientific community values, behavior, and intention were adapted to be more appropriate for the reading level of 14-18-year-olds. The Flesch-Kincaid readability score was used as an indicator of readability. The adapted versions of the scales were field tested prior to use, and authors who had previously used the scale were consulted for expert review and to ensure the meaning of the items remained intact. Scales can be found in Appendix 2.2.

Scientific self-efficacy scale.

Estrada et al. (2011) created a six-item scale from Chemers' (2006) original 14-item scientific self-efficacy scale. The modified scale had high internal consistency ($\alpha = .91$). On a scale of 1 (not at all confident) to 5 (absolutely confident), the scale asks participants to assess their ability to function as a scientist in scientific inquiry tasks.

Scientific identity scale.

Estrada et al. (2011) modified Chemers' (2006) Scientific Identity scale, containing 5 items, and the resulting scale had a high internal consistency ($\alpha = .86$). The scale asks participants to assess on a scale of 1 (strongly disagree) to 5 (strongly agree) the extent to which a series of statements is true of them.

Scientific community objectives value scale.

Estrada et al. (2011) developed a new scale to assess the extent to which participants valued the objectives of the scientific community, because none was yet created. They validated the reduced the items through pilot testing, and the resulting 4 item scale had high internal consistency ($\alpha = .85$). The scale asks participants to rate "how much the person in the description is like you?" Response options included "not like me at all," "not like me," "a little like me," "somewhat like me," "like me" and "very much like me."

Intention.

Estrada et al. (2011) measured the level of integration into the scientific community by asking each participant to rate on a scale of 0 (definitely will not) to 10 (definitely will) their intention to pursue a science related career.

Interview Guide.

Open-ended questions were co-developed with Upward Bound program coordinators based on the themes of the research that include feelings of identity with science, sense of belonging, interest in science, educational and career goals, the program experience, and ongoing challenges and obstacles with science. Similarly, Hurtado et al. (2009) developed a semi-structured focus group protocol that broadly addressed thematic categories that included developing an interest in science and subsequent educational and career goals, understanding the role and requirements of a scientific research career, the program experience, and ongoing challenges and obstacles. The interview guide was field-tested and refined, and the final version is included in Appendix 2.3.

Appendix 3.5: Performance Indicators

PROFILE OF SUMMER PROGRAM IMPACT INDICATORS

The chosen indicators have been identified as important factors for integration into science and STEM fields for underrepresented students.[3]

***Quantitative**

***Qualitative**

	Science Identity	Science Self-Efficacy	Science Community Values	Intention to Pursue STEM
Definition	Seeing oneself as the kind of person who would want to understand the world scientifically and participate in scientific activities.[1]	One's belief in his or her ability to succeed in science tasks, courses, or activities.[2]	Internalization of the commonly held values in the scientific community.[3]	The level of one's educational and professional aspirations in STEM fields.[4]
Unit of Measure	Change as measured by science identity scale.	Change as measured by science self-efficacy scale.	Change as measured by science community values scale.	Change as measured by intention scale.
	Student perceptions of program impact on science identity.	Student perceptions of program impact on science self-efficacy.	Student perceptions of program impact on science community values.	Student perceptions of program impact on intentions.
Method of data collection	Baseline, post-intervention, and six-month post-intervention survey using Qualtrics.	Baseline, post-intervention, and six-month post-intervention survey using Qualtrics.	Baseline, post-intervention, and six-month post-intervention survey using Qualtrics.	Baseline, post-intervention, and six-month post-intervention survey using Qualtrics.
	Post program interviews conducted three months after the summer program.	Post program interviews conducted three months after the summer program.	Post program interviews conducted three months after the summer program.	Post program interviews conducted three months after the summer program.
Measurement tools	Five-item scale adapted from the Estrada et al. (2011) Science Identity scale. The scale asks participants to assess on a scale of 1 (strongly disagree) to 5 (strongly agree) the extent to which a series of statements is true of them.	Six-item scale adapted from Estrada et al. (2011). On a scale of 1 (not at all confident) to 5 (absolutely confident), the scale asks participants to assess their ability to function as a scientist in scientific inquiry tasks.	Four-item scale adapted from Estrada et al. (2011). The scale asks participants to rate "how much the person in the description is like you?" Response options ranged from "not like me at all," to "very much like me."	Single item scale adapted from Estrada et al. (2011) asking participants to rate on a scale of 0 (definitely will not) to 10 (definitely will) their intention to pursue a science related career.
	Interview guide.	Interview guide.	Interview guide.	Interview guide.

[1] (Brickhouse, Lowry, & Schultz, 2000).
[2] (Britner & Pajares, 2006).
[3] (Estrada et al., 2011).
[4] (Estrada, Hernandez, & Schultz, 2018).