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Case study exploring science competence and science confidence of middle school girls from marginalized backgrounds

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A CASE STUDY EXPLORING SCIENCE COMPETENCE AND SCIENCE CONFIDENCE OF MIDDLE SCHOOL GIRLS FROM MARGINALIZED BACKGROUNDS

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ABSTRACT

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The inclusion of learners from underrepresented background in biology field research experiences has not been widely explored in the literature. Increased access and equity to experiences for groups historically underrepresented in science, technology, engineering, and mathematics (STEM) has been identified as a priority for many, yet little is known about the components these experiences should have and what types of transformations participants undergo as a result of these experiences. This dissertation explored the systemic creation of an intervention purposely designed to serve middle school girls from underrepresented backgrounds, the implementation of such intervention, and effect on the girls' science competence and science confidence.

El Espejo, Spanish for "The Mirror," was an ongoing field ecology research program for middle schools girls founded in 2009 at a local interdisciplinary learning center. Girls from all walks of life had the opportunity to be apprentice researchers and to work with scientists and science educators from the local community. All activities were strategically designed to promote student-led inquiry, career awareness, cultural awareness, and opportunities for research and mentorship for girls from underrepresented backgrounds.

An increased understanding of if, how, and why this experience was perceived by the girls to be life changing was of importance to add to the

conversations that seek ways to inspire and prepare this generation of students to be the next generation of scientists. The study built on systems theory, and on theories that were embedded in the participants' system: critical race theory, identity theory, and experiential learning theory, grounded in the context of the lived experiences of girls from underrepresented backgrounds.

The girls' experiences were captured through journals, observer-participant notes, photo-documentation, artifacts (posters, videos) created by the girls, and by using science perception tools as well as ecological knowledge tools to gage change in perceptions before and after the program. Research questions centered on understanding what key components were necessary to inspire and motivate the girls to ask questions about the natural world, exploring ecological knowledge as a component of scientific literacy, and on understanding science identity formation as an integrated process.

Analyses of qualitative and quantitative data occurred through a systems lens to explore the intersection of experience, identity, place, science knowledge, and science perceptions for the girls in this environment. The findings indicate that the program was successful in changing the perceptions of science the girls had at the beginning of the program compared to the end of the program. The experience was overall successful as evidenced by the experiences, stories, and insights from the eight case studies examined in depth. All case study participants indicated a continued interest in science or a newly discovered interest in science related topics that they had not considered before the program. The pre-post content test was not indicative of the concepts the girls

learned through the process of scientific inquiry. These findings have implications for the design, implementation, and evaluation of current and future interventions that seek to provide opportunities for underrepresented populations, for the facilitators, classroom teachers, parents, community members, and policy makers vested in providing a space where creation, innovation, and transformation of experience can take place. This is a pivotal undertaking to inspire and prepare girls from underrepresented backgrounds to be leaders in STEM.

ACKNOWLEDGEMENTS

A journey.

A destination.

A moment in time.

Made possible by mentors, by warriors, by risk-

takers, and by believers.

Ray, Bill, and John—the mentors who made me see that taking risks was well worth the effort. You have been a great inspiration in my life! The Poudre Learning Center—one of my favorite places in Northern Colorado—is an inclusive space where all kids are welcomed and encouraged to take risks, to be scientists, engineers, innovators, or explorers. Ray and Bill, thank you for keeping the vision of the PLC alive and for giving me access to the site.

The warriors at the PLC—Tammy, Paulette, and all the facilitators who made *El Espejo* a reality, and who continue to see the vision for the future—thank you for your inspiration, for your words of wisdom, and for you trust. You taught me that taking risks is a lot more fun with a team. We made an amazing team. I will miss you!

To my risk-takers—the girls, the parents, and the educators who jumped into the experience with both feet—we did not know exactly what we were getting into the first year, but it was amazing to see the program grow year after year. It was amazing to see how a little planning, a little motivation, and a lot of enthusiasm created such a wonderful opportunity for the girls. To all 89 girls who

participated in the program over the years, thank you! I hope you remember the crazy times, the times when the bugs drove you insane, and the magical moments when each of you realized that science was something that was part of your everyday life; the moments you realized science was a *cool* part of your everyday life; and the moments you each realized that you are scientists, you are engineers, and you have the potential to follow those careers if you so desire.

To my committee: You were my believers. Thank you for giving me the opportunity to pursue my passion. Richard, Teresa, Mit, Scott, and Robby—you taught me that a job must be well done to be memorable. I wholeheartedly believe in leaving a legacy. I believe in doing a job so well done, that even when I am no longer at UNC or at the PLC, my impact will still be felt.

To my friends: You have been my cheerleaders in crossing the finish line. Team Jurin—Lacy, Beverly, Kimberley, and Abby—thank you for all “the moments.” Those moments when I came crying for someone ready to throw in the towel, or the moments I needed someone to read a section of this dissertation—your words of encouragement helped a lot. Jennifer and Kimberley, thank you for helping me with the data collection. I really appreciate your commitment.

To my Science Education Research Group friends (SERG) at the Colorado State University, Fort Collins: Thank you for being my “family away from home.” You helped me find that connection that I longed for in a research group. Meena—your guidance and support helped me find paths that I would

have never imagined possible. Thank you especially for helping me see the big picture, for keeping me grounded, for cheering me ‘til the end.

To my partner in life: Juan, who in my eyes earned his new title—Dr. García— thank you for your compassion, for your patience, for all those long, endless nights. Thank you for all the love you have given me as we both survived this journey together. You helped make this dream become a reality.

To my beautiful gift, my little child—Maite—you have made this journey a wild, and fun-filled ride. Being a mother has taught me that we are both warriors. As a family, we survived fevers at night, crazy stomach bugs, breastfeeding adventures all over campus, and many ups and downs. Your beautiful smile, your cheerful attitude greeting me after long days, and your unconditional love made all the difference. *Te quiero mucho, mucho mi monita bella, mucho, mucho.*

A mis padres: Cuando me casé, decidí no cambiar mi apellido en honor a mi familia. Al darme cuenta de que iba abrir caminos para las generaciones futuras, me quede con mi apellido "García" como un recordatorio de su valor, fuerza y determinación. El discurso de graduación siguiente captura la esencia de los maestros maravillosos que ustedes han sido en mi trayecto educativo. La traducción al español se encuentra en la columna de la derecha.

To my parents: When I got married, I chose not to change my last name in honor of my family. Realizing that I would be paving many paths for future generations, I opted to keep my family name, “Garcia,” as a reminder of my family’s courage, strength, and determination. The commencement speech

below captures the essence of the wonderful teachers my parents have been in my educational journey. The Spanish translation is on the right-hand column.

Life’s Greatest Teachers

Good evening, ¡*Buenas tardes*! We are here today to celebrate our accomplishments, our journeys, our joys, and our adventures throughout our tenure as graduate students at UNC. Each us have a unique story, but perhaps one thing we all share is that at some point in our lives, we have had a great teacher. I don’t necessarily mean a classroom teacher, although some of us have had wonderful teachers in that context—what I am referring to are teachers who come from all walks of life. They did not necessarily earn a credential that says they are highly qualified to teach one thing or another; rather, their lessons focused

Los Grandes Maestros de la Vida

¡Buenas tardes! Estamos aquí para celebrar nuestros logros, nuestras jornadas, nuestras alegrías, y nuestras aventuras a lo largo de nuestra carrera como estudiantes de posgrado en la universidad del Norte de Colorado (UNC). Cada uno de nosotros tiene una historia única, pero quizás una cosa que todos compartimos es que en algún momento de nuestras vidas, hemos tenido un gran maestro. No necesariamente un maestro de clase, aunque algunos de nosotros hemos tenido maestros maravillosos en ese contexto, a lo qué me refiero son los maestros que vienen de todos los caminos de la vida. No es necesario obtener un credencial que dice que

on bringing out the best in each of us to fulfill our potential. Today, my message will center on the opportunities I have had because of the great teachers in my life.

están calificados para enseñar, sino que sus enseñanzas se centraron en alcanzar lo mejor de cada uno de nosotros para cumplir con nuestro potencial. Hoy en día, mi mensaje se centrará en las oportunidades que he tenido a causa de los grandes maestros de mi vida.

I am here today, celebrating the completion of my doctoral degree, because I had great teachers who served as my coaches, my cheerleaders, and my mentors. In 1988, my parents made the drastic decision to leave our home country of El Salvador because of the civil war. This was the beginning of a great adventure in the United States, an adventure filled with challenges, with set-downs, with opportunities, and with amazing experiences. My parents taught me to be courageous,

Hoy estoy aquí, para celebrar la culminación de mis estudios del doctorado porque tuve grandes maestros que sirvieron como mis entrenadores, mis porristas, y mis mentores. En 1988, mis padres tomaron la drástica decisión de dejar nuestro país de origen, El Salvador, a causa de la guerra civil. Este fue el comienzo de una gran aventura en los Estados Unidos, una aventura llena de desafíos, con sube y bajas, con oportunidades, y con experiencias increíbles. Mis padres me enseñaron a ser valiente para tomar riesgos y crear

to take risks, and to create opportunities when none appeared to exist.

oportunidades donde no parecían existir.

My mother is an opportunity seeker. She figured out a way to enroll my siblings and I into a magnet program into what otherwise would have been a school lacking in expectations for students such as myself, recent immigrants learning English as a second language. She stayed up on countless nights with my siblings and I to help us with homework even though she did not understand the words on those pages. Her support and encouragement pushed me to persevere.

Mi madre es una perseguidora de oportunidades. Ella descubrió la manera de inscribir a mis hermanos y yo en un programa especializado en lo que de otro modo habría sido una escuela carente de expectativas para los estudiantes como yo, los inmigrantes recientes aprendiendo inglés como segunda lengua. En noches incontables, ella se quedó despierta con mis hermanos y yo para ayudarnos con la tarea a pesar de que ella no entendía las palabras en esas páginas. Su apoyo y aliento me empujo a perseverar.

Life’s greatest teachers are there for you, to support you through the toughest challenges.

Los grandes maestros de la vida están allí, para ayudarte a conquistar de los desafíos más difíciles.

This opportunity to attend a school with higher expectations changed my life. I was able to live up to those expectations. I graduated as the middle school class valedictorian. This accomplishment gave me the opportunity to enter a high school that specialized in marine science and technology. At the time, I lived in Watts, a gang-infested area in South Los Angeles, which in turn placed me at a disadvantage when it came to the educational opportunities available. This opportunity to attend a specialized school exposed me to experiences that prepared me to pursue higher goals. These experiences included conducting research as a high school student off the coast of Catalina Island in California, and volunteering at the local aquarium or in other community events. Being surrounded by a

Esta oportunidad de asistir a una escuela con mayores expectativas ha cambiado mi vida. Tuve la oportunidad de cumplir con esas expectativas. Me gradué de la escuela número uno en clase. Este logro me dio la oportunidad de inscribirme en una escuela secundaria especializada en ciencia marina y tecnología. En esos tiempos, yo vivía en Watts, un área infestada de pandillas en el sur de Los Ángeles, que me puso en una desventaja a la hora de las oportunidades educativas disponibles. Esta oportunidad de asistir a una escuela especializada me expuso a experiencias que me preparó para perseguir metas más altas. Estas experiencias incluyeron la práctica de la investigación como un estudiante de secundaria frente a la costa de la Isla Catalina en California, a ser voluntaria en el acuario local o a participar en eventos de la comunidad. Al estar

community with high expectations for their students inculcated a spirit that going to college was an expectation, from my friends, from their parents, from the magnet program, and from my own family. Life's greatest teachers create supportive networks to help students succeed.

rodeado por una comunidad con expectativas altas para sus estudiantes inculco un espíritu que ir a la universidad era una expectativa, de mis amigos, de sus padres, del programa magnet, y de mi propia familia. Los maestros más grandes de la vida crean redes de apoyo para ayudar a los estudiantes a tener éxito.

My biggest challenge as I graduated 13th in my high school class of five hundred and sixty people was that I was undocumented. My family and I entered the country as refugees, but the war was over in El Salvador, so we had to challenge the order of deportation. It took 10 years for my family to gain permanent residency in this country. The judge dismissed the case and told us it would be an honor to have our family be a part of this nation. My father taught me to fight

Mi mayor reto cuando me gradué número 13 en mi clase de la escuela secundaria de 560 alumnos fue mi situación inmigratoria, era indocumentada. Mi familia y yo entramos en el país como refugiados, pero la guerra terminó en El Salvador, así que tuvimos que pelear la orden de deportación. Tomo 10 años para mi familia para obtener la residencia permanente en este país. El juez que dispuso el caso nos dijo que sería un honor tener a nuestra familia ser parte

for what I want—to fight for what I believe in. His courage to take our family of seven and leave the place we called home, the courage to enter a new country with a new culture, is an act that deserves recognition. His actions taught me that sometimes, we have to leave our homes in search of opportunities in new places. My dad is one of life's greatest teachers. Life's greatest teachers teach you to be a fighter, to be courageous.

de esta nación. Mi padre me enseñó a luchar por lo que quiero a pelear por lo que creo. Su valor para tomar nuestra familia de siete y dejar el lugar que llamábamos "hogar", el coraje para entrar en un nuevo país con una nueva cultura, es un acto que merece reconocimiento. Sus acciones me enseñaron que a veces, tenemos que salir de nuestras casas en busca de oportunidades en nuevos lugares. Mi padre es uno de los maestros grandes de la vida. Los grandes maestros de la vida te enseñan a ser un luchador, a ser valiente.

While I was well aware that my immigration status would be an issue in applying for college, I never lost hope. The hope that I would someday go to college motivated me to prepare myself for the opportunity. Luck—after all, is when preparation meets

Yo estaba muy consciente de que mi estado de inmigración sería un problema en la aplicación para la universidad, pero nunca perdí la esperanza. La esperanza de que algún día fuera a la universidad me motivó a prepararme para la oportunidad. La suerte, después de todo,

opportunity. I got lucky! I created my own luck. My last month in high school, I finally got my green card. The doors to attend college opened for me.

es cuando la preparación se encuentra con la oportunidad. Tuve suerte! Creé mi propia suerte. Mi último mes en la escuela secundaria, por fin obtuve mi tarjeta de residencia. Las puertas para asistir a la universidad se abrieron para mí.

Once I entered college, I was exposed to an environment rich in a diversity of cultures and ideas. With my shiny new green card, I was able to leave the country and travel to other countries. I've been to 31 countries ever since. My experiences traveling taught me about the world. As a student at UNC, I conducted research in Costa Rica and in South Africa.

Una vez que entré en la universidad, fui expuesta a un ambiente rico en diversidad de culturas e ideas. Con mi brillante tarjeta de residencia, tuve la oportunidad de salir del país y viajar a otros países. He viajado a 31 países desde entonces. Mi experiencia me ha enseñado viajar por el mundo. Como estudiante de la universidad practique la investigación en Costa Rica y en Sud África.

I have encountered many opportunities in my life, but what makes me different than other

He encontrado muchas oportunidades en mi vida, pero lo que me hace diferente a otros estudiantes que no

students who didn't "make it" was that I had great teachers, both classroom teachers and life teachers, who helped me acquire the tools I needed to navigate through this system, and to take advantage of such opportunities. My hard work was not enough. Opportunities, coupled with preparation, with inspiration, with a desire to transform systems are what brought me here today.

Many of us may be the first person in our families to earn a doctorate or a master's degree. We are an inspiration for the up and coming generations. In my family, we will have five bachelor's degrees, three master's degrees, and I am the first to earn a PhD. We do not want to be the exception. This has to be the new normal if our nation is to move forward. I believe that role models

sobresalieron es que tuve grandes maestros, tanto los maestros de clase y maestros de vida, que me ayudaron a adquirir las herramientas que necesitaba para navegar a través de este sistema, y para aprovechar esas oportunidades. Mi trabajo no fue suficiente. Oportunidades, junto con la preparación, con inspiración, con el deseo de transformar los sistemas son lo que me trajo aquí hoy.

La mayoría de nosotros somos la primera persona en nuestra familia en obtener un doctorado o una maestría. Somos una fuente de inspiración para los estudiantes menores y las generaciones futuras. En mi familia, vamos a tener cinco licenciaturas, tres maestrías, y yo soy la primera en obtener un doctorado. No queremos ser la excepción. Esto tiene que ser la nueva norma si nuestra nación ha de seguir

and mentors are essential in this endeavor, in closing this gap of opportunity. I know I will be a source of encouragement for Latino students and for students from all walks of life.

adelante. Creo que los modelos y mentores son esenciales en este empeño, en el cerrar los escases de oportunidades para ciertos grupos. Sé que voy a ser una fuente de inspiración para los estudiantes latinos y los estudiantes de todos los caminos de la vida.

As we move forward, it is our responsibility to inspire the next generation of scientists, engineers, teachers, and all youth to believe that they have the potential to succeed. I encourage you to be one of life's greatest teachers for our students coming up the ranks, especially for students who may not have the opportunities and experiences you had in your journey. Take action. Do great things. Congratulations! ¡*Felicitaciones*!

A medida que avanzamos, es nuestra responsabilidad de inspirar a la próxima generación de científicos, ingenieros, maestros, y todos los jóvenes que crean que tienen el potencial para tener éxito. Los animo a ser uno de los más grandes maestros de la vida para nuestros estudiantes que viene en camino, especialmente para los estudiantes que no tienen las oportunidades y experiencias que ustedes tuvieron en su jornada. Tomen acción. Haga cosas grandes. ¡Felicitaciones!

~Yeni Violeta Garcia, December 2012, Graduate Commencement Student Address.

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CHAPTER I

INTRODUCTION

Background

The changing demographics in the Unites States shows Latinos are the largest growing ethnic group (Ennis, Rios-Vargas, & Albert, 2011) and the group with the lowest percentage by group of science degrees attained (Ginder & Mason, 2011). There is an urgent need to inspire and prepare this ethnic group to be part of the next generation of leaders in science. The future of our country depends on training people who will fill the workforce demands to move our country to be competitive in a global economy; however, there is a need to build students' science confidence, or their perception that they can do science, and their competence, or their knowledge and conceptual understanding in science, technology, engineering and mathematics (STEM). President Barack Obama has called for a change at the undergraduate student experience based on recommendations from the President's Council of Advisors on Science and Technology (2010); this call needs to be extended to earlier grades along the educational continuum, otherwise, we will have to continue to import STEM professionals from abroad.

In the United States, there is a paradox that points to an increasing need for STEM graduates with technical, bachelors, and advanced degrees in fields

ranging from bioscience to engineering, yet many of the STEM professionals come from abroad (Carnevale, Smith, & Melton, 2011). The President's council of advisors on science and technology (PCAST) prepared a report, "Engage to Excel," with a call-to-action to inspire and prepare 1 million additional college graduates in STEM careers to match projected economic needs over the next 10 years (President's Council of Advisors on Science and Technology, 2010). We need students who are part of the demographic trends to graduate with STEM degrees to fulfill workforce demands (Carnevale et al., 2011). In order to have enough students to meet this need, we must inspire and prepare students early on to experience science, engineering, technology and mathematics in a whole new light. The issue of student disinterest in STEM begins as early as 5th grade; by middle school, girls specially, may not identify with science or math as subjects they enjoy. Basu and Barton (2007) found that sustained interest in science occurs when there is a strong connection to students' own futures, the learning environment is representative of the social interactions students connected with, and when science activities gave them a sense of agency to enact their own purpose for science learning. Lack of exposure to such experiences that sustain interest in science may lead to disinterest by default.

At the local elementary school, exposure to STEM experiences was lacking especially for certain groups of students (L. Perrich, personal communication, November 3, 2008). During the first couple of years in graduate school, the researcher was invited to work with elementary school classrooms as a fellow from the local university. The three fifth grade team teachers, lead by

Mrs. L. Perrich, shared the frustration that their most needy students, who came from low-income backgrounds and students who could not speak English, were not being exposed to science because they did not score proficient or partially proficient on the state English language arts or mathematics standardized exams. The teachers wanted to create opportunities for these students through extended learning experiences (L. Perrich, personal communication, November 3, 2008). The team, including the teachers and the graduate researcher, developed an afterschool program specifically for this population, and made the opportunity available for all students who wished to participate. They also informed the summer intervention for girls presented in this dissertation as a way to extend learning throughout the summer. This set the foundation for a potential summer program, not only for this group of students, but also for the four surrounding districts in the area. The largest district in the area represents the changing demographics in our country at a local scale.

Changing Student Demographics

The 12.80% change in Latino student demographics from 2004 to 2008 in the local school district (Colorado Department of Education, 2010) indicated that we must pay attention to preparing students from this ethnic group to be exposed to professional careers or trades that reflect workforce needs for the 21st century. Latino students made up 53% of the student population at the genesis of this project; now, they comprise 58% of the total student body in the local district (Colorado Department of Education, 2011). Teachers were expressing their concern that Latino students, many needing English language acquisition

intervention because Spanish was spoken at home, were being kept from science and social studies, and from opportunities that would foster higher order thinking, and opportunities to be exposed to 21st century skills which include invention, collaboration, self-direction, information literacy, and critical thinking and reasoning (L. Perrich, personal communication, November 3, 2008). There was a clear gap in opportunity for Latino students and economically disadvantaged students compared to the general school population (Center for Education Policy Analysis, 2006).

The disproportionate gaps in opportunities for certain ethnic and socioeconomic groups in science and math were made evident in a 1990 report authored by Oakes et al. (1990) for the Rand Publication Series titled, “Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science.” More recent reports (Carnevale et al., 2011; Change the Equation, 2012a; U.S. Department of Labor, 2007) substantiated this finding. With a huge achievement gap prevalent in groups historically underrepresented in the sciences in this region and throughout the United States, there was an evident need to take action. The achievement gap, or the gap of opportunity, was especially prevalent in English learners, in students with disabilities, and in students form low socioeconomic backgrounds. For girls, the discrepancy in performance in mathematics and science added another layer of complexity to the issue of girls being underrepresented in STEM professions (Center for Education Policy Analysis, 2006).

Middle School Girls

Several studies have established that middle school is a pivotal transition in life when youth, including young women, lose their interest in science (see Barton, Tan, & Rivet, 2008; Farland-Smith, 2009; Misiti, Shrigley, & Hanson, 1991; Schmidt & Nixon, 1996). This disengagement in science has a long lasting impact and an effect on the actual number of professionals who complete advanced degrees in STEM fields (Olson & Fagen, 2007). These studies indicated a need to establish an intervention for this target group to fill a necessary void so science would be a familiar experience rather than a foreign affair that has nothing to do with students' lived experiences.

Latina girls perceive science as a field that is foreign and not something that makes up how they identify as young women, or if they exhibit a science identity (Tan & Barton, 2008). Girls perceive science as being a masculine field, and girls who can perform in science are seen as exceptional. They are not the norm. Girls from underrepresented backgrounds who succeed in science are perceived as a greater exception to this notion that scientists are people who typically do not look like them. Providing opportunities to address gender and ethnic barriers are necessary to change these perceptions. Authentic science experiences where middle school girls are seen as leaders and where they see professional women in leadership positions in STEM are pivotal to show middle school girls that a career in science is something that is accessible and possible for them (Archer et al., 2010; Farland-Smith, 2009). When science is relevant, directly connected to student experiences, and when students take ownership of the science being learned and feel that they have something to contribute, there

is a greater propensity that they will develop a sustained interest in this field (Basu & Barton, 2007). The adults involved in such experiences can also play a vital role in student experiences.

Facilitators

The adults involved in any sort of experiences for students can greatly impact participant outcomes. Effective educators in experiential learning foster self-direction, discovery learning, and reflective thought (Mezirow, 1997). They serve as facilitators of learning rather than as authority figures or as dictators of learning (Rodgers, 2010). They create an environment where learners help each other, identify problems together and learn from each other. The facilitator can ultimately become a co-learner as his or her role changes to allow participants to lead the group (Mezirow, 1997). The role of facilitators, and the need for facilitators was made evident when working with the afterschool programs where students began to take charge of what more they wanted to learn. We saw this as an opportunity for continued learning, for collaborative learning, and for girls to experience science learning in a way that was potentially different than their typical, in-school learning experiences.

Problem Statement

In 2009, a team of teachers from the largest local school district noted that certain groups of students, predominantly Latino, second-language learners in the largest local school district were not being exposed to science experiences because of their language need. Students not proficient in the statewide assessment were placed in intervention courses in reading and mathematics instead of being exposed to science. In Colorado, students on average

participate in 2.3 hours of science instruction per week (Change the Equation, 2012a); thus, some students were potentially getting zero contact time in science and some students were participating in 5 hours of science instruction. Because local district control determined that the approach they would take would be more English and more mathematics instruction, this gap in exposure to science for the students of this target population could only be remedied through “beyond-the-bell” programs that place the learner experience and experiences in science foremost in a setting outside normal school hours.

Purpose

The team of teachers at the local school asked for ways to reach out to these students beyond the school day. This study examined what happens when girls from underrepresented groups, Latina students, and economically disadvantaged girls, are exposed to science experiences. The questions that naturally arose from the aforementioned problem were: What happens when girls from underrepresented backgrounds (ethnic and economically disadvantaged) get to be part of science experiences? Why is it so important to provide these experiences to these students? Why is it important that these experiences are a fundamental part of their education? To address these questions, a summer program was created, with the help of the teachers who brought the concern to light, to expose girls from marginalized backgrounds to science in their local community.

El Espejo, Spanish for “The Mirror,” was an ongoing field ecology research program that exposed middle school girls to place-based (Buxton, 2010; Hart,

1979; Scourfield, 2006) science experiences in science at the Poudre Learning Center (PLC). The PLC is a local cross-disciplinary learning center accessible to students from four partner school districts in this Northern Colorado Region. The learning center is a prime location for learning about most of the ecosystems in this Colorado region.

The science summer program was created to provide opportunities for girls who typically did not receive science during the school day to experience science in the field; however, girls from all walks of life were welcome to participate. The girls from the four local school districts had the opportunity to be apprentice researchers and to work with scientists and science educators from the local community. The program was designed with these goals in mind: (1) to provide field experiences for a group of diverse group of girls each summer by getting them outdoors and experiencing their place in this Northern Colorado region, (2) to explore the science competence and science confidence in middle school girls, (3) to expose the girls to career awareness through mentoring, and (4) to provide opportunities for social and cultural integration for girls who are in the process of forming science identities.

Significance

The issue of underrepresentation of women and certain ethnic groups in STEM careers is deep. This issue is further intensified if girls from underrepresented groups are not exposed to science experiences. High stakes test have added more complexity to an already complex problem (Oakes et al., 1990) as these students tend to be the ones deprived of experiences in science

because they need “help” in other areas. So how can we inspire these students if they are not even experiencing science? Potentially, exposure to place-based science experiences could have an impact on the girls’ perception of science.

This issue of underrepresentation of girls and Latinos poses an economic imperative as well. The 12.8% change in the Latino student population in this area over four years is a small reflection of national demographic trends which indicate that the Hispanic population over a 10 year period increased by 43% while the total population increased an average of 10 percent (Ennis et al., 2011). Latino students represent our future workforce and we are not preparing them to meet the demands of STEM fields. Only 7% of all STEM degrees were awarded to Latino students in 2009 (Ginder & Mason, 2011). This small number represents a lack of confidence and a lack of opportunity to pursue and be successful in such fields. There is also a propensity for urban students and students of color to perceive science and their futures in such fields in a negative way (Atwater, Wiggins, & Gardner, 1995). Thus, authentic experiences in science are necessary to engage these students to become interested and engaged in science. If they are not exposed to any science experience, we cannot expect that they will naturally pursue such careers.

For practitioners, the findings of this study can illuminate Latino student potential. The notion of deficit thinking is prevalent in schools today (Valencia, 1997). For example, a student’s inability to communicate in English should not be equated to their inability to understand science concepts. Students can learn language in the context of science.

The findings of this study can also inform educators in formal and non-formal settings on the use of experiential, place-based techniques to improve the quality of teaching and learning of scientific concepts in outdoor settings for diverse students. In addition, the findings can inform educators, policy-makers, and parents on effective methods to maintain middle school girls' interest in the sciences year-round and beyond age 11, when many girls become disengaged in science.

Need for Purposeful Design of Intervention

Evaluating the process and procedures that an emerging program has set is important for future planning and sustainability of this type of intervention. A national organization aimed at documenting the best-in-class programs called Change the Equation (Change the Equation, 2012b) is taking an active role in documenting programs that work. To be identified as a quality STEM program, applicants have to excel in the ten principles for effective STEM philanthropy (Change the Equation, 2012b):

A. Need: Does the program address a compelling and well-defined need?

B. Evaluation: Does the program use rigorous evaluation to continuously measure and inform progress in addressing the compelling need identified in Principle A?

C. Sustainability: Does the program ensure that the work is sustainable?

D. Replication and Scalability: Does the program demonstrate that it is replicable and scalable?

E. Partnerships: Does the program create high-impact partnerships where beneficial?

F. Capacity: Does the program have the capacity to meet its goals?

G. Challenging and Relevant Content: Is the STEM content challenging and relevant for the target audience?

H. STEM Practices: Does the program incorporate and encourage STEM practices?

I. Inspiration: Does the program inspire interest and engagement in STEM?

J. Underrepresented Groups: Does the program identify and address the needs of underrepresented groups?

For this dissertation, the focus was on understanding the process and procedures for understanding the qualities of a STEM learning opportunity for middle school girls that would add to the limited knowledge base of effective STEM programs at the state and national level.

Overarching Goal of Dissertation

This dissertation aimed to explore how providing science experiences for girls in this target population affected their science competence and science confidence. The key theories used to determine the impact of the intervention on the girls experiences were critical race theory (Ladson-Billings & Tate IV, 1995; Solorzano & Yosso, 2001) and experiential learning theory (Kolb, Boyatzis, & Mainemelis, 2000; Kolb, 1984a). Theories informing science competence were systems theory (Boulding, 1956; Chen & Stroup, 1993; Sweeney, 2007) and experiential learning theory. The girls' collective and individual journeys were explored through critical race theory (Ladson-Billings & Tate IV, 1995; Solorzano & Yosso, 2001) to gain insight on how the girls' science confidence emerged throughout the program.

Definition of Terms

Attitudes towards science— defined by an individual's feelings and emotions ranging from positive to negative about science topics including but not limited to "cognitive attitudes towards science, attitudes towards scientists, attitudes towards the methods of teaching science, scientific interests, attitudes towards the curriculum of science, and towards the subject of science," (Haladyna & Shaughnessy, 1982; pp. 548-550) which can fluctuate over time. Attitudes contribute to identity development.

Community of practice— shared domain of understandings and participation at multiple levels of an activity system (Lave & Wenger, 1991). In these domains, members participate in discussions, learn from one another, help each other, and share resources and information and collectively build relationships that bring novices into a legitimate peripheral participation within such communities of practice.

Critical race theory (CRT)— seeks to understand the life experiences of groups that have been historically marginalized (Ladson-Billings & Tate IV, 1995; Solorzano & Yosso, 2001).

Ecological content knowledge—the basic understanding of the three guiding principles of ecology: 1) the web of life, 2) cycles of nature, and 3) flow of energy (Stone & Barlow, 2005).

Experiential learning—"changes in the individual based on direct experiences" (Itin, 1999, p. 91)

Facilitators—systems approach to learning where adults share leadership roles with participants, as co-constructors of knowledge, not through a

hierarchical, top-down relationship (Stone & Barlow, 2005), but rather by guiding students towards becoming self-directed learners.

Legitimate peripheral participation— when "Learning is viewed as a situated activity…where [children] inevitably participate in communities of practitioners" where they move from being newcomers to this community to full participants (Lave & Wenger, 1991)

Science identity— the joining and immersion into a science community of practice through self-recognition and recognition by peers (Carlone & Johnson, 2007a).

Science competence— the matrix of knowledge needed to understand enough about the physical universe to deal with issues in the news and elsewhere (Trefil & Hazen, 2010); understanding the nature of science as a way of knowing, basic terms and definitions to understand and make sense of current issues in science.

Science confidence— student's perceived self-efficacy in doing science.

Sense of place— the biophysical connection to a place, the personal/psychological, sociocultural and politico-economic structures that adds meaning and a deep connection to a place for any given person or groups of people (Ardoin, 2009).

Situated cognition/situated learning— posits that knowledge is created through the interactions of a learner in an environment (context) and cannot and should not be decontextualized (Orgill, 2007).

Systems theory— refers to the science of systems whereby the whole has unique properties that function in a collective way and not as a gathering of the individual functions of each part. In biology, systems theory was introduced to help explain the role of organisms in an ecosystem (Schwandt, 2007).

Transformative learning— exploring questions that describe learner experiences leading to a change in perspective (King, 2009).

Chapter Summary

This chapter identified the problem of lack of science exposure for girls from underrepresented and economically disadvantaged backgrounds. There was a call by the president's council on science and technology to inspire students to pursue careers in STEM; however, students representing the largest demographic change in this region were also the most underrepresented in science experiences. Latina girls, who were also second language learners, were not being exposed to opportunities in STEM. A potential mismatch between the future workforce and adequate preparation of students who would soon be entering the workforce created an opportunity for change. Creating opportunities for students who are not experiencing science during the school day was a first step in addressing this challenge. Exploring the effect that this intervention had on middle school girls' science competence and science confidence established the foundation for the rest of this dissertation. This chapter also contained definitions of terms relevant to understanding the study.

CHAPTER II

LITERATURE REVIEW & THEORETICAL FRAMEWORK

Literature Review

Science Education Reform

For the past three decades, science education reform has sparked a conversation centered on achieving “science for all” (National Research Council, 2012; Rutherford & Ahlgren, 1990); however, this great endeavor is still a work in progress. Today, there still exists a huge need to provide opportunities for marginalized groups to be exposed to high quality science experiences. In some regions, reform efforts in language arts and mathematics have transformed science education in a negative way (National Research Council, 2012; Oakes et al., 1990).

Because of high-stakes testing, schools have pushed science to the sidelines in the early grades and in grades not included in the state standardized test. Students who do not meet proficiency cut-scores undergo intervention in the form of additional language arts and mathematics courses. At the elementary level, this means little-to-no exposure to science experiences for groups with the highest achievement gaps—girls and racial minorities—which tend to also be populations who have been historically underrepresented in STEM careers (Center for Education Policy Analysis, 2006).

In some schools, students who are fortunate to take some science during the school day may be limited to 30-45 minutes per week, with an average exposure being 2.2 hours per week which represents a drop from 2.9 hours per week in 1994 (Change the Equation, 2012a). This trend is also evident nationwide where the average hours spent in science class in 2008 was 2.3, down from 2.9 in 1994 (Change the Equation, 2012a). An unintended consequence of this lack of exposure may be the perceived idea that students who are not exposed to science may not be interested in these disciplines. This is especially prevalent for marginalized students who tend to be pulled out of science for remedial assistance. Exposure to science in the current educational climate is inadvertently reserved for students who are proficient in English language arts, and in mathematics. Science *is not* for all.

The achievement gap only worsens throughout a students' educational continuum (Center for Education Policy Analysis, 2006). Many students who make it to college still need remediation. This is a huge economic imperative. Colorado spends more than 16 million dollars providing remedial mathematics education for post-secondary students who enroll in community colleges (Change the Equation, 2012a). For many students entering college and needing remediation may limit their options for pursuing potential majors that require advanced mathematics skills (Fry, 2002). Math remediation is among the many factors that add to the "leaky pipeline" in STEM and the underrepresentation of certain ethnic/racial groups and women.

Underrepresentation in Science

Women and minorities (National Science Foundation, 2011) are an untapped resource to stop the unfilled STEM pipeline. I use the phrase “unfilled pipeline” instead of “leaky pipeline” because by using the term “leaky” we imply that at some point, there were enough students interested in pursuing STEM degrees. This may not necessarily be the case, since many students may not have had the opportunity to experience what STEM learning is, or what a STEM professional does. Women, for example, make up a high percentage of the college population, estimated at 60%, yet they only earn 32% of all STEM degrees in the state of Colorado (Colorado Departmern of Higher Education, 2012). The same trend is evident in Latino and Black student populations. Latinos make up 21% of the total college population in Colorado and only earn 7% of all STEM degrees and certificates; Blacks/African Americans make up 4% of the population and earn 3% of all STEM degrees and certificates (Ginder & Mason, 2011).

While women overall have increased in pursuing careers in biological and biomedical sciences and now comprise 60.7% of the field, (National Science Foundation, 2011), the same trend in not evident in Latinos and groups historically underrepresented in the sciences (Nelson, Brammer, & Rhoads, 2007). This issue poses great concern because the demographics in the United States are swiftly changing. By 2020, the United States Census Bureau has predicted that the American population will be composed of 32% underrepresented minorities, outnumbering Whites; 30.1% (U.S. Census Bureau, 2000). To put this issue in perspective, girls who began middle school in 2009

should be entering the workforces as early as 2016, or completing their college degrees by 2020.

An increased sense of urgency is raised in a recent Census Bureau report that sets the number of minorities closer to 50% by 2050 (National Science Foundation, 2011). Current trends in Latino undergraduate degree recipient rates in the sciences are not keeping up with demographic changes with approximately 16.5% (Nelson et al., 2007) of degrees being awarded to this group. Latinas fare far lower, making up 1% of science and engineer occupations as documented in a National Science Foundation report (2011); this number is also very small for biology professionals from underrepresented groups. To highlight a specific example, the Ecological Society of America's student section membership is comprised of 26% minority, and 60% women. Professional members represent 13% minority and 40% women ("Women and Minorities in Ecology [WAMIE] Committee Reports," 2012). While this may appear to be a number that is doubling, the reality is that 50% of student, or pre-professional members, do not become professional members. In other words, the number of women registered as professional members is much smaller than the student member population because there is a 50% attrition rate from being a student to becoming a professional in the organization. A second explanation could be that once female student members graduate, they leave this professional organization altogether, which is highly unlikely. Therefore, the issue of women and certain ethnic groups being underrepresented in the biological sciences still remains.

Several efforts from varying perspectives have been put forth to address the underrepresentation of certain groups in science. Some experts argue that intervention efforts should be focused at the university level to retain the students who have already progressed through the educational continuum (Summers & Hrabowski III, 2006); others argue that youth develop science identities around 11 years old or during the middle grades, and that opportunities should be provided long before they reach advanced studies (Amos & Small, 1998).

A major national effort, the “National Girls Collaborative Project (NGCP): Advancing the agenda in gender equity for science, technology, engineering, and mathematics” aims to decrease the gap among these under-served groups (National Girls Collaborative Project [NGCP], 2012). The NGCP is committed to forming linkages among organizations throughout the United States that are working towards this common goal of informing and encouraging girls to pursue careers in science, technology, engineering, and mathematics in addition to documenting the effectiveness of programs through rigorous program evaluation efforts. A noteworthy program in California, “Girls on the Bay,” invites students from two local high schools to participate in “an interdisciplinary, standards-based, hands-on inquiry study of the San Francisco Bay with a focus on water quality, plankton, benthos, and fish (NCGP, 2012, p. 1).” Real world, authentic application was evident in their studies outdoors and provides opportunities for girls to team up with researchers to conduct field investigations onboard research vessels. To date, the NGCP has documented 2,500 programs throughout the nation. This highlights that there are many efforts throughout the country to

provide experiences for under-served students in science. The main issue with these programs is the lack of program evaluation to see if these programs are actually effective in increasing interest and preparation for girls from under-served groups (NCGP, 2012).

Examples of efforts at a local scale in Colorado include Girls Exploring Science, Technology, Engineering & Math (GESTEM) or Exploring Your Horizons (EYH). GESTEM provides workshop-style format for girls to explore careers within the STEM disciplines. The second example, EYH, is a one-time event, presented in a conference style format where girls explore different careers. In all, there are 33 known opportunities in Colorado for girls to explore some aspect of science (NCGP,2012); collectively, they form a collaborative for STEM, the Colorado Collaborative for Girls in STEM (CoCoSTEM), with one program, Cool Girls, solely focused on STEM experiences with the mission of achieving gender equity in science, technology, and engineering (CoCoSTEM, 2012). Indeed, few programs offer experiences lasting more than a day, and no specific programs in this region focused on middle school girls from underrepresented groups developing and conducting their own field investigations during the summer; when school is out of session, and with the help of facilitators, local scientists, and engineers.

Nationwide, many experiences for students are offered to minority high school students who have demonstrated a keen interest in pursuing math or science careers, especially in the biomedical sciences, who are at the top of their class (Bell, Blair, Crawford, & Lederman, 2003; Knox, Moynihan, & Markowitz,

2003; Markowitz, 2004); students selected for such programs may be the ones who most likely would have “made it anyway.” This effect is called the “Matthew Effect” (Merton, 1968) and is used in conjunction with the phenomena where people who already know a lot are further advanced. Many times, programs seeking the best and brightest enhance this effect. The top students in a school or a program keep moving up, while the middle, or average students, and those below average move further away, creating a larger gap between groups.

While the above examples are great efforts to introduce girls to careers in STEM, many were one-day interventions or “one experience” intervention, but longer exposure may be necessary for girls to develop a deeper sense of belonging into a community of science. Residence programs, especially at the high school level can be found for engineering and biosciences but they are very costly, at about $4,900 per student (Summer Science and Engineering Program, 2012). Weeklong programs in our region were in the range of $300 to $325.00 for “Camp Rocky” and for “STEM Institute” respectively (Colorado Association of Conservation Districts, 2012; STEM Institute, 2012). Thus, there was a need for the purposeful creation of a relatively low cost intervention targeting middle school girls from diverse backgrounds. As far as the researcher knows, there have been no specific interventions in programs in Colorado targeting this demographic and not only providing hands-on experiences, but also opportunities to be agents of change in their own life by learning transferable skills that would not only help them in their every day lives, but in a school setting, or in the jobs for the future. The need for the creation of STEM programs

for particular groups was evident. Documenting the girls experience was something the researcher and the local agencies requested do better understand the importance of experiences for this population.

Importance of Experiences

People as active seekers of knowledge (Lambert & McCombs, 1998). Every day, every moment, people encounter experiences that shape their lives and their identities. Some experiences may be ordinary, others extra-ordinary. These experiences are defined by the learner's attitudes and perceptions towards that experience, and the environment of which the learner is a part. Contextualizing experiences is important in creating a learning environment where the learner is motivated and eager to learn (Lambert & McCombs, 1998). Experiences in context can include the learning of science in nature, out in the field.

> *"I think I need to get in [to the program] because I am afraid of nature's creatures and activities. I need to bond with mother nature."* – Pele, 11 years old.

Experiences with nature. The quotation above highlights a need for children to be exposed to nature. When a child acknowledges that she has not bonded with "mother nature" there should be alarms alerting a call to action from educators and parents. Exposures to science experiences have become very limited for children, as fears for the unknown and strangers have increased (Frost, 2006). There is a pressing need to get children outdoors to learn about their local environments. In the book, *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder,* Richard Louv (2005) focused on the issue

of connecting children with nature. Louv exposes the increase in children who are missing out on opportunities to explore nature. Children need experiences to become one with nature instead of fearing the unknown because they spend their times indoors, plugged into an outlet staring at some sort of technological device. When 4th graders were asked where they like to play, they replied anywhere near an outlet to plug in their electronic games (Louv, 2005). While technology itself should not be seen as in a negative light, what we are losing is creativity.

Children are naturally curious about the world (Hart, 1979; Louv, 2005). They take things apart and try to figure out how they work (Petroski, 2003). Cultivating students' natural curiosity and describing their activities as doing science or engineering can minimize future anxiety towards those activities in the future (Petroski, 2003). Therefore, it is imperative that children experience real world application of STEM content embedded with 21st century skills: information literacy, critical thinking and reasoning, self-direction, collaboration, and invention (Trilling & Fadel, 2009). This natural curiosity is lost as children are immersed into the traditional school system characterized by the assumption that children come with no prior knowledge, where the teacher is the authority figure, and where learning outcomes are only valued and measured by focusing on new knowledge or on a specific type of knowledge (Lambert & McCombs, 1998; Zacharia & Barton, 2004). It is the natural, inquisitive nature in children that must be fostered to help them become critical thinkers who are able to formulate questions to study the natural world *in situ* and to understand their place in this

larger world, the larger systems to which they are a part (Lambert & McCombs, 1998; Peacock & Pratt, 2011; Ramey-Gassert, 1997). Louv (2005) described this disconnect children are experiencing as “Nature deficit disorder.”

There are children who have very limited opportunities to explore nature due to parental fears (Gill Valentine & McKendrick, 1997). Parents are afraid to let their kids roam outdoors like they used to 50 years ago; thus, providing a safe place where students can roam and learn about their place is important. This is where they can get a chance to experience “*Ah ha!”* moments, to explore the potential they have as junior researchers, and to experience things that may be that spark to get them to ask queries about their place. Therefore, exposure to field experiences in an informal setting may be one way of inspiring children to ask science questions (Stocklmayer, Rennie, & Gilbert, 2010). Parental fears may be one reason for lack of exposure to nature; as second reason may be missed opportunities in the traditional school science classroom because children may be seen to have a deficiency in other areas, such as reading and writing. Potentially, experiences with nature may affect children’s perceptions towards the natural world and their science confidence, or their ability to do science, and their science competence, or their ability to understand science, creating a closer bond to their place, a deep connection to where they live (Hart, 1979).

The Experience of Place

Learning about the living world in an experiential way (Wurdinger & Carlson, 2010) helps create a “sense of place” for children and adults alike. The notion of *place* refers to a location that has a deep meaning for people (Hart,

1979). This concept has been explored in various disciplines such as biology, geography (Hart, 1979), and the social sciences (Low & Altman, 1992). Place-based teaching and allowing students to develop a sense of place enhanced student performance on standardized achievement tests and significantly improved student motivation and critical thinking skills in a study by Semken (2005).

A deeper understanding of the concept of place may help us understand how connection with the natural world and the communities present within these natural areas may increase children's willingness to make informed decisions that impact their lives in subtle and not so subtle ways. Michael (2005) adds to this notion of place noting that children not only have to explore the beauty of a place, but to learn about their connection to it. Incorporating strategies and opportunities for place building in beyond-school learning opportunities such as summer research programs can foster the development of science process and application skills necessary to enhance literacy in the sciences.

Schmidt & Nixon (1996) expressed the need for learning opportunities to occur through active participation to effect meaningful learning. In particular, their study focused on understanding factors that could improve girls' attitudes towards science with an emphasis on experiences that were for girls only. A unique characteristic of their intervention was that they were open to the inclusion of male volunteers as facilitators who showed commitment to encourage participation in science for girls (Schmidt & Nixon, 1996). Learning in

an all-girl environment (even with a few male role models) served as a useful strategy towards increasing student participation in studying science.

This present study focused on examining what happens when girls from underrepresented groups, ethnic minorities and economically disadvantaged, are exposed to science experiences in a contextual setting, out in the field. The researcher does acknowledge that there is a huge need to expose boys from underrepresented backgrounds to these types of experiences, but with monetary and human capital constraints, the intervention focus for this study was on opportunities for middle school girls from underrepresented background (i.e., Latina/Native American/African/African American girls, and girls form low socioeconomic status).

Theoretical Framework

Experiences are a part of complex networks that can be studied and understood by examining aspects of a system that make up a students' experience. The conceptual framework in Figure 1 depicts the intersection of critical race theory (Ladson-Billings & Tate IV, 1995; Solorzano & Yosso, 2001; Wing, 1997), contextual science identities in practice (Tan & Barton, 2008) , contextual science experiences, and how these three components inform the formation of an individual's science identity in a social context, or in their "figured worlds" (Costa, 1995). "Figured worlds" has been explained as being similar to a child's fantasy play (Holland, Lachiotte, Skinner, & Cain, 1998). It resembles the potential for children to play scientists, or engineers, or technicians, or mathematicians and perhaps using the skills such professionals use, such as

asking questions, using science tools, or developing their own studies where they see themselves as a member in this figured world. When girls see science as “another world” their likelihood of developing a strong identity diminishes (Costa, 1995). Therefore, the experiences that girls internalize can affect their confidence and competence in science and the future possibilities that are available in this world (Costa, 1995).

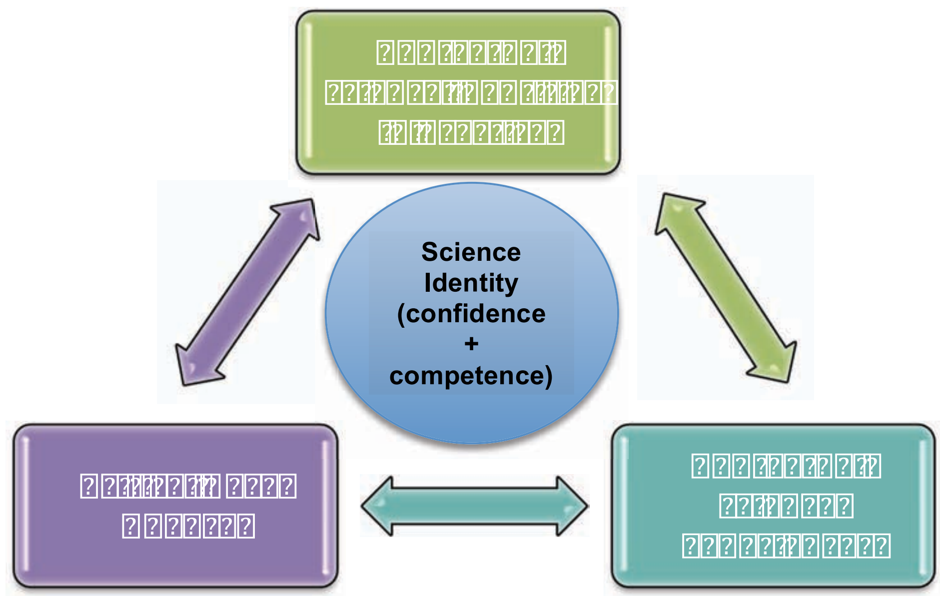

Figure 1. Conceptual framework depicting the intersection of critical race theory, contextual science identities in practice, contextual science experiences, and how these three components work systemically to inform an individual’s science identity formation.

Critical Race Theory

Taking action for change was an idea that immerged from critical theory (CT), inspired by the work of Karl Marx (Creswell, 2007; Thomas, 2009). CT gives marginalized communities a space to voice their stories rather than the

stories being told from someone else's perspective (Ladson-Billings & Tate IV, 1995).

Critical race theory (CRT) explains a component of a system interacting to afford or deny opportunities to girls from underrepresented groups to experience science. Critical race theory expanded the domain of CT by focusing on the "historical problems of domination, alienation, social struggles and how social inequities" (Thomas, 2009, p. 54) arise as a result of oppression from dominant groups (Ladson-Billings & Tate IV, 1995). CRT seeks to understand the life experiences of groups that have been historically marginalized. This theory informed the conceptual framework (Figure 2) for the study.

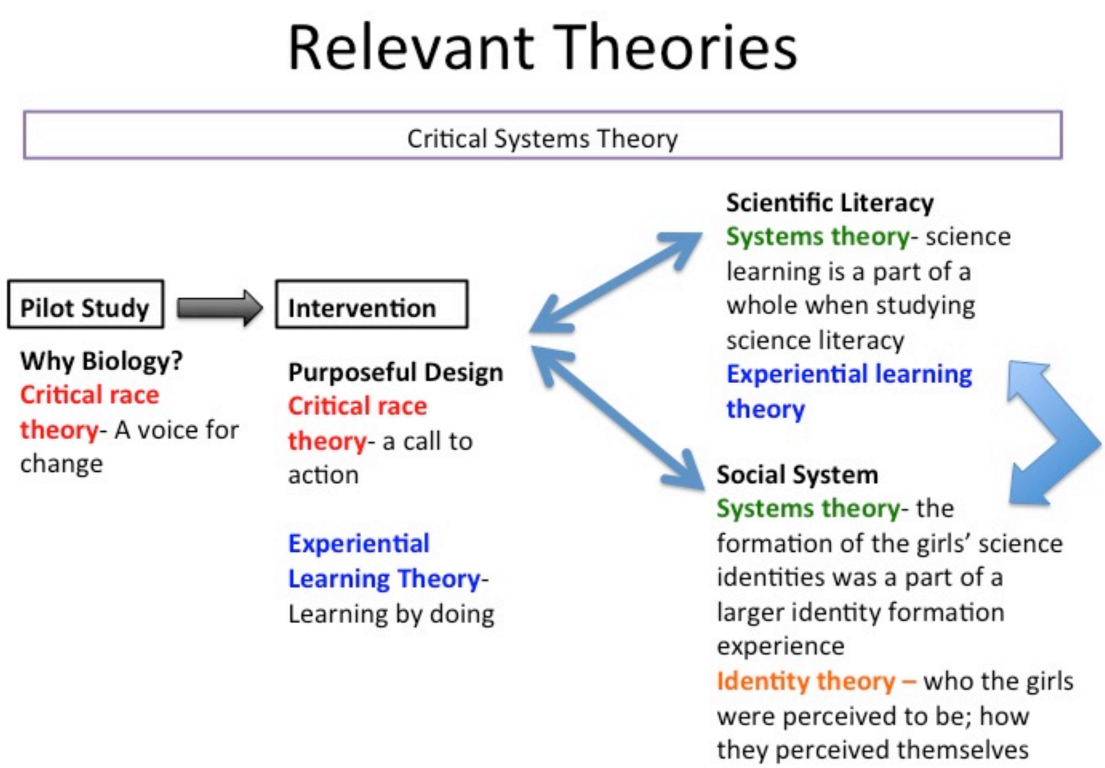

Figure 2. Theories informing the different components of this dissertation.

CRT provided a lens for conducting more valid and ethical research in this diverse community (Thomas, 2009) found in Northern Colorado. In the pilot study critical race feminism provided a finer focus lens to explore the experiences that afforded or denied opportunities for Latina girls to pursue a career in biology. The pilot study will be presented in-depth as a section in Chapter III. CRT also informed the nature of the intervention designed for middle schools girls from marginalized background to experience science learning in context (Lambert & McCombs, 1998); the findings from this main study make up the core component of this dissertation.

Experiential Learning

Experiential learning (EL) helps us understand one important dimension of how people learn— through experiences (Kolb, 1984a; Wurdinger & Carlson, 2010). It provides a venue for learners to explore and develop questions first-hand. Learning experiences in the natural environment have been accepted as effective strategies towards the enhancement of positive student environmental learning outcomes, attitudes, and responsible actions as citizens (Ballantyne, Anderson, & Packer, 2010; Bordeau & Arnold, 2008; Brossard, Lewenstein, & Bonney, 2005; Hayes, 2009). The characteristics of experiential learning proposed by Kolb (Kolb, 1984a) are listed in Table 1.

Major theorists who contributed to the development of Experiential Learning (EL) were Lewin (Coghlan, 2005; Kolb, 1984a), Dewey (Kolb, 1984a; Wurdinger & Carlson, 2010), and Piaget (Kolb, 1984a). Lewin's major contributions were in developing new approaches to view group dynamics that focused not only on understanding and explaining processes but also changing

the nature of those interactions by directly involving the people in those systems (Coghlan, 2005). Dewey's work on lived experiences and inquiry based learning as an iterative process and the use of reflection to modify ideas as learning occurs, also contribute a wealth of insight towards experiential learning (Wurdinger & Carlson, 2010). Lastly, Piaget's work with children and cognitive development also contributes to experiential learning, looking at EL through developmental stages that go through adulthood. These stages represent "experience, concept development, reflection, and action (Kolb, 1984b)."

Table 1

The Six Characteristics of Experiential Learning (Kolb, 1984a).

Learning is best conceived as a process, not in terms of outcomes.
Learning is a continuous process grounded in experience.
The process of learning requires the resolution of conflicts between dialectically opposed modes of [accommodation] to the world.
Learning is a holistic process of [accommodation] to the world.
Learning involves transactions between the person and the environment.
Learning is the process of creating knowledge.

A second line of contributed work came from Freire through the development of "critical consciousness" (Freire, 2000) and Illich on de-schooling societies (Illich, 2000). Merging the ideas from Lewin, Dewey, Piaget and other radicals such as Freire and Illich to form a unified theory of experiential learning brings us to the definition of learning proposed by Kolb (1984b), where "Learning

is the process by whereby knowledge is created through the transformation of experience (p.38).” For children, learning through experiences in a real-world context, in their backyards, may impact their science competence, and their science confidence, which in turn, will influence the complex system that informs their science identity development in their figured worlds.

Identity as a Component of a Larger System

The development of a science identity, defined as the joining and immersion into a science community of practice through self-recognition and recognition by peers, is a key component of feeling empowered towards being a scientist and being able to “do” science (Carlone & Johnson, 2007a). Thus, if a student does not identify as a science person the chances of pursuing any career in this field are minimized. Wenger (1998) defines this as “models of belonging” that are important sources for the development of a science identity.

A science identity is a component of a girl’s social system. The reasons why a girl is identified as science person or not, can be explained by exploring her interactions with the environment and what sense the girls make out of such experiences. Thus, defining the roles that people embrace in different situations was an important component to understanding how people learn.

Learners embrace different identities based upon how they interact with their environment and on what they previously experience (Lambert & McCombs, 1998). A system that includes science interactions that provide new experiences where learners can be actively involved in their learning can create a sense of identity in science (Carlone & Johnson, 2007b; Tan & Barton, 2008). This has

huge implications for the exploration of future careers, opening up the possibilities for any particular girl being part of that experience to see herself as a person who does science, thus bringing out one or more science identities-in-practice (Costa, 1995; Tan & Barton, 2008; Tan, 2007).

The development of a science identity, defined as the joining and immersion into a science community of practice through self-recognition and recognition by peers, is a key component of feeling empowered towards being a scientist and being able to “do” science (Carlone & Johnson, 2007b). Incorporating systems theory (Sweeney, 2007) to understand identity can help us understand how the learners make sense of experiences that may include learning new concepts and ideas in the life sciences.

Contextual Science Experiences and Science Identities

Lambert & McCombs (1998) proposed reforming schools by changing learner experiences through learner-centered education. Human beings are constantly learning from their environment. As such, contextualizing learner experiences can play a pivotal role in what students are willing and able to learn. Learning in a place where risk-taking is encouraged, where learners ask their own questions, and where positive affective domain is maximized, could potentially enhance motivation to learn and enhance self-efficacy in the ability to do science (Lambert & McCombs, 1998). Learning in this type of environment is more self-directed (Lambert & McCombs, 1998) which can have an impact in the science identities learners exhibit.

Science identities in practice can also vary according to environmental factors such as the circumstance or the people involved in such experiences. New experiences provide a venue for the creation or emergence of identities that learners may not be aware they had (Tan & Barton, 2008). The validation of such identities by outside forces (e.g., teachers, scientists, community leaders) afford participants agency that leads to social behavior that says “yes, I am a scientist,” or “I can be one if I chose to do so” or the opposite can occur as in Carlone’s (2004) study where girls in a physics class were constantly reminding themselves that science was not their forte and did not want to try new experiences. The validation or reaffirmation of such identities (Gee, 2000), is important in gaining recognition as a doer of science. The connection between the different components in Figure 2 can be linked through systems theory.

The Creation of a System

Systems theory (ST) refers to the science of systems whereby the whole has unique properties that function in a collective way and not as a gathering of the individual functions of each part. In biology, systems theory was introduced to help explain the role of organisms in an ecosystem (Schwandt, 2007). Using ST to propose that experiences are a part of an interworking of systems is useful in understanding interaction within a system or how an individual makes sense of such interactions. This is evident when studying individual parts of a system or selected networks within a system (Chen & Stroup, 1993). For this dissertation, systems theory refers to two types of systems: (1) a scientific, interdisciplinary system of experiencing and understanding the world, and (2) a social system, which includes the girls’ peer group, the facilitators, parents, and community

members. Both systems can affect the development of a science identity in girls from marginalized backgrounds.

Critical race theory provides a venue to explore the stories and experiences of learners form marginalized backgrounds (Ladson-Billings & Tate IV, 1995; Solorzano & Yosso, 2001; Thomas, 2009). Experiential learning theory provides a venue for the exploration of contextual science experiences (Kolb, 1984a; Wurdinger & Carlson, 2010). CRT, EL, identity, and systems theory provide a framework for exploring science identities that emerge as learners “do” science. These theories make up the cornerstones of the creation of empowering experiences for middle school girls from underrepresented backgrounds. Different components of the research project focused on one or two theories as being prominent, but the connection, the interweaving occurred through critical race theory.

Chapter Summary

This chapter provided background information on science education reform in the past three decades, issues of underrepresentation of certain groups in science, on the importance of experience and the experience of place for learners from diverse backgrounds. A second purpose for this chapter was to develop a conceptual framework to make sense of experiences that will inspire middle school girls to experience science in their place. The conceptual framework was built on contextualized experiences for science learning, the creation or emergence of science identities, which will be explored through a critical race theory lens. Chapter III opens with the full pilot study where the

researcher explored the feasibility of two Latina girls to pursue careers in biology. The second part of the Chapter III describes the methodology for this dissertation and research design.

CHAPTER III

PILOT STUDY, METHODOLOGY, AND RESEARCH DESIGN

Chapter Overview

This chapter is organized into two parts. The first section presents the pilot study for this dissertation, which explored the life trajectories that led two Latina girls to want to pursue careers in biology. The findings from the pilot study informed foundational ideas used in the design of the intervention for this dissertation. The second section presents the methodology and research design for the main study presented in this dissertation and details the specific procedures for data collection and methods for analysis used conduct this larger case study.

Part 1. Pilot Study

When Preparation Meets Opportunity: A Case Study Exploring the Feasibility of Pursuing a Career in Biology for two Latina High School Girls

The pilot study is presented as a manuscript which includes an introduction, methodology, findings, discussion and conclusion specific to the pilot study research question: What are two Latina high school students' perceptions, regarding the feasibility of pursuing a career in biology? The pilot study served two purposes: 1) for the researcher to try out case study research

as a methodology to be used in the main study and 2) to inform the researcher's thinking about the main study design.

Pilot Study Introduction

> "As Latinos become more than one-third of the American population, it is imperative for our economic future that they earn a college degree. It's not a Latino issue; it's an American issue"
> (New Futuro, 2012, p. 1)

The future of this country depends on utilizing human intellectual resources from varying viewpoints to make informed decisions on issues from conservation biology to biotechnology, or even bioengineering. A university in the Rocky Mountain Region with a population of 14,000 currently has a nine percent of the total student body comprised of Latino students. As a further cause for concern, only one Latino/a student graduated with a biology degree in 2006, and in 2007, the department did not have any Latino/a graduates. The same trend is evident today. This seemed peculiar since the surrounding school district had a 49% Latino/a population (Colorado Department of Education, 2011). Taking into consideration that within this population there are a smaller percentage of students who are "college bound," it is of even greater need to this community to inspire more Latinos to pursue a post-secondary degree. The concern with issues of equity and underrepresentation of certain ethnic groups is evident in science technology, engineering, mathematics (STEM) disciplines. In the state of Colorado, meeting the workforce demands is also a priority. For every unemployed person with a background in STEM, there are 1.5 jobs available (Change the Equation, 2012a).

An increase in Latina students in biology would bring a variety of viewpoints, as well as personal and cultural experiences (Bernal, 2002) to academia. To insure that we have enough experts in biology in the future, the researcher sought out a resource that has not been previously explored to the fullest potential. Understanding why Latina girls would want to pursue a career in biology and the barriers they encountered in that endeavor was of great interest to the researcher, to make sure the main investigation as part of this dissertation adequately targeted future intervention needs. The research question that guided this pilot study was: What are two Latina high school students' perceptions, regarding the feasibility of pursuing a career in biology?

In this study, a career in biology was defined as a career that requires an expertise in biology that is gained by completing bachelor’s degree in biology or an affiliated field. The goals of this study were to explore the experiences that Latina students were encountering in their final two years of high school and to investigate the nature of the experiences that influenced their desire to pursue a career in biology. Ultimately, research findings provide valuable insight to inform programs that aim to inspire and prepare young Latina girls to consider careers in biology.

Latinos in Higher Education

Research in Latino/a education has increased in the last couple of years. Denner & Guzmán (2006) provide a detailed account of research that challenges stereotypes of Latinas that keep them from opportunities to be seen as professionals and leaders in their communities. The authors highlight issues such as teen pregnancy, gang involvement, and the notion that Latina girls will drop

out of school. Having a “science identity” is definitely not a stereotype that people think of when they think of Latina girls. The under-representation of Latinas in science must be addressed since the growing number indicates that this ethnic group will make up a large percentage of our future workforce.

A report compiled by the Pew Research Center acknowledges that there is a serious issue of underrepresentation in general for Latinos in post-secondary programs (Fry, 2002). The average graduation rate for Latinos is 52%; 9% enroll in post-secondary programs (Fry, 2002), and only receive 7% of all awards in STEM (Ginder & Mason, 2011). In recent years, there has been an increase in research focused on career goals and aspirations of Latino students; however, no research has been done specifically on Latina students who show an interest in pursuing a career in biology or a biology related field. For example, a nationwide study focused on career expectations and goals of Latina adolescents found that while 7.2% of Latina students selected a career in a science/technical/engineering field in a survey, none showed an interest in these fields when prompted by direct questions when interviewed by the researcher (Denner & Guzmán, 2006). Most of the girls were interested in pursuing a career in medical/health care related fields when directly prompted to elicit a response (Denner & Guzmán, 2006).

Other studies have focused on what types of post-secondary schools Latino students are attending. In 2002, the Pew Latino Center conducted a study that defined the national profile of Latino students (Fry, 2002). Their results indicated that most Latino students attend a high school that is predominantly

Latino and once they graduated, enroll in college at similar rates to White students. Latino students also tend to enroll in low costing colleges, mostly two year colleges, compared to White students. One in three Latinos attended community colleges in contrast to one in five white students enrolled in community colleges; the remaining students enrolled in four-year institutions (Fry, 2002). There is a huge deficiency of college bound Latinas who fulfill the requirements to pursue a four year degree, and even fewer Latina girls who decide to pursue biology as a career.

Latina Voice

Bernal (2002) recognized students of color as holders and creators of knowledge. She recognized that for years, “the histories, experiences, cultures, and languages of students of color have been devalued, misinterpreted, or omitted within formal educational setting (p. 105).” By adding the voice of Latina students into discourses happening at the post-secondary level, we will better understand the lived experiences of these students. Latina students have the potential to add their personal experiences and innovative ways of thinking to solve problems in biology. Their experiences can also inform the field of ways to help students in this population reach their aspirations. Therefore, this project developed as an opportunity to hear the voices of two Latina girls. It resulted in an in-depth study of academic/career goals, resources, and barriers of two Latina girls who showed an interest in pursuing a career in biology. One of the participants was an undocumented student. The Dictionary.com definition of “undocumented” is 1: lacking documentation or authentication, or 2: lacking proper immigration or working papers (undocumented, n.d.). This study provided

a means where her story could be told in the context of understanding why she would or would not pursue a career in biology.

Theoretical Framework for Pilot Study

The theoretical framework for the pilot study was informed by critical race theory, explained in Chapter II of this dissertation. The foundation of critical theory (CT) emerged from the work of Karl Marx (Creswell, 2007). Critical race theory (CRT) expanded the domain of CT by focusing on the "historical problems of domination, alienation, social struggles and how social inequities" (Thomas, 2009, p. 54) that arise as a result of oppression from dominant groups (Ladson-Billings & Tate IV, 1995). CRT seeks to understand the life experiences of groups that have been historically marginalized. Many terms have derived from critical race theory and from legal traditions such as critical legal studies. One of these terms was critical race feminism (CRF). This theory embraced the multiple identities of women to understand their stories. CRF acknowledged race as a part of women's every day interactions. CRF became a venue to explore the way race and gender interact in structuring social inequality (Thomas, 2009). Similar to CRT, CRF has influenced how the researcher views their ethical responsibility in acknowledging the knowledge the two participants have and to further improve the position and opportunities for women of color in society.

Researcher Personal Stance

It was important for the researcher, and author of this dissertation, to acknowledge, "Persons of color speak from an experience framed by racism, which in turn, gives them a voice that is different from the dominant culture and

one that deserves to be heard" (Thomas 2009, p. 58). CT provides a space that calls for action. This call for action provides a space for learners who are typically not recognized as scientists to be scientists, to explore what they want to study, and to enjoy the experience. It gives them a space to be active agents of change in their own learning process where they are known as science people, or as someone who identifies with science identity (Gee, 2000).

The researcher's greatest subjectivity pursued in this project was that their own experiences were a reflection of what was possible for students historically underrepresented in science careers. The researcher emigrated from El Salvador during times of civil unrest in the 1980s. Her experience allowed for the opportunity to know what it feels like to be part of what Thomas (2009) refers to as the "Others". Nonetheless, the researcher managed to overcome multiple barriers that attempted to keep her from becoming a professional Latina in a country where such title is a rarity (Fry, 2002). The researcher is a scientist. She is also a science educator. The researcher has embraced multiple identities depending on life circumstances. Other people brand her with their own perceptions of who she is supposed to be. But ultimately, the researcher has the last word. Her educational trajectory and life experiences have influenced the researcher's definition of self.

Throughout the researcher's life, she experienced many barriers as well as many opportunities that have impacted her decision to pursue a doctoral degree. A take home message from these experiences was that the researcher would be successful if she learned to take advantage of opportunities afforded to

her. Therefore, the researcher acknowledged that there may be some bias towards the belief that all students can succeed regardless of where they come from as long as they too take advantage of opportunities (Ceballo, 2004) similar to the ones the researcher encountered in their journey. The researcher developed an interest in exploring what Latina girls were currently experiencing as they decided on careers and future aspirations especially as they pertained to careers in biology. Alejandra's story presents a scenario of an alternate ending to the researcher's personal life history—her history as an undocumented student. At the very end of her high school years, the researcher's life took a turn: she gained U.S. citizenship after a 10-year process. Eliza's story represents an alternate version of this story, the story that included opportunities, a college education, and a path towards success.

Methodology for Pilot Study

The methodology for this study was case study research. The focus was on exploring the lived experiences of two Latina girls who expressed an interest in biology as a future discipline of study. The two participants life histories represented a bounded system (Merriam, 2009). One participant, Alejandra, was a student in the researcher's classroom during their tenure teaching in a program for newcomer, or recent immigrants to the United States. The second participant, Eliza, was a student at an International Baccalaureate (IB) school where a colleague worked. Mrs. SP, a teacher from the local district, recommended Eliza for the study since she had expressed an interest in pursuing a career in biology upon entering college.

Participants. The Latina girls who shared their life histories in this study were Eliza and Alejandra. Both names are pseudonyms. The participants were both 17-year old, female, Latina high school students who attended local public schools in a Rocky Mountain state. Both participants came from working class parents who did not attend college. Also, one participant came from a family who was undocumented. This presented an opportunity to understand her perceptions of pursuing a career in biology and how her perceptions may differ from another Latina student who did not have to deal with immigration issues. The two girls selected a pseudonym to protect their identity per request of the Institutional Review Board.

Alejandra. Alejandra was a senior in an International Baccalaureate (IB) high school; however, she was not a student in the IB program. She did not even know the program existed at her school. She was born in Mexico and immigrated to the United States when she was in 9th grade. Her family consisted of her mother, who is the head of household, her sister who has a child of toddler-age, one older brother, and Alejandra who also has a one-year old baby of her own. Alejandra would be the first in her family to attend college and hoped to one day become a pediatrician or a forensic pathologist.

Eliza. Eliza was also a senior in high school. She was one of two children and lived with her mother and father. Eliza also attended an IB diploma granting high school. She was a student in the IB program. Even though she was born in the United States, her family made the decision to move back to Mexico immediately after her birth, and the family did not return for permanent stay in the

until Eliza was 10 years old. Eliza's brother graduated with bachelor's degree and a teaching credential, and is currently a practicing teacher in a Rocky Mountain school. Eliza hoped to someday become a medical doctor, specializing in pediatrics.

The researcher recruited these two participants because they expressed an interest in biology or a biology related career at some point during their high school years. Eliza shared her plan to study biology with Mrs. P. Mrs. P contacted me saying she had a Latina student in her class who was interested in biology and recommended her to be part of the study. Alejandra expressed her interest for biology many times during the time she was a student in my newcomer biology class. Both participants were first generation college students with differing vantage points regarding the feasibility of pursuing a career in biology. This study presents their stories.

Setting the context. This qualitative case study (Merriam, 2009) took place in a Rocky Mountain Region State. The girls lived in different cities in this region and attended different high schools. The researcher met with each girl individually. Each participant and the researcher agreed to meet at a location close to her home for convenience. Each girl named a location of their choosing and if they did not have ideas, the researcher suggested some possible meeting places. They each selected local coffee houses near their homes. Eliza was able to drive to the meeting location and Alejandra needed a ride for each interview.

In this qualitative case study (Merriam, 2009), the main sources of data were three semi-structured interviews and artifacts from each participant. The

questions for the interviews were open-ended with the intent that the girls would tell their story freely but centered on examining their experiences and the reasons they were interested in biology. The researcher wanted to capture each girl's life narratives and cultural descriptors (Creswell, 2007) to gain an understanding of the girls' past, present, and future decisions regarding the feasibility of pursuing a career in biology. The researcher made initial contact with each girl via phone and email. She informed the girls that the interviews could be conducted in Spanish if they felt more comfortable expressing themselves in their primary language since the researcher was fully bilingual in all aspects of the Spanish language. The researcher interviewed each girl independently and each interview lasted 45 minutes to 1 hour. There were three interviews per participant. Each interview was audio recorded and transcribed. The researcher treated the girls to coffee/tea or a snack of their choice at the beginning of each interview.

On the first interview, the researcher asked the girls general questions about themselves to establish the importance of sharing their life histories (Bernal, 2002). Given the choice interviewing in Spanish, Alejandra opted to take that choice. The researcher wanted to make sure that their full narratives were shared in a way that did not cause much discomfort. On our second interview, each participant brought three artifacts to share that reflected 1) where they came from, 2) who they are or how they see themselves, and 3) who/what they hope to become. The researcher took notes of their perceptions of those objects. The final interview focused on unanswered questions or questions that arose

from analyzing previous interviews (Creswell, 2007). For each interview, the researcher took notes about behaviors, body language, or responses to document if the girls hesitated or if a particular question caused discomfort to address any issues immediately and a means of triangulating the data.

Data sources and analysis. The researcher analyzed the girls' narratives by coding the data for key themes that emerged from both girls and themes that were particular for each girl. Four common themes emerged: 1) early educational experiences, 2) common deciding factors in choosing to pursue a career in biology, 3) support networks, and 4) challenges or barriers that caused the girls to deviate from their path towards pursuing a career in biology.

As the researcher collected the data, she analyzed it and coded it (Merriam, 2009) to define the next set of interactions with the participants. Therefore, the researcher was constantly comparing the data (Creswell, 2007). She revisited the entire data set at the conclusion of the study to categorize patters that both girls exhibited in their desire to pursue a career in biology. Internal validity was supported through triangulation (Merriam, 2009), which included looking for supporting data and multiple methods to confirm the ideas arising from the interviews, such as the interviews and the artifacts the girls shared. It is not always necessary to have three specific methods, just multiple sources of methods. However, for this study the researcher conducted interviews, collected artifacts, and member check (Creswell, 2007) to verify that the data the researcher collected matched with the participants ideas. Also, having two participants and multiple interviews increased the validity and

reliability of the pilot study since the researcher used cross case analysis to verify patterns or themes that emerge from the data specific to each participant, and themes that occurred between the individuals.

The common trends in the data reflect four major themes. The first major trend was in the girls' educational experiences and early exposure to experiences. Second, the researcher saw that each girl had very specific reasons for wanting to pursue a degree in biology. Third, support networks seemed to be a large factor in the girls' life stories. Last, there was a trend in the challenges or barriers that have caused the girls hardships toward achieving their career goals.

Findings

Educational experiences. Alejandra was the top of her class in Mexico. When she arrived in the United States, she was placed in all English classes with English Language support as a separate class. The following year, her home school made the decision to bus her to a local school where she could receive more support to learn English and primary language instruction in two core areas: science and mathematics. This new program was designed for high school students, but it was housed at the local junior high that also had a large English language learner population. The local junior high included 9^{th} graders who took biology.

Even though Alejandra had already fulfilled the requirements for freshman courses at the new high school, she was required to repeat the courses in Spanish because she was sent to a new program in the district, the "Newcomer Center" housed at the local junior high, even though she was a high school student. Alejandra was still eligible for admittance to the Newcomer Center

because she had been in the United States of America less than two years and was considered Not-English proficient. Alejandra joined a newcomer class consisting of 12 students who were also Not-English proficient and she was required to take the same courses as the other 11 students, which included primary language biology and mathematics. The researcher was the teacher in charge of these two courses as part of their workload. The intent was to increase content mastery in biology and mathematics in the primary language. The remaining two hours, the newcomer class was exposed to two periods of intensive English. In the afternoon, the class was bused to the high school to take elective courses with their peers. Alejandra was in a tough position. Alejandra could not be bussed separately to take the two hours of intensive English every day, so she had to re-take biology and introductory mathematics. She was also needed to keep the “count” to justify the need for the class.

Alejandra shared, “*Pense que estaba hacienda bien, pero me dijeron que tenia que seguir con los* ‘newcomers’. [I thought I was doing well, but they told me I had to stay with the newcomers].” She was inadvertently placed at a disadvantage because she was seen as having a deficit in English, even though she successfully earned a “B” average in the English-only classes she took as a newcomer the previous year, which included courses in biology, math, and history. This notion of deficit thinking has been conceptualized by Valencia (1997).

Alejandra was labeled as being deficient, because she did not speak English well, and there was a domino effect that placed her with a group of

students who not only needed support with learning English, but with learning content as well. If Alejandra would have felt comfortable speaking English a year after she came, she would have been allowed to stay in regular classes and perhaps she would have had an opportunity at fulfilling the four year course requirements that four year universities have in place. Her mom did not question her placement because she assumed that the school was doing what was best for Alejandra (Zarate, 2007). Alejandra's mother trusted the school as an authoritative structure that should not be questioned.

Alejandra felt a missing sense of opportunity. She could not take advantage of advanced classes because she did not feel confident in her English abilities. Needless to say, by her second year attending school in the United States, she was almost a year behind in coursework. As a result, she would not be able to fulfill all the courses necessary for a four-year institution because her schedule did not allow it. Alejandra's counselor tried to get her up to speed, but in four years, she only completed the basic high school requirements for graduation set by the local school district. The message was that "graduating from high school was good enough." Her disadvantage grew. Not only was she labeled deficient in English, and hence there was the assumption that she also did not have content mastery but she was also an undocumented student. The hopes of pursuing post-secondary education dwindled really fast. Unfortunately, this problem is all too common (Collatos, Morrell, Nuno, & Lara, 2004).

Alejandra shared personal fear. She had peers that had graduated from high school and they still worked at factories, cleaned houses, or worked in

slaughterhouses similar to their parents, and she did not want that kind of life. Behnke, Piercy, and Diversi (2004) reported that there is a correlation among parents with higher educational aspirations and the impact this had on their children: Youth that aspired to complete a higher education degree had parents who also wanted to further their education, whereas youth who had parents that focused on working and making money to sustain the family also sought opportunities to work as soon as they could (Behnke, Piercy, & Diversi, 2004). Alejandra questioned the purpose of a high school diploma and clearly stated that she must continue her education, "*Para ser alguien en la vida* [to be someone in life]."

Eliza has had a different educational experience than Alejandra. Most of Eliza's family moved to Mexico when she was an infant, except for her father. He stayed in Colorado to work to make ends meet to send money to his family back in Mexico. The continuous trips to visit her dad exposed her to some English but she was by no means fluent. Her family moved back to the U.S. when Eliza was in 5th grade. She shared, "I didn't want to leave… my only home… that's all I have known…I had been here [in the United States] before but I only…stayed like a couple of days or a couple of weeks. So it was…[the] fear of the unknown."

Upon enrolling in school, she was placed in a mainstream class, but was pulled out for one hour of daily English language acquisition (ELA) instruction. Eliza remembers playing games, at least that's what she thought she was doing, but apparently her teacher was very successful at scaffolding instruction for Eliza to learn English quickly. Eliza mentioned that her teacher truly cared for her and

helped her in any way possible. Calaff (2008) examined practices that supported culturally and linguistically diverse students and found that care and support from teachers had a positive impact on students. Eliza's teachers taught and demonstrated this ethic of caring in everyday interaction (Noddings, 1984). By the end of fifth grade, Eliza remembers feeling comfortable with English as a second language.

Even though both girls attended schools with an IB program, only Eliza fully participated and was successful in completing the IB requirements. Unlike Alejandra, Eliza would receive her International Baccalaureate Diploma upon graduation. Alejandra was not aware that the IB program existed in her school and she claims that even if she would have known about the program they would not want someone like her, "*no creo que quieran alguien como yo* [I don't think that they want someone like me]." Being in a program that fosters higher educational goals, Eliza felt she was well prepared to undertake a major in biology. As she completed her high school diploma Eliza is was confident in her skills and felt well prepared for college.

Deciding factors in choosing to pursue a career in biology. Alejandra had memories of studying biology as early as third grade. She remembers learning about human anatomy from basic body parts to the structure and function of various body systems. She was very interested in the topic at an early age. Alejandra continued to be interested in anatomy in 9^{th} grade as well. Alejandra hoped to pursue one of three career aspirations that included this particular interest. She wanted to be a forensic pathologist, a nurse, or a veterinarian (all

science, or science-related careers); however, she hesitated and concluded that "*cualquier cosa* [anything]" would be good enough regarding her future aspirations.

When asked what path she would have to take to pursue a career in forensic pathology, she jumped at the opportunity to emphasize the importance of pursuing a degree in biology to meet her career goal. She mentioned that in all three careers she would have to know anatomy. Alejandra not only wanted to know more about the human body, but also hoped to someday develop a drug as a treatment for a disease. Eventually, she wanted to attend a professional school to complete a veterinary or a medical degree. She liked the idea of studying biology because, "…*me gusta la investigación y estar viendo organismos. Para mi eso es muy interesante* [I like inquiry and observing organisms. For me, that is very interesting]." She explained that this passion started at an early age and was reinforced through experiences in middle school.

Eliza's career options were also along the lines of the medical field which is a common career aspiration among Latina girls (Denner & Guzmán, 2006), because there exists a need to help people or give back to the community. Eliza noted, "Well, I wanted to be a nurse at since I was in elementary, and part of middle school. But I saw that doctors get paid more." I commented that they also go to school for a longer time. Eliza added, "I know that's true, but I decided that if I was going to do it, that I would go the whole way." Being part of a program that fostered high expectations taught Eliza that she was capable of aiming high.

Eliza aspired to someday work in a small clinic in a small town and have a personal relationship with her community. She figured she needed to pursue a lot more science related courses if she was to ever fulfill her dreams. Therefore, she had taken three courses in biology, two in chemistry and attempted higher math but struggled a bit with advanced Calculus. It was evident that Eliza's career aspirations were well defined based on her life narrative. She attended a four-year private institution, declared biology as a major, and is on her way to graduating in four years. A couple of years into college Eliza decided that being a physician's assistant (PA) gave her more flexibility for the future. She is currently in the process of applying to PA school.

Support networks. There were support networks that manifested in different ways in the girls' lives. Their support systems consisted of the home networks, school networks, and the community network. The girl's social systems helped but sometimes hindered their career aspirations. Critical systems theory helps us understand the changes that are necessary at multiple levels to help students navigate through academic and social systems they encounter.

In-home network. Alejandra's mother shared that she is willing to support her as long as she stays focused on her goal of completing an education. Alejandra mentioned her father once, but did not emphasize the role that he has had in her education. Alejandra showed a deep respect for her mother, but she hoped to finish a career so she would not end up working odd jobs like her mom. There was a part of her that was willing to take on the challenge to break the social stereotypes associated with Latinos (Denner & Guzmán, 2006).

Eliza had her parents' support in pursuing a college degree. At our initial meeting, Eliza's father joined us to sign the informed consent form and he expressed great concern regarding the cost for college and asked me to give Eliza some *consejos*, or advice. At the time of the initial interview she still needed to secure $16,000 to cover the $44,000 yearly cost of attending a private institution. Eliza applied to many scholarships and grants and was determined to go to her first choice, a private university in a major metropolitan area. A few months after the interviews concluded, she informed me that she was one of two hundred Daniel's scholars. The Daniel's Fund is dedicated to covering the remaining costs of college education so long as there is an effort from the family and other financial aid options explored. Eliza had just secured a "full ride" to her dream school.

Both girls had support from their parents to pursue a college education. However, Alejandra was still in the investigation phase of selecting a community college to attend since she did not have the prerequisites to enter a four-year institution, and cannot afford to out-of-state fees imposed for being a "non-immigrant alien." She had not learned to navigate the system that was working against her in her desire to pursue a career in biology. Her mother was not aware of what requirements Eliza had to fulfill to enter *la universidad* [the university]. The reality of her situation was that she could only realistically pay community college fees with a lot of effort.

School networks. Alejandra shared the importance of a supportive network she found at school. She mentioned that the outreach coordinator

helped her tremendously, especially since she had her baby, "*Si no fuera por Lolita, ya no estaría en la escuela* [If it were not for Lolita, I would not be in school anymore]." Lolita's sense of agency in the local school community provided a voice for new students on campus, especially students with language needs. Agency refers to Lolita's capacity to choose to speak out on behalf of the students she worked with who perceived they could not speak out on their own in the present school climate. Lolita was the voice for change in the students' eyes. Lolita could go to the administration and request special services such as food and clothing, and push to get these students' basic needs met. The student's sense of agency, on the other hand, was non-existent. Lolita made sure that students came to school provided a safe space for students to voice their concerns about issues not only related to school, but to their home life as well. Lolita was truly an advocate and Alejandra recognized that. Lolita encouraged them and reprimanded them if they got in trouble or failed to complete their "student duties," such as maintaining good grades and succeeding in their classes. Alejandra expressed her appreciation for Lolita. Needless to say that having a caring adult was a great motivating factor for Alejandra to stay in school (Noddings, 1984). The system that Lolita created for students like Alejandra was a system that valued their cultures, respected their hard work, and understood that there were many factors out of students' reach that worked against them in their pursuit of education.

Alejandra had 10 close friends; three of them attended the local community college, and planned on getting a job right away. None of her friends

planned on attending a four-year institution. The common trend among Latinos is to enroll in community college because it costs less (Fry, 2002). Also, besides her teachers, Alejandra did not personally know any professionals from the community and did not have friends who had the vision of completing a four-year degree. She shared, "*No tenia amigos porque en la escuela no habían muchos Hispanos, habían muchos Americanos y no tenia con quien comunicarme* [I did not have friends because, at school, there were not many Latinos, there were a lot of Americans and I did not have any one to talk to]." Her inability to communicate cross-culturally prevented her from finding and taking advantage of opportunities to which English-speaking students at her school had access. Alejandra's social network lacked a space where talking about college and career aspirations was seen as "normal." Alejandra feared that if she shared her goals, she would be seen as someone who thought she was better than them.

On the opposite spectrum, Eliza, unlike Alejandra, had a supportive network of college bound students around her. She had 15 close friends. Seven, to include Eliza, planned to attend a four-year institution. Five would attend a two-year college and the rest were unsure if they would join the military or start working. Eliza knew many professionals in her community. Her volunteer experience exposed her to doctors and nurses at the hospital and she is looking forward to turning 18 so she can have an opportunity to shadow these professionals to learn more about what they do on a day-to-day basis (Tate IV, 2008).

Challenges and barriers. Alejandra had three major challenges that kept her from pursuing a degree in biology: 1) financial constraints, 2) her immigration status, and 3) language barriers. Alejandra's financial concerns were evident in the following occurrence:

> "*[E]l costo si es caro porque no te ayuda el gobierno, como no tienes papeles o un seguro social, el gobierno no te puede ayudar así como les ayuda a las demás personas a lo mejor con la mitad. Pero, no se… yo pienso en trabajar, juntar un dinerito y seguir una carrera corta* [the fees are high because the government will not help you, since you do not have documents or a social security, the government cannot help you the way it helps other people at least with half (of the cost) But, I don't know…I'm thinking of working, saving a little money and completing a short career]."

Alejandra added that if money were not an issue, she would not have to worry about having *papeles* or documents because she would be able to pay whatever amount the school charged. Being undocumented was Alejandra's second major barrier. Collatos et al. (2004) also identified that being undocumented can be the biggest hurdle for students who want to pursue higher education have because the financial barrier to pay for school is a major problem for most of these students.

The lack of opportunity to prepare students from our local communities poses a great challenge when issues such as immigration status keep bright students from becoming productive members of society in a place they call home. The state where the study took place is importing bio-scientists, engineers, and other STEM professionals to meet the demands of the workforce needs of key industries because there are not enough graduates form the local schools who can fulfill that demand (Change the Equation, 2012a).

Language was also a major challenge Alejandra encountered in her journey. Even though the school she attended tried to help her by placing her in an “intense English program” being in primary language instruction courses where Spanish was used to help students in her cohort master mathematics and science content did not help her move forward. Alejandra thought, “*a lo mejor había sido mejor tomarlas todas en Inglés para haber aprendido más Inglés* [maybe it would have been better to take all (the classes) in English to have learned more].” She knew that learning English was really her need (Dávila, 2008), not necessarily mastering content, because she already had content mastery compared to the peers in her cohort. Although she saw the benefit of first language instruction she felt that the program did not fit her needs and saw it as an easy year because the program focused on skills that she already knew, but her classmates lacked.

Alejandra’s career aspirations took a detour when she found out she was pregnant with her first child. Contrary to the notion that Latinos do not value higher education (Valencia, 1997), she still held a high value on the opportunities that a college degree could bring. At one point she said she might just stay home and take care of her children, but she was aware that money might be an issue. On the other hand, because Alejandra had a child, she felt more compelled to give him a better life than what she had and was more motivated to continue with her education (Denner & Guzmán, 2006). She planned to pursue a degree in biology at the community college, but recognized she still has to learn a little more English.

At school Alejandra experienced different forms of oppression (Denner & Guzmán, 2006) from classmates and teachers alike. In some instances, some of the girls in her classes stared at her as she entered the classroom and made her feel as if she did not belong there (Fernández, 2009). She chose to ignore them, but since she shared this experience as part of her life narrative, this tells us that this impacted her perception of how others perceived her (Gee, 2000). In one way or another she might have felt like an "Other" and perceived as not belonging (Thomas, 2009). On another occasion, Alejandra felt that some of her teachers ignored her because she could not communicate effectively (Valencia, 1997). She shared that her math teacher would call on all students, and skipped her. She loved math and remembers receiving top prizes in competitions "back home" as early as 3rd grade. In this situation, she lacked a support system that embraced her culture, the wealth of information she knew and brought with her. There was no space for her to share her funds of knowledge (González, Moll, & Amanti, 2005). She was ignored. The system making up her in-class experiences was not supportive in helping her become a confident person with a strong science identity (Gee, 2000). The message she received she was that she was part of a system that did not want her there.

Eliza on the other hand, mastered the English skills that she needed to succeed. She returned to the US at the end of elementary school. She describes her early experience in the United States as being "fun" because her teacher taught her English through games. Her teacher taught science "hands on" through inquiry methods. This was an effective way for Eliza to develop an

interest in asking questions and finding solutions to problems. Early experiences played a key role both girls' development.

Eliza learned English right away and was placed in honors classes in middle school. This gave her the opportunity to be part of the IB program once she entered high school. Both girls were equally capable and had similar desires and interests; however, the opportunities afforded to Eliza were not comparable to the lack of opportunities that Alejandra felt she encountered.

Both girls wanted to build independence and to earn enough money to support their families to help their parents with the bills. Also, both girls commented on the need to help their communities in one way or another. For example, Eliza commented on her desire to work in a small community where she would know all her patients. Alejandra commented on her desire to someday find a drug that may help cure a disease and she also commented about her interest in environmental issues and how they are affecting her community.

Pilot Study Findings
Informing Practice

Although schools may have the best intentions in developing programs to students learn English, involving students and parents in the decision-making process is imperative because it gives them a voice to share their concerns (Zarate, 2007). For example, Alejandra saw the program she was placed in as "easy" when she would have preferred to continue pushing herself in English only classes. The experiences of other students in the program may have been different than Alejandra's and it is important to take this into consideration;

however, all too often we see how student's voices are silenced and decisions are made without the students and parents understanding the implications.

For Eliza, joining the IB program placed her in a college bound track. Her older brothers did not have this opportunity because they were unaware of this educational opportunity; however, her family's exposure and experience in the United States helped her in the long-run because they learned more about different programs to help Eliza fulfill her dream of completing a career in biology and earning a medical degree. She learned to navigate a complex system.

The importance of social networks and support from peers or adults was very important for both girls. Social networks hindered Alejandra's opportunities and facilitated Eliza's trajectory. However, having a support system through Lolita helped Alejandra complete her high school education.

The primary reason for choosing to pursue a career in biology was as a means to pursue a degree in medicine because of the financial rewards and their need to help their communities. Neither girl was aware that applicants to medical school do not need a degree in biology for admission, but only the successful completion of the necessary coursework listed in admission criteria.

The themes that emerged form Eliza's and Alejandra's stories indicate that life experiences made a lasting positive or negative impact to the two girls' trajectories and they were an important component to developing an interest in biology. Both girls in the study believe that early exposure (e.g., in the elementary and middle grades) to science experiences had an impact in their own decisions to pursue careers in biology. The literature backs up this claim,

noting that girls' may lose interest from 5th-8th grade, which is the age when many girls often develop a negative attitude towards science (Zacharia & Barton, 2004). By high school girls have already been tracked into courses that can help them accomplish their goals or keep them from being college-and career ready in science (Oakes et al., 1990) .

The second theme that emerged was the intrinsic desire to serve their community or people in need, a factor that adds a dimension to their sense of belonging to a place, to their community. The participants from the study felt they needed to understand the community issues facing Latinos when dealing with healthcare issues. The girls were not able to articulate problems that dealt with the immediate environment or about the ecosystems in areas where they live because they had never been prompted to ask such questions. They wanted to develop a deeper connection to the issues of the Latino community where they lived, but their visions were limited to in-hospital, clinical settings, and issues such as the inability to communicate health-related concerns experienced by family members with limited English abilities. Issues of housing, water quality, and other environmental stressors were not part of their discourse because they had never been exposed to such issues. This finding identified a need to provide a safe place for experiences that broadened the definition of biology for students coming up the ranks.

In addition, the feeling that the girls were part of a system that supported their endeavors was very important. Each girl had different levels of support towards pursuing post-secondary education. Alejandra was undocumented and

could not pursue a biology degree even if she yearned to do so simply because she could not afford to pay out of state fees to enroll in college. Thus, being part of a sociocultural support network that afforded opportunities to go to college was of key importance.

Having a sense of opportunity framed how the girls saw the next step in their educational continuum. Their notion that not all opportunities, such as attending college, are equally accessible to the girls was a major factor impacting the girls' trajectories, even if they were equally talented. A lack of opportunity caused Alejandra to deviate from her path towards pursuing a career in biology. For Eliza, the sense of opportunity motivated her and inspired her to continue on her educational trajectory. There are issues that we can actively focus on that could possibly enhance middle school girls' perception of science, their science identities, and the preparation in science necessary to enter the workforce or continue with post-secondary education.

The future of this country depends on capitalizing on the human intellectual resources from varying viewpoints to make informed decisions, to be innovative at creating solutions to real world problems. Even though Alejandra mentioned her interest in environmental issues, she did not see herself pursuing a career specifically dealing with these issues because she could not see the monetary benefits that she sought for a better life. Though these two Latina students said that they want to become doctors or nurses, they were not equally informed about the educational requirements to pursue such careers.

The field of biology encompasses many sub-fields. By providing girls with opportunities to explore biology in a different context, they may be more open to pursue a career in biology with wider options than medicine. While we need an increase in representation in health careers, the reality is that most students who pursue a biology degree do not end up in medical school. Therefore, it is imperative that young girls are exposed to the plethora of careers within the discipline of biology.

Bernal (2002) argues that an increase in Latina students in biology would bring a variety of viewpoints, as well as personal and cultural experiences to academia. To insure that we have enough experts from varying viewpoints and experiences in biology in the future, we must provide opportunities for these girls to explore biology in a context they have not experienced so far. Therefore, interventions to provide opportunities to girls in the process of exploring

Programs that are student centered are of need because girls need to have ownership of their learning so they can see that their voices are valued and respected (Denner & Guzmán, 2006). To call for social change (Thomas, 2009), the researcher challenges the notion that Latina girls do not value education and that they do not have what it takes to be successful in college as explained by this notion of deficit thinking (Valencia, 1997). If they develop a passion for issues impacting our community, tackling issues of access, equity, navigation through this system, and a feeling that science is part of the girl's identity may be a solution that will inspire and prepare students from underrepresented groups to pursue careers in biology and other STEM disciplines. Improving the graduation

rates of underrepresented groups should be a priority for institutions of higher learning because diversity *per se* promotes excellence (Ely & Thomas, 2001). Providing access to pre-collegiate programs as early as elementary school where students from groups historically underrepresented in STEM careers can experience science in action and be part of a science community can be one step in this effort to inspire and prepare the next generation of STEM leaders.

Pilot Study Implications for this Dissertation

The pilot study for this dissertation explored the life trajectories that led two Latina girls to want to pursue careers in biology. Findings from this study identified three key components that informed the development of an intervention designed to expose girls to research experiences in biology. These components were: 1) early educational experiences, 2) exposure to career options and mentors, and 3) creation of systems that bring a sense of community or a sense of place. Complementing the findings from the pilot study to findings in the literature that pertained to experiences for girls from underrepresented groups in science framed the present dissertation. Themes from the pilot study led to the thoughtful creation of an opportunity (*El Espejo*) that exposed middle school girls from marginalized backgrounds to an experiential opportunity to learn science. The second part of Chapter III focuses on the methodology for the main study of this dissertation and describes the research design. The use of case study as a methodology also informed the data collection for the main study.

Part 2. Methodology for Dissertation

Case Study

A case study is a detailed investigation of a single individual or group used to describe and explain certain phenomena (Swanborn, 2010). The pilot study focused on the stories of two girls. Using lessons learned from the pilot study in applying case study methodology, the case study that frames the main portion of this dissertation focuses on a descriptive account of the experiences of eight girls who participated in an ecology-based summer research program, *El Espejo* (The Mirror), at the Poudre Learning Center in Northern Colorado.

The focus of this case study was on exploring the experiences of girls as they participate in an ecology field experience and how those experiences affected the development of the girls' confidence and competence in science. The specific design for this study was an embedded case study because the focus was on exploring the process, meaning, and understanding of the experiences of the participants in a particular program, *El Espejo*, which represented a particular, bounded system (Merriam, 2009). Thus, the girls' experiences in this program defined the "case" studied. Eight individual cases represented the embedded cases to understand the experiences of particular participants contextualized within this bounded system. This case study relied on multiple sources of data: interviews, journals, photographs, and work samples to capture a holistic account of the girls' experiences (Swanborn, 2010). The research questions informing this descriptive study, the study system and context where the case study took place, the eight participants, and the methods for collecting data will be described in the following subsections.

Research Questions

The original study began with a broad, overarching question: What motivates girls from marginalized backgrounds to consider a career in science, in biology in particular? More specifically, the initial question of interest for the pilot study was: What are Latina high school students' perceptions, whether documented or undocumented, regarding the feasibility of a career in biology? After answering this initial question, the research area of interest, still in the inductive phase, focused on the necessity to figure out how to develop a program that would address the community needs for exposing Latina girls and girls from marginalized groups from local schools to summer learning experiences where they could learn about science in their local environment. This question led the way to determine what type of experiences would help engage girls from marginalized backgrounds to study science during the summer. This research question of interest then became: What are key characteristics needed for an intervention to increase girls' interest in science careers?

This dissertation primarily focused on reporting on the most recent stage of *El Espejo* during year 4. As such, research questions centered on describing the girls' experiences doing science, what they learned during the program, and how science identities developed or emerged as a result of this intervention. The following research questions guided this dissertation:

Q1 Understanding a program that targets a special population. What characteristics of the intervention were necessary to engage girls from underrepresented background in the experience? What roles did facilitators undertake in the intervention that contributed or hindered the girls' experiences? What attributes of a defined intervention

contributed to the effectiveness of the intervention as measured by the goals fulfilled?

Q2 Ecological Knowledge as a Component of Scientific Literacy. What ecological knowledge did middle school girls have before and after the intervention?

Q3 Understanding Science Identity Formation as an Integrated Process. How did girls' science identities emerge or change over the course of the program? In what ways did being part of a “system” help or hinder the girls’ science identity formation?

Study System

The intervention originated as a summer experience for girls designed to provide them with the opportunity to envision what it would be like to be a researcher, whether a scientist, a mathematician, or an engineer as a future profession. The girls were exposed to seven days of research oriented, inquiry activities. Figure 3 shows the three major stages: planning, development, and follow-up.

This intervention was designed as a community collaborative. For four years, teachers, university students and professors, business partners, and individual donors all came together to make the program happen. Their continued involvement will ensure long-term viability of the program.

The experiences of the girls participating in this intervention make up the cases examined for the remainder of this dissertation. The remainder of this chapter sets the stage for studying the science identities that emerged from the girls’ experiences, and how those experiences added to their perceptions of science and their ability to do science, their perceived self-efficacy in science.

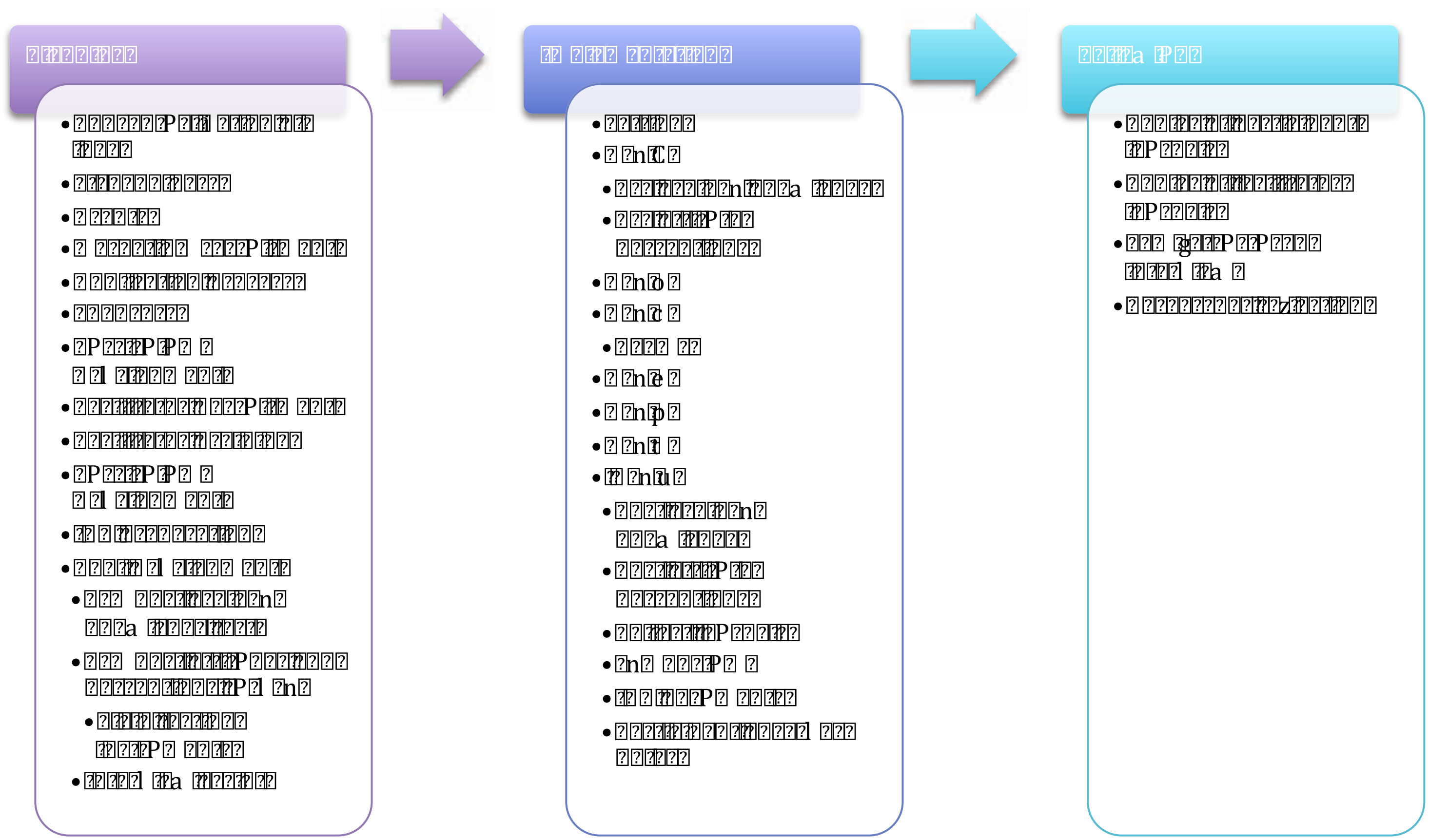

Figure 3. Planning, implementation, and follow up of program for Year 4.

Planning

Overview of research context. The Poudre Learning Center (PLC) is a 65-acre, "interdisciplinary learning site focusing on the importance of the history, science, economics, and stewardship of the Cache la Poudre River (Poudre Learning Center, 2011, p. 1)" watershed in Northern Colorado. Learners from local school districts can easily reach the center with a short bus ride, funding permitting.

As a community learning site the Poudre Learning Center is committed to providing opportunities for all community members to explore the outdoors with an inquisitive mind, using inquiry-based instruction, promoting student-led critical questions, innovation, application, and collaboration in an outdoor setting. The researcher first visited the center as an educator where she experienced her first inquiry methods class. A couple of years later, she became one of the university research fellows at the center.

The creation of *El Espejo* began through meetings with the director of the Poudre Learning Center, local teachers, and the researcher. The director, Mr. T, the teachers, and the researcher brainstormed possible ways to keep students engaged throughout the year. A major concern and community need was that local students at the elementary school were not getting science during the school day because they needed to take extra reading and mathematics class.

Mr. T proposed a summer learning experience that would be beyond the school day to expose them to research protocols and to expose them to what science is like in the field. We decided to create a program that would engage

girls who were not being exposed to science to have an opportunity to experience science at the learning center over the summer. This would add to the already existing efforts by the local teachers to expose these students to an after school program since they were not receiving any science instruction during the school day. In the pilot study the researcher investigated why Latina girls would consider a career in biology, the findings informed the next steps—providing girls from marginalized backgrounds opportunities to be scientists early in their educational trajectory as they exited elementary school and into middle school. The decision was made not to go down to earlier grades because the expertise of the researcher focused on middle school students.

Findings from this pilot study with the two Latina girls' highlighted key characteristics that made one girl have a greater sense of opportunity compared to the other case. Eliza had early educational experiences, exposure to career options and mentors, and a supportive system that helped her feel confident in her ability to successfully pursue her goals. Alejandra lacked these experiences and was missing that sense of opportunity and faced many challenges, including limited exposure to science experiences and mentors. These findings helped inform the development of the experience we wanted to create for students who were not being exposed to science in school or who had very limited exposure.

Mr. T connected the researcher with two additional teachers who were working with afterschool programs at the time. Mrs. R. and Mrs. C both worked with high English language populations and they were growing a garden with a community partnership with the church across the street from where the school

was located. The team of teachers and the researcher began planning what the experiences could look like, what experiences students could have, how long the program should be, planning out the costs, and determining key stakeholders who would need to be involved to make this experience happen.

Role of program coordinator. Qualitative research methodologies call for the researchers as “the primary instrument of data collection and analysis” (Merriam, 2009, p. 266). As such, direct and continuous reflection on the researcher’s behalf was important to understand how personal experiences contributed to or possibly hindered the findings and data interpretation.

The author of this dissertation took on multiple roles as the researcher, the program coordinator, and other duties as necessary. To assist with data collection and program implementation, the researcher had assistance of a graduate student who also served as a coordinator. The researcher dedicated her time to writing grants, improving the program, recruiting participants, and building relationships with their families. As a program coordinator she maintained a working relationship with the staff at the nature center. She collaborated with partner teachers in the surrounding school districts. She was in charge of creating a vision where middle school girls from marginalized backgrounds would be able to have authentic experiences to conduct their own research at the field site. The program coordinator was funded through the National Science Foundation. She committed four years of work to this program.

Stakeholders. The list of stakeholders included all the middle schools in the area, the principals, assistant principals, counselors and science teachers,

funders, and community members including the girls' families. Teachers who would be involved with the implementation and either graduate students or outside people who would be involved in the implementation of the program were critical so we planned together to be able to coordinate next steps, from grant writing to recruitment of participants and volunteers. Also, the girls' and their families were key stakeholders because the program would not have been possible without them. The girls took the risk of showing up on the first day, and the girls' families had to support their continued involvement.

Grant writing. Program developers, including the program coordinator, and the teachers involved in the genesis of the idea were able to secure funding through various agencies including the National Science Foundation, the Women's Fund of Weld County, the Littler Youth Fund of Weld County, the Success Foundation, as well as private sponsorships. Private sponsors helped us by paying for one or two participants. We matched donors to students whose family indicated they could not afford the program costs.

Marketing and recruitment. Participants of the intervention reflected the demographics of the community for the school age population in a local diverse district. The coordinator held informational sessions, contacted school personnel (principals, assistant principals, counselors, teachers) at schools serving 50% or more underrepresented groups or students on free or reduced lunch (typically used as a measure of poverty). There was a point person, a counselor or assistant principal, who sent reminders to invite girls to attend the informational sessions. Between 5 and 50 girls attended a total of 10 information sessions.

Typically, the presentations took place during lunch. The girls brought their lunch and ate during the presentation. The coordinator had a 10-minute PowerPoint presentation highlighting key experiences from the previous year to show the girls the opportunity they could be a part of. Each girl who was interested in the program filled out an “interest card” that was traded for an application to take home. The applications were collected four days after they were handed out.

The researcher called the girls who did not return an application to remind them to take the application to their school contact person, typically an assistant principal or a counselor. One week before the program, the program coordinator placed reminder phone calls to parents. A bilingual (Spanish-English) research assistant called Spanish-speaking parents. On the first day of the program, the coordinator was in charge of calling the students who did not show up to make sure they were okay and to invite them to come the following day if they still wanted to participate.

Recruitment efforts centered on meeting individual girls, visiting schools with the target population while building and establishing relationships for continued support and open communication for future years. Program coordinators and facilitators built relationships with counselors, teachers, students, and parents at the girls’ home schools whenever possible. Parents spoke to a program leader personally or over the phone at least once before their child arrived on the first day. Both parents and students knew who the program coordinators were before arriving on site. The drivers were also trained to greet parents or guardians when they picked up the girls—this was a key component in

building trust. This effort also assured that we collected the adequate paperwork for each student.

Four days after the presentation to the girls, the program coordinator returned to the school to pick up the applications and to help students if they had problems with any of the questions. She reviewed all applications for completion. If the coordinator could not visit the school, the contact person collected the applications and the program coordinator stopped by to pick them up. The girls were automatically enrolled in the program if there was space available. We allocated 60% percentage of the spots to students historically underrepresented in the sciences and 40% of the spots to the general school populations. These numbers reflected the demographics of our largest partner district.

Application process. The application had two parts (see Appendix N and O). The first part of the application had several sections including demographic information, the questions about why they wanted to participate, transportation needs, a photo release statement, and a signature space for both the parents and the students to show commitment to attending the program. A second form asked questions specific to the family's financial need if the particular student was requesting. We did not reject any girl who said she was not interested in math or science, rather we encouraged her to come since she took the time to fill out the application. By filling out the application, the particular applicant indicated an interest in the program. We did have one case where a parent filled out the applications for the student, and the student was willing, but for the most part, the applications reflected authentic student responses.

Some girls applied because they trusted their teacher's judgment regarding the quality of the program; others applied because their teachers recommended them personally. Teachers were also instrumental in helping us determine which students needed financial assistance. Besides our own efforts, the teachers and counselors who promoted the program needed to be sure that this intervention would be something that would ultimately benefit the girls.

Sponsorships. Since there was a program fee for the participants, families who could not afford the program were matched with a sponsor. Families who documented a financial need filled out the second part of the application (Appendix O). We matched them up to a donor or we granted a scholarship based on grant subsidies available.

Program fee. The program fee, $150 per participant, was determined based on grant subsidies. This fee covered food, equipment, supplies/materials, graduate student stipend and teacher stipends. Most of the equipment bought was grant subsidized. Equipment included waders for girls, Vernier probes, nets, etc. The program fee covered the remainder of the equipment costs. The equipment stayed at the Poudre Learning Center and will remain there until it is worn out or replaced by a piece of equipment of similar or better quality. Thousands of students have the opportunity to use the equipment throughout the year. The Poudre Learning Center averages 15,000 visitors per year, with the majority being k-12 students from the partner school districts.

A percentage of the fee also covered materials that the girls used and included poster boards, any printing costs for photos for their presentations,

supplies for their studies, jars, pencils, and notebooks or journals. It also included bandanas, bug repellant, two healthy snacks, and a brown bag lunch to ensure they had enough energy and they stayed hydrated especially on hot days. We also purchased materials for art and science activities, fishing materials, and materials requested by the guest speakers. The last major cost was the girls' research vests which were filled with basic science tools such as a ruler, a thermometer, small fly tying scissors, and other tools they gathered during their rotations. The girls kept their researcher vest at the end of the program.

Transportation. Based on teacher input, the design team determined that getting the participants to the site would be an issue since many families in the community relied on one car per family. Two weeks before the program we sent out letters with transportation information. If the girls indicated that their parents were going to drive them to the PLC, we remind them of that. If they stated that they needed transportation, they would be riding a university van. There were four pick up spots per van, typically at their middle school. The university sponsor for the two vans was the Earth Science Department. Without sponsorship, the cost to use these vans would be around $500 each. University students drove two vans and picked up/dropped off the girls every day. Drivers were paid $10 per hour for their service, averaging 20-28 hours for the program. The drop-off locations were set as a central location at local middle schools that covered the range of where participants lived.

Study Participants

Participation in this study was voluntary and consisted primarily of 5th-8th grade female students, with an occasional 4th grader being invited pending space

availability. The participants of the *El Espejo* Science Research Institute applied to be in the program. We actively recruited girls from the four school district partners as a starting point to serve the local community needs; however, girls from other areas also attended the program as long as they had transportation to the PLC

All girls interested were able to attend the program on a first-come, first-serve basis until the 30 spots were filled. They represented the demographics of the local community in our largest partner district with 58% of youth from underrepresented backgrounds, and 53% participating in free or reduced lunch during the regular academic year (Colorado Department of Education, 2011). Academic records were not considered when participants were selected—only an indication of the slightest desire to learn science or to learn outdoors as expressed in their application.

Table 2

Participant Demographics Year 4

	Groups historically underrepresented in STEM			Groups historically represented in STEM		
Cohort	Latino	African/ Black	Multiple ethnicities, at least 1 underrepresented	Asian/ Pacific Islander	White	Total
Year 4	11	1	6	1	14	33
Percentage of total participant population	55%			45%		

As shown in Table 2, there were 33 participants for Year 4. Eighteen participants were from groups historically underrepresented in STEM and 15 girls were from groups historically well represented in STEM (Chinese and White in this particular setting). The percentages of the total participant population were 55 and 45, respectively. Of the 33 girls, eight were selected to participate in in-depth interviews.

Even though the qualitative case study account for this dissertation focuses on eight participants from the 33-student group in year four there were 111 girls who participated in the program over the course of four years. For these four years, the mean number of participants per year was 27. There were 81 unique participants, 30 girls who participated multiple years, not necessarily in sequence, 20 girls who participated two years, 8 girls who participated 3 years, and 2 girls who participated 4 years in a row. Unique participants means the girl was only counted once, even if she returned multiple years. Facilitators who were actively involved more than one year played an important role in the recruitment of multiple year participants and of new participants since they could share their experiences with the girls and get them energized and excited about being part of this experience.

Facilitators. Active recruitment of facilitators occurred year-round. Most facilitators had a previous connection to the learning center. Adults serving as facilitators included practicing science educators, retired science teachers, undergraduates, graduate students in biology, and scientists from the two local higher education 4-year institutions. Facilitators were the primary go-to person for

each team of girls grouped based on their topic of study. The girls requested materials, planned their studies, and interacted with their facilitators constantly.

The main intent in having facilitators as part of the field experience was for them to assist the girls in developing their study questions. During the first two days of the program, three facilitators conducted rotations to teach the girls research techniques and protocols. Day 3 they focused on helping the girls narrow down their research topics to a manageable project. Days 4-7 were spent on helping the girls gather their data, helping them with skills they needed to learn to complete their projects, such as reading a plant identification key. The facilitators spent the last two days helping the girls organize their projects into a product to present to the community on the last day.

Facilitators also helped collect data for the researcher to gain a better perspective of the interactions occurring and to know what happened when she was not around. Facilitators kept journals where they documented key experiences and their own reflections on the program. Some facilitators participated in daily debriefings, interviews and focus groups conducted by the researcher. During year 4, we had 10 facilitators for the week; however, not all could be present at the same time so they took turns making sure shifts were covered and making sure that the girls had a consistent team of two adults who knew what was happening with their projects. Along with facilitators, there were also had mentors, volunteers, and researchers who were all part of the girls' experiences. There were funds available to pay facilitators with teaching

credentials a stipend of $500 for their time helping the girls. College students were paid $300 for the week.

Facilitators participated in a 1-day training the day before the program started. The training lasted from 9-3PM. During this training, the facilitators experienced some of the activities that they would be doing with the girls during the seven days of the program. The researcher and Poudre Learning staff took the facilitators out to the field and they took notes about things they would like to learn more about. They learned to prompt questions development with “I wonder” statements. The trainers also showed them the types of data that could go in the girls’ journals. Data gathering possibilities included, observations, diagrams, thinking process, and the process for the development of the girls’ project.

The third part of the training focused on logistics. The facilitators learned how to request equipment and they were given a schedule of what should be happening on different days. This schedule included lunch and two snacks for all participants.

The second part of the training focused on the modules that were from the Eco-Inquiry book (Hogan, 1994) so the facilitators could review them to learn the protocols and determine which protocols needed to be modified based on PLC site specifics needs or on specific learner needs. Facilitators use their professional judgment to make those decisions. The majority of the facilitators have been classroom teachers at some point in their careers. We've had two groups led by graduate students and one group led by a community member well versed in educational issues as a member of a water conservancy group in town.

Mentors. Mentors were community leaders, teachers, or college students interested in building personal relationships with the girls throughout the week. They were involved in teambuilding, leadership activities, and science activities. They did not have to be experts in science to be mentors. This was an unpaid position.

Volunteers. This group of helpers were high school or college students with strong leadership potential. As a volunteer, they were in charge of documenting the team's experience through video and photography. They also served as the team liaison with the program coordinator and helped the facilitator gather any materials needed based on the team's project.

Researchers. This group of professionals were practicing scientists, engineers, or graduate students in research based programs in biology related fields interested in guiding the team through an inquiry based project. Research scientists or engineers working with individual teams had the option of deciding if you want students to carry out an individual project or a team project. Researchers worked hand-in-hand with facilitators. Some researchers were only able to stay half a day while others came for 1 to 2 days.

Researchers scientists or engineers who were time constrained had the option to visit the girls for 90 minutes to present a short talk at the beginning of the day or after lunch. In this short period of time, they presented a 15-minute overview of their profession. The remainder of the time was spend on an activity in the field where the girls experienced what that researcher did out in the field. Researchers for year 4 included an ornithologist, a chyropterologist, and a forest

ecologist. We had other speakers including a photographer, and a woman who taught the girls about tying flies. The girls were also able to meet other professional women during the Women Leader's Tea. This event will be discussed in the week-at-a-glance section.

Program Curriculum

The curriculum used during *El Espejo* was the Eco-Inquiry curriculum (Hogan, 1994) developed by the Institute of Ecosystem Studies and adapted by our facilitators for the purposes of this program. Eco-Inquiry has a strong focus on inquiry and application. Year 4 cohort used the first module "Who Eats What" which focused on concepts relating to food webs. The remaining Eco-Inquiry modules were on decomposition and nutrient cycling. Although we used some protocols from these modules, we did not dig deeper into these two modules, leaving an open opportunity for future interventions.

Module one consisted of eight lessons all focused on the concept of interactions and food webs. Lessons 1.1 and 1.2 are included in Appendix E as examples of the activities the girls experienced during the week. These two lessons show an example of the types of science protocols the girls were exposed to during the first two days of the program.

Program goals and objectives. The major goal of the intervention was to offer extended learning experiences that introduced middle school girls to projects in science originally focused on mastering Standard One from the Colorado Model Content Standards in Science (Colorado Department of Education, 2007). In 2007, standard one was "Students apply the processes of scientific investigation and design, conduct, communicate about, and evaluate

such investigations (Colorado Departmet of Education, 2007, p. 2)" Since then, new Colorado Academic Standards have been adopted (Colorado Department of Education, 2009). These new standards are concept-based and include grade level expectations of what students should understand and evidence outcomes stating what students should know and be able to do (Colorado Department of Education, 2009).With these new academic standards, the focus of the program shifted to the transfer and application of scientific concepts and practices in grades 6-8th.

As listed in Table 3, there were three major areas of emphasis for the creation of program goals and objectives. They were academic, career, and cross-cultural goals and objectives. For the academic goals, we also used a knowledge tool to gage what ecological principles students knew before and after the program.

Table 3

Academic, career, and cross-cultural goals and objectives

Academic	Career	Cross-cultural
By the end of the intervention, students will:		
Design, set up, and implement an inquiry-based, interdisciplinary investigation.	Be exposed to at least 5 careers that involve research in STEM disciplines.	Meet professional women from various cultural groups and various STEM disciplines.
Engage in using at least five scientific protocols in a variety of settings.	Meet at least 5 women professionals in STEM fields that incorporate research as part of their professional duties.	Be exposed to experiences to create cultural awareness and understanding of other for different points of view.
Communicate findings to fellow researchers and community members.	Build an understanding of the differences in community college, four-year college/university, and a professional school.	Experience intercultural communication.
Develop greater ecological awareness through meaningful outdoor experiences to learn about their place.	Understand what the word “major” refers to when deciding on a career path.	Build a greater tolerance to respect diverse points of view.
Understand that research is a dynamic process, not a linear way of finding an answer.	-	-
Make scientifically informed decisions.	-	-

Ecology Tool Development

Content knowledge test. The content knowledge test consisted of two parts. The first part was adapted from Morrone, Mancl, & Carr (2001). The second part was written based on the knowledge progressions identified by Hogan (1994) (see Appendix K). Open-ended questions were written to reflect the three knowledge progressions: food webs, decomposition, and nutrient cycling.

The first part of the test, adapted from Morrone et al. (2001), consisted of 33 items exploring 8 ecological principles. This instrument was validated for adult populations of Ohio residents, for minority populations in Ohio, and for students in an environmental science class. Questions for the present study were selected based on the Colorado Academic Standards life science concepts in grades 5 through 8. This narrowed down the 33 questions to 11 questions. The questions selected are found in Appendix H, questions 1-11 (Appendix I for Spanish test). Only questions that applied directly to concepts found in the Colorado Academic Standards were selected.

The adapted instrument was taken to the field and administered to one group of summer school girls (N=10) in the same area/school districts similar in demographics to the group in the present study. Researcher observation data included comments the girls had about the construction of the instrument, the language/wording, and on anything that was unclear. A Spanish translation of the instrument was also available, but none of the girls chose this option because even though most of the girls were native Spanish speakers, they were not literate in written Spanish. Feedback from this trial included adding an option of “I

don't know" to each of the questions. The girls who took the trial test liked having an option to say they simply don't know rather than to guess randomly (see Appendix H, Appendix I for Spanish test). The researcher conducted a post-hoc reliability analysis on the content knowledge test. Items were coded on a binomial scale, correct responses were coded "1" and incorrect responses were coded "0." The sum of participant scores for the pre-test was paired to total scores for the post-test for each participant. Findings pertaining to the reliability of the ecology principles tool will be presented in Chapter IV.

Science Perceptions Survey

The attitudes and perceptions towards science survey was developed using Farland-Smith (2009), "Attitudes Towards Science Survey" as a starting point. The new science perceptions survey developed for this study (see Appendix J and Appendix K in Spanish) includes items that were trying to get at a participant's perception of herself doing science and what other people thought of her actions when doing science. The items were reviewed by the summer school class mentioned in the ecology knowledge tool development, which was composed of a population similar to the participants in the program. The items were reviewed by for legibility, language appropriateness, and age appropriateness. The researcher also took advantage of this sample test to time how long it would take to administer the survey. Twelve of the 39 items in this science perceptions tool were worded negatively, so they had to be reverse-coded for the post-hoc reliability analysis. Findings from the science perceptions survey will be presented as part of the findings in Chapter IV.

Interview Script

The interview script (Appendix C) consisted of 29 open ended questions. The researcher conducted one test interview with one participant with a very general statement, “Tell me about *El Espejo.”* This data were not used in the analyses. The sole purpose was to develop more specific questions to guide future interviews. From this interview, the researchers developed questions to ask the eight interviewees what happened during the week, what they thought about the program, how they found out about the program, questions specific to their content knowledge, and their suggestions for future improvement. The interviews were conversational in nature. If the participant answered a question later down the list, the question was not asked again. The researcher used clarifying statements such as, “What do you mean by…?” when the participant response was unclear or statement such as “Tell me more” to elicit rich descriptions of the girls experience whenever necessary. This script was used to interview eight participants after the program ended.

The researcher trained two undergraduate student assistants to conduct interviews; one assistant was bilingual. Both student assistants participated in a 1-hour training where they listened to a clip of an interview, and discussed ways to interact with the participants with minimal bias. For example, we discussed on the role of agreeing to the statements or nodding head too much or probing too much to the point where the participant was no longer answering the question. The last part of the training consisted of a mock interview. The researcher conducted five interviews; the trained student assistants conducted the remaining

three interviews. The student assistants were also involved in transcribing the interviews so they helped clarify statements whenever necessary.

Participant field observations*.* The researcher was in the field every day during the program. As a participant-observer, the researcher was the primary research instrument for data collection purposes (Merriam, 2009). For this reason, she kept detailed accounts to the extent possible of everything she heard, saw, or experienced that could help her understand what happened during the program and how this impacted the girls. In her field journal, she documented careful descriptive observations of events that happened throughout the week, observations of what the girls did in the field, and of the research process itself.

Implementation

The seven-day program took place at the Poudre Learning Center (PLC) in the month of June. Temperatures in the week reached 100ºF. We had to take precautions to keep the girls out of the heat, but to expose them to the field at the same time. A detailed schedule for the week can be found in Appendix G. Table 4 is summary of major occurrences during the week.

Day 1. Upon arrival, the girls received a field journal to record all observations and their process developing the project. They received an empty researcher's vest (fly fishing vest) to carry their personal items and to carry research tools as they acquired them. After taking a picture of each of the girls, we gathered them in the main classroom of the Poudre Learning Center to administer the pre-content knowledge test and the pre-perceptions survey.

Table 4

Week-at-a-Glance for the Events During El Espejo- Girls Summer Research Institute

Day	Overview
1	First day of program, pre-content knowledge test, pre-science perceptions test, icebreaker activity "Dress a scientist," hand out field journals, rotations 1-3 to learn protocols, end-of-day reflections, facilitator debrief, photos, and participant field observations throughout the day.
2	Rotations 4-6 to learn protocols, lunch speaker, end-of-day reflections, facilitator debrief, photo documentation, and participant field observations throughout the day.
3	Morning speaker, project development, project proposal due, end-of-day reflections, facilitator debrief, photos, and participant field observations
4	Art and science activity, lunch speaker, data collection, Women Leaders Tea, end-of-day reflections, facilitator debrief, photos, and participant field observations
5	Data collection, question modification, data analysis, preparation for presentation, lunch with Rotarians, end-of-day reflections, facilitator debrief, photos, and participant field observations
6	Fishing, data analysis, question modification, procedure modification, finalize presentations, end-of-day reflections, facilitator debrief, photos, and participant field observations
7	Finish presentation, practice, set up, post-content knowledge test, post-science perceptions test, group activity, summer symposia for public, collect journals, end-of-day reflections, facilitator debrief, photos, and participant field observations

We did an icebreaker activity "Dress a scientist" and moved on to the three rotations for the day. The first activity was "Biological surveys of plants and animals." The second was "Study plot techniques." The third rotation was "Feeding habits." We separated the girls into three teams of heterogeneous make-up. There were about 6 girls from underrepresented backgrounds and 4

girls from backgrounds better represented in the sciences. At the end of the day, the program coordinators held a facilitator debrief and gathered equipment requests for the next day.

The researcher took field observations and participated in some activities with the girls. Whenever she had an opportunity, she documented events or interactions between the girls or the facilitators. The researcher spent 20-30 minutes on reflections at the end of each day.

Field journals. The girls and the facilitators maintained a field journal to document their experiences. The journals were handed out on day one and collected on day seven. Facilitators received prompts to help the girls reflect on their days. They included questions such as "What was the best part of your day?" "What did you learn today?" and "What would you do differently?" Original journals were returned to each participant once a copy was made. For data collection purposes, two research assistants were designated to make a copy of each research journal. The original was returned to the participant before their interview or at a later time by the program coordinator.

Day 2. The second day of the program, the girls wrote a letter to the board of education as the opening activity because we originally planned to camp out at the PLC over night; however, the superintendent did not advance the paperwork to the school board so we were automatically denied the opportunity to have the girls experience spending the night at the PLC. The girls wrote a personal letter to the board of education in this school district to tell them about the missed opportunity. The remainder of the day, the girls participated in three additional

rotations. Rotation four was “From observation to researchable questions.” Rotation five was “Making aquatic food chains and food webs.” The last rotation was “Interactions and human impact: Simulations using a riparian trailer.”

The girls remained in the same groups as the previous days. They continued taking notes about protocols in their field journal. As they learned new protocols, they reflected on the possibility of using the particular protocol for their own study out in the field. To end the day, the girls reflected on their experiences for the past two days. Since we were not able to secure permission to camp, the girls went home at the same time as the previous day. The facilitators debriefed on the event of the day and prepared for the following week.

Field protocol rotations were held on Friday and Saturday. The girls had Sunday off because many parents had prior commitments scheduled. The following week, the girls returned to finish remaining five days of the program.

Day 3. Day three began with a 90-minute talk ornithology presentation. Dr. Lauryn Benedict spoke to the girls about her profession as an ornithologist. She brought field equipment such as spotting scopes, and sound recording equipment and allowed the girls to touch it and experience what it feels like to use it in the field.

After the morning talk, the girls began brainstorming possible ideas for projects. Girls with similar interests were placed in groups together. We had them pick two top ideas to help us divide them into small groups. There were a couple of girls who had unique ideas for projects so we grouped them into topic groups to make sure a facilitator could work with them. For example, if one girl wanted to

study cricket behavior and another girl wanted to study feeding behaviors of turtles, they were placed in the "Organisms Behavior Group."

By the end of the day, most of the girls had a basic research proposal completed. This included documenting their proposed study question(s), predictions, alternate predictions, methodology, materials they would need, and if working in a team, who would be responsible for conducting specific tasks.

Day 4. On day four, the girls spent the day collecting data. We had a speaker and the Women Leaders Tea as well. The speaker was a Laura Heiker, a doctoral student in the Chiropteran Lab at the University of Northern Colorado. She presented a slideshow for the girls to see all the different types of bats. She also brought samples of skulls and skins. Laura also taught the girls a game called, "Bat, bat, moth, moth," to show the girls the concept of echolocation. In the afternoon, the girls had a second visit, which included women leaders from the community for our annual "Women Leaders Tea." There were five women professionals who came to have tea with the girls to talk about careers and what their interests were when they were the girls' ages.

Days 5 and 6. The girls spent these two days working directly on their study question. They collected data or adapted their questions if their initial question was not feasible either making it manageable, or taking one aspect of the question to work during this short time frame. The girls had a couple of prompts to help them reflect on their experiences. In their journals, they were to record what they did throughout the day, what they enjoyed about the experience and if they would change anything about their day. Most of the girls wrote

something down in their journals, but there were a couple of girls who refused to write. The girls reflected on their questions and experienced the iterative process of science. Many girls chose to work in teams of 2-3 girls. If a girl decided to go solo on a project, she was still placed in a group with girls doing similar investigations. For example, if the junior researcher decided she wanted to study insect distribution at the PLC, she may have been part of the larger “Insect team.” This helped us with facilitator responsibilities, where most facilitators had 3-6 girls to assist and it all depended on the girls’ interests. Whether working in in teams or alone, each girl or each team had to decide how to present their experience to the public. All participants created a poster presentation. Some included sample models to mimic habitats, or samples of organisms whenever possible such as insects, samples or animal tracks, or diagrams as part of their projects.

On Day 6, the girls went fishing and Aramati Casper gave the third science talk. Early in the morning, the girls headed out to fish, before the heat became too unbearable. A couple of them were able to catch a few fish and release them back into the wild. The PLC pond is catch-and-release only. For the afternoon speaker, Aramati, a forest ecologist, came to talk to the girls about forests and forest fires and their impact on ecosystems

Day 7. The girls spent the entire morning finishing their presentations and practicing with at least three people. There were activities available, such as scavenger hunts, and games that mimicked energy loss through trophic levels. Other activities included writing thank you notes made from recycled paper for

people involved in making this program a reality. Teams who finished early were able to participate in such activities while they waited for everyone else.

After lunch, we administered the post-ecology content knowledge test and the post-science perceptions survey and welcomed community members soon after that. Half of the posters were set up to present on the first rotation and we saved the rest for the second part of the community event. The girls had 15 minutes to talk about their experience to the community members who visited their poster. Most girls had the opportunity to talk to 5-6 visitors during that time frame. After the first group, we rotated so the other half of the girls could present. By the end of the day all the girls had the opportunity to present at PLC annual research symposium. Parents and other community members, such as parents, teachers, and principals, had the opportunity to see the girls preset the projects they worked on all week.

After the poster presentations, the researcher gave a brief presentation to the parents about the intent of the program and handed out the IRB consent and assent forms. This was the first time most of the parents were present in the same room. The researcher explained the dissertation project to parents and they took a form to fill out if they were willing to give their consent for the data collected to be used in the study. Each family kept a copy of the signed IRB consent and assent forms (Appendix B).

Photo-documentation. There were 1,006 photos taken year 4. Photos were coded, split into folders and subfolders based on the interactions among the participants or the activities occurring. Each folder was named using a

researcher-developed name for the theme represented from the codes that emerged from the interactions occurring in the photographs.

Semi-structured interviews. Participants were invited to participate in semi-structured interview (Merriam, 2009) one month after the end of the program. Interviews lasted from 20 minutes to 1 hour. Interviews were guided by 29 questions developed from a test interview described earlier in this chapter. Interviews were recorded using a hand-held digital voice recorder and a computer embedded recorder. The research's bilingual skills were used upon request if the participant being interview had limited English abilities. Besides the primary researcher, one of the undergraduate research assistants was also bilingual. The bilingual research assistant was in charge of contacting parents to schedule interviews with the girls.

Because this dissertation focused on exploring the experiences of girls from marginalized backgrounds conducting field research, the selection of participants who were interviewed began with this group of girls. Interviews were contingent upon the participants responding to the interview request. There were 16 girls in the original group of interest, of these girls, 8 families returned our calls to schedule an interview. The researcher visited the girls' home or conducted an over-the-phone interview. Responses were transcribed in the original language and translated if used in the final analysis.

Table 5 summarizes data collected over four years. Years 1-3 informed the development of the data collection tools used for year 4. The main focus of data analysis for this dissertation was on year 4 data.

Table 5

Summary of Data Collected Each Year the Program Took Place

	Program Year			
Data Source	1	2	3	4
Student applications	X	X	X	X
Pre/Post Ecological Principles test				X
Pre/Post Attitudes and Perceptions survey				X
Student Journals			X	X
Facilitator Journals			X	X
Focus Group			X	
Participant Field Observations			X	X
Women's tea conversations			X	
Photographs	X	X	X	X
Researcher Reflections after program ended			X	X

Methods for Data Analysis

This study produced a large amount of data that was analyzed. The conceptual design incorporated multiple pieces of data collected to understand the girls' experiences. Also, understanding the system the girls were a part of and how the interactions of the different components helped or hindered the girls' competence in science and confidence in science was of importance in this project.

Data protection. Voice files and transcripts were stored on the researchers' password protected personal laptop computer. All hard copies of data were stored in a locked filing cabinet located in the researchers' locked office. The confidentiality of the persons interviewed was protected through all means possible; however, based on IRB committee approval, the researcher was

allowed to keep the program name and the real site name. All participants were given pseudonyms and real identities were kept confidential. However, the researcher respected any participant's desire to use her own name. Efforts to protect participants' identity in the final presentation of this dissertation were made by using pseudonyms and composites when appropriate.

The qualitative components of this dissertation represent a flexible and iterative process. This process assured that the researcher built an "intensive, holistic description and analysis of a single bounded unit" (Merriam, 2009, p. 203) for this field ecology intervention for girls. The stages of data processing were divided into three episodes as suggested by Reid (1992): data preparation, data identification, and data manipulation.

Data preparation. During this stage of data processing, the researcher made sure all the data that was needed was indeed collected. The researcher assembled a team of three undergraduate researchers and mentored them in the process of data acquisition and organization. She trained them in conducting interviews and one of them was trained in transcribing from digital devices including one-on-one interviews.

In this stage of analysis, the team read the transcribed interviews, cleaned up observation field notes, and copied all data containing documents. The researcher "cleaned up" the transcripts by listening to the interviews for accuracy. The researcher backed up all digital data to a cloud service. As the data were collected, the researcher organized it using Excel for ease of copying and pasting for coding.

The researcher read all documents multiple times. At least two people in the research team listened to each interview. As the researcher read the transcripts, she made reflective comments on particular text segments that captured her interest as they related to the three research questions listed preceding the methodology section of this dissertation. The researcher wrote short reflective journals to process what she was encountering as she interacted with the data.

Data collected using the instruments described earlier in this chapter were also processed at this time. All data from the pre/post content knowledge test and from the perceptions towards science survey were typed and organized. Each participant was assigned a number by the researcher to protect his or her identity.

Data identification. Once the researcher had a rough idea of what possible codes she could encounter, she hand-code each text segment using a physical or an electronic highlighter to review all transcripts and data sources. She coded text segments with preliminary codes such as “experiences in the field” or “something different than school.” Multiple codes created themes.

The researcher kept a file for each girl with all the documents pertaining to that girl’s story. The researcher also added numbers to each transcript to locate particular excerpts if they were re-organized in later stages of data analysis. She replaced names with pseudonyms to ensure the privacy of all participants.

Data manipulation. The researcher established 13 categories by grouping the preliminary codes. She checked the emerging themes with peer

reviewers, such as professors of science education or colleagues at her own institution or at nearby institutions.

The three stages of data analysis described above were conducted as new data were acquired, such as an interview, to inform future interviews. Data analysis was an iterative process. This occurred for the girl's experiences as embedded cases (Scholz & Tietje, 2002) and for the cross-case analysis of themes that applied to all the girls and to examine potential differences between the girls' experiences. Interpretation of major findings occurred in an iterative manner as well.

Coding. Saldaña (2009) divides data coding into two cycles, the first being simply breaking down the data into manageable pieces and the latter being much more involved. The second cycle coding involved the researcher's analytic skills. It reorganizes and deconstructs codes that emerged from the first cycle into larger, more developed themes. Analysis was primarily done through thematic analysis (Saldaña, 2009).

Qualitative research calls for the researcher to be the primary means of data collection. In order to get a get a holistic perspective of the queries of interest it is important that data is organized and analyzed throughout the process. This analysis informed the research as it proceeded. The researcher systematically analyzed the data through an iterative process that informed further data collection. She took an additional 20 hours post-program to conduct interviews and focus groups until she reached data saturation (Schwandt, 2007). At this point, she no longer encountered new findings. The data transcriptions

from audio files to word files took approximately 60 hours and took place over a two-month period. Multiple people listened to each interview. This method would help ensure inter-rater reliability.

Authenticity Criteria

Establishing rigor and confidence was a key step in this research project. This is referred to as validity and reliability in quantitative research, and trustworthiness or credibility (Merriam, 2009), and confirmability (Schwandt, 2007) in qualitative research.

Rigor. Rigor can be achieved by utilizing methods that consider the credibility, transferability, dependability, and confirmability of a study (Merriam, 2009). Qualitative research also calls for confirmability of findings. To do this, the researcher used member check (Merriam, 2009) by having the participants review the responses to their interviews by providing them with a copy of the transcripts. Member check served to enhance the accuracy, credibility, and transferability of the findings to similar situations and to confirm the accuracy of the data. The researcher also made sure she took advantage of the semi-structured interviews to ask clarifying questions to ensure she had an accurate grasp of the field observations by asking participants to verify her observation notes.

Confidence. The formulation of a rich/thick description, peer checking, and my own researcher reflexivity added to the establishment of confidence, or trustworthiness. Acknowledging my own biases as the primary researcher, theoretical orientations, and background is also a key component to establish confidence in the interpretations of the findings. In addition, all participants were

be asked to be reflective as well by keeping a field research journal that also includes reflections embedded in the work they do throughout the week.

Lastly, maintaining a detailed audit trail is suggested by Lincoln and Guba (1985) in establishing consistency and dependability. The intent is not necessarily for someone to "trace" every single step the researcher took in this study; rather, it is to explain how the researcher arrived at the results. The researcher also kept an audit trail, which is a detailed log of the research process including reflections, and how different decisions were made as to the categories and themes and how they emerged from the data. Ultimately, the researcher sought consistency in the results from the data collected (Lincoln & Guba, 1985).

Relying on multiple sources of data helped build trustworthiness through triangulation. Using multiple sources of data, such as journals, interviews, questionnaires, and multiple theoretical perspectives as well as multiple investigators helped establish the trustworthiness of this study. Ultimately, these multiple sources of data lead to crystallization of the findings (Mertens, 2009).

Subjectivities

The researcher is an immigrant of Latino descent. This gives her a perspective that understands and empathizes with the struggles that learners from marginalized backgrounds experience on a day-to-day basis, through the hidden school curriculum, and through the inherent bias that most people typically have but fail to recognize. At the same time, as she advanced in education, an increase in academic privilege provided her the ability to create opportunities for learners coming up the ranks. Similar opportunities are what helped the researcher achieve her success.

The researcher attended an experiential Marine, Math, Science, and Technology Magnet school. She perceived that her teachers did not know they were "experiential learning designers" *per se*, they just happened to have the resources (pre-budget cuts) to expose us to many experiences that had a long-lasting impact and completely changed her future. The researcher recognized the bias she has towards experiential learning and project based learning as useful means to expose underrepresented students to science, but questioned why these ways of teaching and learning were not widely adopted.

The researcher's experience as a former teacher highlights another bias: Her intrinsic desire to advance education. Acknowledging where her ideas emerged from was a huge step towards the subjective analysis in this dissertation.

Ethical Considerations

Educational research focuses on the human experience. Because the researcher worked with human subjects, she obtained approval from the university's Internal Review Board (IRB) protecting participants throughout the research process, including during the collection of preliminary data (see Appendix A). The researcher added an extension to the original IRB to finish the study. Letters of consent and assent to participate in the study can be found in Appendix B).

Limitations

In determining the research design, a mixed methods approach was a limitation because it naturally added more variables that could potentially make the research findings much more complex to analyze. In addition, the use of self-

report by the girls limited the findings because I could only document what they told me and had to rely on interpretation or triangulation to verify that what they told me is truly what they meant. Also, the instrument for the knowledge test of this nature have only been validated for adult learners (Morrone et al., 2001) in a specific region of the country, which may limit their applicability to middle school girls. This was evident in the reliability analysis. My intent in this piece of work was not to validate an instrument as that is a potential undertaking for a separate study; however, the researcher made sure that the data she collected was as valid and reliable given the conditions present, considering factors such as the small sample size prohibiting me from undertaking such a task. Therefore, for the purpose of this study, the researcher did not intend to generalize the findings to broader demographic groups, but for the findings to be transferable to similar situations and populations, leaving it up to the reader to determine if the findings are applicable to the unique phenomenon or group he or she may be studying.

Participant interviews were limited to those who responded to the request and who represented the group of interest for the research study; thus, only data collected during actual program was available for non-interview participants. Once again, the idea was not to generalize findings to describe a homogenous experience; rather, it was to highlight key cases that represent unique findings and themes that emerge as the data were processed. In addition, participants may have exhibited courtesy bias which is when they answer what they thought the researcher wanted to hear, not what they truly thought or believed.

This study did not go beyond the experiences that the students shared with the researcher during the program. The researcher visited some of the girl's homes to conduct one-to-one interviews, but the purpose of the study was not to conduct an ethnography or a detailed account about the girls' culture or their daily life experiences. The focus was in understanding the girl's lived experience at the Poudre Learning Center during the *El Espejo* summer research program.

Lastly, long-term impact evaluation (tracking) was not accomplished within the timeframe of this study. The researcher wanted to know if the intervention motivated the participants to take additional science courses beyond the minimum requirements for high school graduation or for college enrollment; however, collecting this type of data would have taken 4-5 years beyond the completion of this dissertation.

Chapter Summary

Chapter III began with a pilot study that examined the perceptions of two Latina girls regarding the feasibility of pursuing careers in biology. Findings from the pilot study informed the creation of the intervention to provide experiences in biology targeting middle school girls from marginalized backgrounds and provided an opportunity for the researcher to pilot case study methodology to inform the design of the main research. The intervention was created with the following findings in mind: 1) the importance of early educational experiences, 2) exposure to career options and mentors, and 3) the creation of systems that bring a sense of community or a sense of place for participants. The second half of Chapter III presented the methodology, the research questions, and the design

of the study for this dissertation. This second section also included methods for generating data and methods for data analysis.

CHAPTER IV

FINDINGS & DISCUSSION

Overview

This chapter begins with a brief introduction to eight girls who participated in the case studies. These cases present experiences of eight girls in a program designed to foster learning centered opportunities through field experiences. Findings are organized through a thematic approach. The findings for each theme listed below will be discussed using examples from eight participants who participated in semi-structured interviews.

Engaging the Girls in Science

1. Program Design Features
2. Connection to Place
3. Unique Experiences
4. Importance of Experiences
5. Role of Facilitators in the Girls' Experiences

Building Science Competence

6. Learning Ecology
7. Learning Science Practices
8. Applying Reflective Practices

Building Science Confidence

9. Entering a Community of Science
10. Joining a Science Community
11. Creating Science Identities
12. How Others View Me
13. Interest in Science Maintained or Ignited

A summary of conclusions organized by primary research questions can be found in Chapter V of this dissertation.

Research Questions

1. Understanding a program that targets a special population. What characteristics of the intervention were necessary to engage girls from underrepresented background in the experience? What roles did facilitators undertake in the intervention that contributed or hindered the girls' experiences?

2. Science competence explored through knowledge of ecological principles. What ecological knowledge did middle school girls have before and after the intervention?

3. Science confidence and the formation of a science identity. How did girls' science identities emerge or change over the course of the program? In what ways did being part of a "system" help or hinder the girls' science identity formation?

Meet Eight Participants

The girls interviewed were Angel, Maya, Winter, Lilly, Issa, Selena, Valeria, and Selena2. The majority of the girls selected a pseudonym. The researcher selected a pseudonym for the girls if they did not write one in their assent form (see Appendix B). The researcher asked permission from the Institutional Review Board (IRB) for the opportunity for participants who decided to keep their real names to do so; this respected their individuality as long as this decision did not place them at risk in any way. Only one participant kept her real name. The eight girls interviewed were selected from a group of 33 participants from the year-four cohort. Appendix A contains IRB approval for the study.

The demographics and the data collected for the eight cases presented in this section and summarized in Table 6. Under demographics, there is also an

indication of the participants' English language proficiency level since for two girls, Issa and Valeria, which may have had implications to their prior experiences with science or the lack of experiences for this population. The data collected for each case includes the program application, the pre/post ecology knowledge test, the pre/post perceptions towards science survey, the girls' posters, journals, and one interview conducted after the program in year 4.

Table 6

Data Collected From Each Participant in the Descriptive Case Analysis

		Data Collected					
Participant	Demographics	Program Application	Pre/post Ecology knowledge	Pre/post Attitudes and perceptions	Poster	Journal	Interview
Angel	Latina	2012	X	X	X	X	X
Maya	Latina	N/a	X	X	X	X	X
Winter	Native American/ White	2009-2012	X	X	X	X	X
Lilly	Latina	2012	X	X	X	X	X
Issa	Latina, LEP*	2010-2012	X	X	X	X	X
Selena	Latina	2009-2012	X	X	X	X	X
Valeria	Latina, NEP**	2011-2012	X	X	X	X	X
Selena2	Latina	2010-2012	X	X	X	X	X

*LEP = Limited English Proficiency
**NEP= Not-English Proficient, English language learner with less than two years learning English as a second language

Angel

Angel is a first-generation college student. Her parents did not attend college. Angel has one sibling currently attending community college but she is still considered to be a first-generation college student. Angel speaks English as her primary language and is of Mexican American Heritage. Angel enjoys playing sports such as basketball, softball, and she runs cross-country. Angel's first exposure to the research site, the Poudre Learning Center (PLC), was on a

cross-country run. Angel had never taken time to stop and learn about the environment out at the PLC. Angel's family applied for a full *El Espejo* Program Scholarship in order for her to participate in the program.

Maya

Maya comes from a second-generation Mexican-American working family. The teacher that recommended her for the program, Mrs. P, a local teacher who helped us recruit every year, said that Maya has ability but lacks confidence in her abilities. Maya is bilingual in Spanish and English. Maya was very willing to help students who didn't speak English very well to help them move forward. Maya worked closely with Lina, another participant who spoke a dialect of Mayan as a first language, and Spanish as a second language. Maya became good friends with Lina because Maya felt she could help Lina. Maya's family applied for a full scholarship for her to attend the program.

Winter

Winter identifies with being Native American and White. Winter is monolingual, speaking only English. Winter comes from a well-educated family with both parents having advanced degrees. Her parents were older and shared her behavior concerns noting that she's a good girl but she's also "A handful." We're thankful for the opportunity she has to be part of this program." Winter's mom also shared that she felt a lack of connection to what her daughter enjoyed which she perceived had to do with the 40-year gap in age.

Winter was one of the original program participants. This was her fourth year in the program. Winter was a girl that people perceive as a "problem child" and her behavior, described as "Loud, whiney, needy, and non-compliant" by the

facilitators gave people this kind of first-impression. Winter's family was able to pay for her full registration fee and she was eager to participate in the program year after year.

Lilly

Lilly tested out of the English Language Acquisition (ELA) program at her home school but is considered to have limited English proficiency (LEP). Her parents prefer to communicate in Spanish. She feels comfortable in either language although she admits she cannot write in Spanish. Her classroom teacher describes Lilly as "Very forward thinking and independent, and likes to learn the how and the why." A skill she mastered in her classroom instruction was the ability to question what she's reading. Her self-confidence in academics was "a strength" as noted by her former fifth grade teacher.

Lilly is a first generation college student. Her aunt went to college but from her immediate family, Lilly will be the first. Lilly's mom started community college but she dropped out. Lilly was one of the fifth graders selected by Mrs. P served as a facilitator or volunteered at various capacities every year. Lilly was perceived as a hard-worker and Mrs. P perceived that, "Lilly needed a program like this to reinforce how good she is in science."

Issa

Karissa (Issa) was 10 years old when she first participated in the program. There were unfilled slots during the second year of the program. Issa had just completed 4th grade, and the program coordinator recruited her apply to partake in the opportunity: she was among two of the youngest participants. Issa is the youngest of six siblings who are all first-generation college students born in

another country. Issa was born and raised in the United States. Most of her siblings no longer live at home. All of her five siblings have gone to college, and going to college is an expectation for her, but she doubts her potential.

Because Issa's family speaks Spanish as a primary language, Issa was placed in the Language Acquisition (ELA) program at school. Issa had been part of the ELA program since she started school in kindergarten. Issa remained in the ELA program for six years; this limited the number of hours she spent in science and social studies class since she had to take extra hours of English instruction. Last summer, Issa was moved into the mainstream program, but is still classified as limited English proficient (LEP). To encourage Issa's development in science and to provide one other girl this same opportunity in science, Issa's parents paid for her registration, and provided an extra registration for another participant in need of a scholarship.

Selena

Selena comes from a family of first-generation college students. English is the primary language spoken at home. Her dad is an engineer and her mom is a teacher. Selena's sister is currently pursuing a Bachelors of Science in engineering at a local university. Going to college is an expectation for her family. Her grandmother, a local schoolteacher, has also served as a facilitator for the past four years. Selena's grandmother was one of the founders of the program. Selena has been participating from the very first year. This is her fourth year in the program. Selena's family was always able to pay for her registration fee.

Valeria

Valeria entered the program as a newcomer from Mexico, which means Valeria had been in the United States for less than two years. Year 3 of the program was Valeria's first year at *El Espejo* and Valeria had had very limited English abilities. Year 4 Valeria spoke a lot more English, but she is still in early English language development, classified as Non-English Proficient (NEP) at school. Having a venue where being bilingual was an asset was important for her experience. Valeria has a younger brother and is in constant contact with Mrs. B, the outreach worker who recruited her. Mrs. B recruited three participants for year 4. Valeria was one of the recruits matched with a donor who received a full scholarship.

Selena2

Selena2 is a first-generation college student in her immediate family, such as her mom, dad, and sister. In her extended family, including her aunts and uncles, Selena2 has well-educated people in her family including four engineers and one teacher. Her mom and dad did not go to college and did not express a desire to attend college even though all of her mom's siblings completed bachelor's degrees. Selena is Mexican and White and speaks English only. Her mother is first-generation Mexican American, born and raised in the United States, and chose the Navy as her career path. Her father is White and also chose the Navy as his career path. Selena2's grandmother on her dad's side went to college. Selena2's dad is now on permanent disability and retired from the Air Force. Her family insisted on paying her registration fee even though her father is disabled and permanently out of work. Her mom works as a nurse assistant. Selena2 participated in the program for three consecutive years.

Findings

The preliminary thematic analysis began with the analysis of the photographs documenting the girls experience during the program. The preliminary themes that emerged were: Being part of a team, cross-cultural interactions, emotions, exposure to experiences, scientist in action, importance of friendships, nature of the program, peripheral participation in a science community, role of facilitators, and women as role models. These themes informed the remaining data. In the end, there were 13 themes that emerged from the findings. These themes, or topics, will be presented in three sections based on their relevance to the research questions for this dissertation.

Engaging the Girls in Science

1. Program Design Features
2. Connection to Place
3. Unique Experiences
4. Importance of Experiences
5. Role of Facilitators in the Girls' Experiences

Building Science Competence

6. Learning Ecology
7. Learning Science Practices
8. Applying Reflective Practices

Building Science Confidence

9. Entering a Community of Science
10. Joining a Science Community
11. Creating Science Identities
12. How Others View Me
13. Interest in Science Maintained or Ignited

Beside the data from the eight case studies, there are brief examples from girls who were not part of the in-depth cases because they add to the story of the girl who was interviewed. Only the stories of the girls who exemplify the particular theme will be presented; therefore, the reader will not find evidence of all eight girls' stories presented under each theme.

Engaging Girls Historically Underrepresented in Science Fields to Research Experiences in Science

Q1 What characteristics of the intervention were necessary to engage girls from underrepresented background in the experience? What roles did facilitators undertake in this intervention that contributed or hindered the girls' experiences?

1. Program design features. This theme explains what unique components of the program were beneficial to each of the girls presented as embedded cases in this larger case exploring the nature of the girls' experiences in this program. Some attributes of the program were more important to some girls compared to others. For example, the role of facilitators was extremely important for a student needing guidance with the development of her project. Other participants describe the importance of having rotations first to get ideas for their project and then having the opportunity to do a study as a team or individually.

Angel. For Angel, having a focus on science was a very important component for the program. Angel has an entry in her journal where she writes about the importance of being part of a program like *El Espejo.* Angel mentions that from this experience she was able to see there were other things besides math and reading and writing, "This program [made] me more awear [*sic*] that

there's other things besides math, reading, and all that." It appears that science does not take the same level of importance as math, reading, and writing in her every day experience and now Angel knows that science learning is something that is important for her.

Angel was able to determine the importance of taking advantage of such opportunity when the researcher went to her school to recruit potential participants. Angel said she was captured by the presentation and determined she wanted to be part of this experience. Angel was particularly attracted to the potential "to do research and learn how everything goes in the different experiences you can have because of that."

After the program ended, Angel described her experiences during her interview and was so excited she barely paused to catch her breath as evidence by the following remarks during her interview:

> The first day we got to do papers [paperwork] … and then we did a little pre-test about it and then we started and people came to meet us and tell us about what their job does and explained what they do for living and then we started working on our project. We got to find, we went out and went around the Poudre Learning Center looking at different things and trying to see what we would want to do during the week for our project. During our project we went out and we picked a question that we wanted to learn about. Mine was how redwing black bird respond to bird calls and so we would go out and do our project and get the results and put it in a board or a piece of paper and then lay it out and then on the last day we presented it to different people and telling them what we did.

Angel's description of the program shows how this experience was meaningful and that *El Espejo* was a program that helped her learn more about science careers:

> *El Espejo* is more than just a tiny science camp but it's more about learning about different women who do science and if you wanted to extend out a dream in science that you can do it because anything is possible and learning about science in *El Espejo* help you branch out into pursuing that career.

The program design components important to Angel were the inclusion of career awareness in science, the opportunity to do her own project, and the ability to communicate science.

Maya. For Maya, the opportunity to design her own project and to apply leadership skills by working with other students who needed her help was really important. The program was designed so Maya could plan a field study without feeling the pressure that somebody was watching her "I can explore when nobody else is around me and I can use what I need like materials and those things." Maya also felt that having a sense of belonging was important for her experience, "I enjoy it because it's like, I learn a lot and I'm not going to be left out and I know more when I'm out in the world." Her concern over feeling left out also drove her to be inclusive of girls whom she perceived would be left out, such as students who had limited English proficiency. The opportunity to work with other students with English language needs as evidenced by the following quote was important for Maya:

> I helped. I had the ability to help other kids with their projects…I felt responsible because I was helping other kids that didn't know English and I helped translate and, well they did know English but they didn't know that well so I helped some girls and we just became friends.

Maya was able to help other kids that didn't speak English. Maya helped them with their projects on her "down time." The program was designed so there

would plenty of opportunities for heterogeneous group work including participants from different ethnicities and English abilities.

Winter. Winter mentions that she was really excited she was able to go out and study tadpoles and she really got into observing them morph into toads and frogs. The program design allowed her to develop this idea of experimenting and observing nature and being able to ask her own questions. Winter really enjoyed was explaining things in a way that people could understand and that everything can be put down into simple steps to make things simpler. Winter also looked forward to sharing what she did during the week at the PLC Community Symposium at the end of the week.

The Community Symposium was something that Winter really found important for her experience, "…The very end, when we had to explain our projects because you got to show everyone what you did that week, what was important and you got to explain everything and it was just a lot of fun." Explaining her project was something Winter found to be fun and an important part of the program. Validation by members from the community was a key component for her experience, not only her parents and peers, but of community members who came and asked her about her experience. Validation and recognition that the girls in the program were capable of developing their own questions and sharing their findings was an important component evident in culturally responsive teaching and learning communities (Gay, 2002).

Selena. Selena enjoyed having speakers as part of the program because Selena learned things that she didn't know before:

> Selena: I enjoyed learning about the bats and about the birds. The guests that came to speak with us about them, they were interesting.
>
> Researcher: Tell me more what did you enjoy most about that?
>
> Selena: I enjoyed with the bats, she showed us what kinds of bats lived around here and some around the world and there were tiny bats and huge bats and I didn't know there was that many kinds so that was fun. And with the birds I enjoyed trying to find out which bird was which in the book so that was also fun.
>
> Researcher: Do you think that if you would have gone to observe the bats that would have been a different experience than looking at pictures?
>
> Selena: Yeah I think so, well it's kind of the same because she had them in a box, it's the same but it's just dead. But it would have been a better experience to see them alive, like where its habitat was and everything.

The visiting scientists were an important program design component to engage Selena in new learning experiences. There was a third speaker, but Selena did not talk too much about that experience. Selena remembered, "she talked about that fires have a bad side and a good side. So the fires help renew the area that is damaged but it also burn everything that you have." The forest ecologist did not include an engaging activity the same way the two other speakers did and this had an evident effect on how Selena described the excitement she felt with the scientists that did include engaging activities as part of their talk.

Valeria. When the outreach worker recruited Valeria for the program, she did not give her too many details about the program. She thought it would be a summer program with "activities." Valeria was really glad that it was not just

activities, "*No me imagine que era de ciencias. Yo pensé que era diferente.* [I did not imagine it was about science. I thought it was different]." Valeria expressed her gratitude for having program facilitators who could help her. She also enjoyed doing activities where language was not a barrier. Valeria enjoyed a game we played when Laura, the chiropterologist, the bat expert, visited. Valeria shared, " *Aprendí de* echolocation *cuando jugamos el juego de bat bat moth moth.* [I learned about echolocation when we played the game of bat bat moth moth.]" We asked speakers to make presentations interactive instead of talking at the participants for 90 minutes. The bat speaker played an echolocation game. Valeria really enjoyed this and remembered the concept the game was meant to convey.

1. Summary. Experiencing science through this intervention was different on many levels for the girls but by in large, the biggest difference was that they perceived school science as boring, or not as exciting. For five out of eight girls, the program design played an important role in their engagement. For Issa for example, breaking her typical routine provided a venue for an increased desire to learn. For Angel this program was "a fun place to learn." The intervention, by design, was very different from the educational experience students receive in most science classrooms. The program provided authentic learning experiences; girls did not sit in a classroom as passive bystanders receiving information from an expert and go through testing on this information. They constructed science knowledge by doing science, by experiencing science in a whole new way.

The nature of the program included providing the girls time to reflect and ask questions of their own interests. The girls had opportunities to experience science out in the field. Each year, all participants were able to design, set up, and implement an inquiry-based, interdisciplinary investigation. Even though participants were able to ask their own queries, make claims, and draw conclusions, the majority of the girls had difficulty differentiating an “experiment” from an investigation. The girls were able to experience research as a dynamic process, not a linear way of finding an answer.

The girls were able to partake in opportunities to develop science practices. Details were provided in depth in the “Science Practices” theme. The girls were actively engaged in science experiences. Participants had the opportunity to learn at least five science protocols each year. Protocols included setting up transect lines, using quadrats for biodiversity sampling or ground cover sampling, soil sampling, setting minnow traps, collecting specimens, and using dichotomous keys to identify macroinvertebrates, birds, plants or insects, testing water quality, and setting camera traps. The girls learned other protocols as necessary based on their study questions.

2. Connection to place. Sense of place refers to a connection to the land, to the place (the Poudre Learning Center), to the river, to anything nature-related that the girls felt they formed a connection to because of their experiences throughout the program. This deep connection, the yearning to learn more, and a constant reflection about wanting to explore new areas at the PLC were included in this theme. Exposure to the outdoors, to the place itself, was a necessary

component to create or enhance this bond. For Maya, this place provided a liberating experience.

Maya. When Maya spoke about being "out there" and doing her own thing that was sense of place. She spoke of this place as a place where she could study science and no one was keeping a watchful eye. Maya was able to find different areas where she could conduct her studies. This helped create this notion of place for Maya. The feeling of not being “watched” provided a liberating experience for Maya to do science on her own in a safe place.

Lilly. This idea of being outdoors and really feeling what scientists who work outdoors do was important to enhance Lilly’s sense of place. Lilly had a natural connection to the PLC because Lilly was one of the local school children who helped plant the sensory garden. Lilly had visited the PLC a couple of times. That connection was reinforced through the program because now Lilly was looking at studying specific components of the center such as the grasshoppers who live there and learning more about them.

Lilly talks about learning more about nature and the outdoors, "What we usually did was to be outdoors to discover what was out there. To discover and pay attention to things you may not see but it's there." Being out there with a different purpose than before gave her a different perspective about the PLC. There was a different use for the PLC than what Lilly had previously experienced before this opportunity.

Lilly showed her connection to the PLC by saying, “It’s a very fun place you could learn about science and you get to hang you with other girls and share

your knowledge with them and you could have fun over there. You could explore other types of animals and things like that." This is a place where you can have fun and explore. This sense of place is created by her saying that if someone else comes, they will be part of this experience, they will also get to have fun out here and experience something new that they probably didn't know about.

Lilly was excited for the creation of new opportunities for future years. Lilly looks forward to camping at the center to give her the opportunity to study bats at dusk so long as Laura is willing to bring her equipment. Lilly wants to explore more about the ecological system making up her larger system.

Issa. Being outside was definitely something that created a sense of place for her. For Issa being outside was something that was very important for her experience in the program. "Doing our own projects about what we learned, going outside, and learning new things" were all components that added to Issa's sense of place. Being part of nature was something Issa looked forward to and perceives she will miss once she is no longer part of the program, "I'll miss doing projects and being outside with everybody learning new things." That connection to nature, to the plants, to the animals, at the center, and the people there brought her back year after year. Issa always looked forward to learning more about the PLC. This connects her to this particular place because there is always something new to learn about at this place.

Selena. Selena questions show a desire to learn more about insects in different ecosystems at the PLC evidenced by the following account:

> So my question was about finding if there's different types of butterflies and damselflies in the garden and the prairie and I found

> that I saw different kinds of, a lot of butterflies in the garden more than the prairie, like in the prairie there was more of the white ones I think they were the white checkered ones and then in the garden I found, I'm not sure what they're called but it's the black one.

Selena's experience gathering data reflected a connection to place, "I enjoyed gathering data outside and catching the butterflies and damselflies for my project." The first year Selena studied terrestrial insects. Selena studies the same topic in different regions. Selena is really interested in seeing how important it is for her to experience all the areas and learn about the insects there. Selena also highlights the importance of using all your senses and being attentive to detail as an ecologist when you study different regions.

Valeria. Valeria felt that an increased exposure to the site would create an enhanced sense of place where she may be able to experience the site at different times of day as evidenced by her letter she wrote to the school board. To see different organisms, like the eagle and the frogs, was something she yearned for. In her interview, Valeria talks about her scientific study and about her desire to learn about the river. Being at the river created a sense of place where she could learn out in the field. Valeria was knowledgeable about the organisms that she sampled and learned and remembered most of the names of the organisms she found. Valeria feels a certain connection to the river and a yearning to learn more about different areas at the PLC as well.

Selena2. Selena2 expressed a connection to place when she questioned, "What happened to all the water?" She noticed that the place, the PLC, has changed from one year to another. This created a sense of place where Selena2 notices changes in not only the water level, but also the organisms that she

found at the center. Selena2 was able to tell that there were differences from previous years.

A second connection to place is created when talking about the friendships found at the Poudre Learning Center. Selena2 equates her system as being composed of the girls who are also part of the program. Selena2 talks about how she would rather be out at the PLC with her friends and being in nature rather than sitting at home, alone.

2. Summary. At the Poudre Learning Center participants had opportunities to personally connect with nature; this allowed them to develop a sense of place for this local environment. Wurdinger & Carlson (2010) remind us that learning about the living world in an experiential way helps create a “sense of place” for children and adults alike. The notion of *place* refers to a location that has a deep meaning for people (Hart, 1979) and connects to the physical environment (Stedman, 2003). Although connection to place was important at some level for all the interviewed participants, for six of the girls, this connection was extremely important in adding to their experiences in science. When examining the entire sample of 33 girls, for 20% of them, this was the first time they set foot at the PLC. For 60%, this was the second or third time they had visited the center. Twenty percent of participants were “regulars” coming with their families or schools on an ongoing basis, at least four times per year.

Besides previous year participants, only four of the girls who participated in the program year 4 came in with some experience conducting different types of studies at that site because their former teachers created such opportunities.

One of these teachers helped as a facilitator year 1 and year 4. There was a larger group of girls who had done “an activity” at the site such as studying biodiversity of plants along the Poudre River trail, or testing soils at the various soil pits, such as Maya and Selena. There was also a group of girls who had used the center for cross-country runs, such as Angel, or had ridden their bikes to the center from the middle school nearby.

Participants developed and enhanced their sense of place, a connection that got deeper over time as evidenced by Issa’s desire to return to be “outside,” and moved beyond seeing the PLC a place that is “used” for other activities, such as cross-country runs, as mentioned by Angel. Her perceptions about the PLC changed as a result of this intervention. She shared that the experience during the program was “not just a place where you learn about new things but you get to adventure out and try different things from your everyday life and learn new things.” She created a new definition for this place as a place where she could venture out and learn new things that mattered to her because they are part of her everyday life. Science became relevant and this place, the Poudre Learning Center, made the experience more concrete.

For the majority of the participants interviewed a full week immersion in nature helped ignite this connection to place. They started developing a sense of place. The same girls showed interest in returning year after year, which means they must have had a connection to the place, the experience, and the program. This was most evident for Selena who felt a sense of connection to nature and felt like a scientist when she was out at the PLC, but not when she was in other

places, including at home. For some participants, the connection lasted longer than the experience itself. Former participants asked if they could return as volunteers.

Even after the girls “graduate” from the program they asked to be volunteers at the camp as soon as they could. Lahna, a three year participant, and a first year volunteer shared her excitement for coming back as a volunteer the following year, “I get to actually get to help them create questions or actual projects and maybe help them with what I would do with my projects and maybe give them an idea in how to do that.” Lahna’s desire to share what she learned was evident. She not only wanted to return to help other girls along the way, but to visit the center too to see how it changed over time. We had three girls return as volunteers who had previously participated in the program. Returning as volunteers created an environment where former participants built relationships and shared stories about high school life with the current participants.

Access to the PLC provided a situated experience in the girls’ local community. By inspiring them to learn about this place, the hope was that the girls would return or motivate their teachers to bring them out to the center to have real-life exposure to natural science. There were yearlong opportunities for the girls and their families to stay involved at the PLC, but there was little evidence that this actually happened. A citizen scientist program was created to foster year-round involvement. The program was called *Ciencia en familia:* Experiencing nature with our families. The basic premise of this opportunity for continuous involvement is that families would learn about a nationwide or a local

project that they could participate in as citizen scientists, in an opportunity for the entire family. We held sessions for three projects: Project BudBurst (http://budburst.org), the Community Collaborative Rain, Hail & Snow Network (CoCoRHaS, http://www.cocorahs.org) and brought awareness to a project through the Cornell Lab of Ornithology (http://www.birds.cornell.edu). Two families from the *El Espejo* participants came to learn about these programs throughout the year. There is an obvious need for further intervention to engage *El Espejo* families throughout the year.

The Poudre Learning Center site was selected for this intervention to have a real-world application for the girls since it was in was located in the girls' local community, within a 15-minute drive for most of them. In order to inspire and retain girls' interest, they were provided with opportunities to conduct authentic science projects out in the field. In the context of the community of study, the Poudre Learning Center is the local natural area for exploration of ecological issues in this community. Multiple girls mentioned that the PLC was actually a fun place to be at.

Connecting this fun place as a key component of their environment, river ecology, restoration efforts, and about anthropogenic disturbances in this riparian habitat was very important in influencing what questions the girls explored. Thus, having a choice as to what project to pursue played a key role in keeping the girls interested beyond 5th grade and helped them learn about their place.

3. Unique experiences. Unique experiences included experiential learning (Kolb, 1984a) opportunities that were unique because of structure,

location, or because they provided opportunities different than school learning. This category reflected experiences that the girls would be limited to were it not for this program. Sometimes the girls expressed that this program was a truly unique experience and other times the researcher read in context to determine if what they were describing was something that deviated from their everyday experiences, making the experience an extraordinary experience. Some of these experiences also added to the girl's self-efficacy in doing, learning about, or being immersed in science experiences.

Angel. Angel was selected to be in the program because when the researcher recruited at her school, the assistant principal called all the girls in an already existing program called Advancement Via Individual Determination (AVID). Angel said in her interview, "I'm in AVID in my middle school and my vice principal thought that AVID girls would be more mature to learn about this [science] than most the other girls that they don't take it as seriously as we do." Being classified as a person who would take the program seriously was a self-fulfilling prophecy. Angel perceived herself to be one of the chosen girls because her vice principal sent the message that girls like her, girls who participate in AVID, take things such as this summer opportunity seriously. AVID is a program that targets middle performing students, C average, to push them to achieve higher grades and exposes them to opportunities for post-secondary education. Six students including Angel participated from her middle school, which is the most diverse school, ethnically and economically, in the largest PLC partner district. The middle school Angel attends has the largest ELL population and the

largest number of students on free or reduced lunch, a direct measure of poverty, in the four partner districts that help maintain and run the Poudre Learning Center.

Before attending, Angel thought this opportunity would only be “Just a science camp learning about regular science. Nothing real different than what you learn in school.” Angel describes regular science as being “just like the table of different [elements] oxygen and H_2O and stuff like that and then how they do experiments with chemicals and learning about the human body.” Angel said this was not what she experienced in the program. It was a place where she learned new things as evidence when she says she learned “…Stuff I didn’t know about like I didn’t have any background knowledge.”

Angel perceived she was learning more during this experience than in school. During the program, Angel felt that the way she learned was something she had not experienced before, it was “just a different way of learning, something that I didn’t know…[which I realized was] something that I kind of knew about but [other things were things] that I knew nothing about [and I] learned more about it.” This was a unique experience for Angel because she just felt this was a different way of learning but she could not quite pinpoint what that was. She experienced leaner-centered opportunities, a main premise of *How Students Learn* (Lambert & McCombs, 1998).

Winter. On Winter’s first year application, she wrote “I have lots of potential for science…I hope you consider me as an *El Espejo* camper.” Winter was always looking for ways to be a leader as evidence by the response to the

question “What leadership skills do you have to offer” on her most recent, year 4, application. Winter participated all four years. She states, “I am always prepared and organized. I work well with other team members. Most of all I am enthusiastic and responsible.” Winter considered herself to be a good candidate for the program, “I am a good candidate because I enjoy science and have had experience in this program before and it was a lot of fun. I am a great team player and would love to experience the fun again.” The opportunity of being part of a fun program where Winter also could learn science was something she looked forward to year after year. Her plan for her continued involvement in these unique experiences was stated when she shared, “I’m probably going to start doing helper work and volunteering when that happens,” when she is no longer eligible to apply for the program.

Winter mentions that her engagement and enthusiasm in the program was because "we had a lot more hands-on activities where we got to go out and do it [science] ourselves instead of just sitting there and reading it [science] from a book. We were able to see proof…” This unique opportunity to experience science in the field brought real world connection for Winter as evidence when she shares:

> [W]e got to learn more in depth when we were there…like we learned that every time you put something down a drain it goes into the sewers and eventually that goes into the lakes and so for example when the rain water comes down if there’s anything on the ground in the gutters it will take that down as well and if it isn’t to big it goes out into the lake through the sewer systems.

Winter's exposure to the riparian trailer station helped her learn the use of modeling when studying science. In the quote above, she references her learning using the riparian trailer. She used this modeling system to study and manipulate variables to see the effect they would have on the scenario she created using the materials available, such as farms, houses, trees, sources of pollution, etc., on riparian ecosystems. Winter makes real-world connections based on an activity where she was able to predict and test different scenarios. For Winter, the ability to learn in-depth, to do science herself, and to be part of a fun community were unique experiences she looked forward to year after year.

Lilly. Lilly yearned for the opportunity to participate in *El Espejo* as shown in her program application response: "I would love to participate in *El Espejo* because I will make new friends. I would use my skills and work with other intelligent people. I hope to become better at science and being a leader." For Lilly, this experience provided an opportunity to take a risk. "My teacher, Mrs. P, she got kids that really love science and she picked me and some other kids to join and I was one of the few that joined." Lilly was one of the few who joined the program even though her teacher invited a lot of students. Lilly felt privileged to be part of the experience because she knew that other girls from her class were not there.

The experience of doing her own project was something unique for Lilly. Although she had visited the PLC on multiple occasions, she had never done her own project out there.

> I thought it was just like they just teach you more about science I never knew that you had to use your knowledge to try to figure out

> some stuff that they teach you that's new and [some things] you already knew about and I didn't know you had to do a project at the end where you study about something specifically.

Besides designing her own project, other unique experiences that Lilly encountered included learning about bats and birds. Lilly had not learned about bats previously and made her newly acquired interest evident in the following quote:

> I enjoyed learning about bats. How there's some bats that eat fish and there's only a few bats that live here and there's some bats that lived in some trees in *El Espejo* [at the PLC] and I also learned that some bats their wing span is 6 feet long and that was really interesting for me because I usually don't like to talk about bats and that made me more interested in bats.

In addition to learning about bats, using sound equipment to learn more about birds was a unique experience for Lilly. She explained what happened the day the ornithologist, Dr. Benedict, visited:

> Lilly: There was one day when this girl that studies birds, we got some equipment to hear birds and to see more louder and clearer and we rotated to another station where we could spot birds and try to look them up to see what kind of bird it was.
>
> Researcher: Had you ever done anything like that?
>
> Lilly: No, it was a very cool experience for me because I like birds but I had never did [*sic*] that so that was cool.
>
> Researcher: Did you know there were scientists who specifically study birds?
>
> Lilly: No.

Using the equipment that the ornithologist brought also created a “cool” experience for Lilly. She felt that learning during the program was different than learning science at school as evidenced by the following quote:

> It [school] was different from learning science from *El Espejo* then from school because we got to explore outside and learn in the nature and [the facilitators] gave us examples. Not just a teacher teaching us from paper it was real life and we got to do experiments. We got to do more experiments on how to learn with science and we did a few of them and we had to write them down and they just did step by step on how we would do this and that and it’s kind of the same over there but it was more fun.

Lilly was able to learn about nature in "real life" and see examples of different things related to nature. It was more than her in-school experience where the teacher did the talking with the hopes of transmitting information to students. Lilly was able to learn science in the field and document what she was learning in her field journal. Working like a scientist out in the field was another unique experience for Lilly where she truly felt she was doing what scientists who work in the field experience. Lilly was exposed to new topics, used equipment that scientists use and learned science in real life. These were all unique experiences for Lilly.

Issa. Issa looked forward to the opportunity to attend *El Espejo*. On her application, she wrote, “I am a curious person and like to learn many different things. This will be a new experience for me and I believe I will like it.” On her third year application, Issa wrote, “I participate in *El Espejo* because it’s fun and exciting to do the projects and you have a great time learning outside of the routine of things I do.” Issa pointed out a reason why she perceived that this

program added a unique experience for her. It adds to her typical routine. It gives her something exciting to do over the summer and she enjoys the experience. The program provides a *different* experience compared to her every day routine. Issa participated in the program three consecutive years and is looking forward to returning next year. The program is continuing after the primary researcher, and author of this dissertation, leaves.

Like Lilly, Issa felt that being outdoors in “real life” added an important component to her experience. Issa shared, “It’s [The program’s] really fun to go to and you learn new things about science that you never knew about. You go outside and see different things like plants and animals.” She also enjoyed the autonomy of choosing a project of her choice as evidence when she said, “Doing our own projects about what we learned, going outside, and learning new things” were all things she enjoyed. For Issa, being outdoors or outside was important for her experience.

She adds that this experience differs from her typical routine in school, “It’s different because you’re inside a class just sitting down and the teacher just keeps talking and the one in *El Espejo* is different because you go outside and talk about things, that’s different than class.” Issa saw going outside as an opportunity to do something different and experiencing nature and the outdoors was important to her, “You go outside and see different things like plants and animals.” Issa had the opportunity to study plants and animals she would not normally study in her typical routine.

Issa learned about nature and the program provided an opportunity for her to learn more about science. Science was something Issa enjoyed as evidenced when she said “Science interest me because it’s fun to go outside of any were and find out about new things that you never knew about.” Experiencing different things in their natural environment was important for her. She specifies, “It [The program] means to me that I would want to be there every year and it means a lot because it’s really fun.” Coming up with her own project, working outdoors, and having fun created a deep connection to being a part of this experience year after year.

Valeria. The opportunity for Valeria to experience science even though she was an emerging English speaker was unique. Valeria shares in her native tongue, “*En El Espejo enseñan más y también te explican mejor y también me hizo mucha falta* (during the school year) *y me enseñó mucho porque es bilingüe.* [In *El Espejo* they teach a lot and they explain much better and I really missed it during the school year and I learned a lot because it’s bilingual.]” Valeria really needed "it," this support and the experience she had to learn science during the program during her regular science class during the school year. The program was a place where Valeria could learn science and understand science, which is why she returned for a second year. She liked “…*como enseñan y tambien me gusta mucho aprender de ciencia, me gusta mucho la ciencia* […how they teach and also I like learning about science a lot, I like science a lot.]”

Valeria was able to get in-depth explanations whenever she needed clarification for what she was learning. She felt the facilitators helping her "*explican major* [explain better]" compared to her teachers at school. Valeria felt the facilitators were able to spend more time with her to teach her a little more about whatever she was interested in learning about "*Me ayudaron a entender mejor las preguntas y a translate* [They helped me understand the questions better and to translate]." For Valeria, the program provided a unique opportunity to get in-depth attention that may not be possible in a large classroom with one teacher. Facilitators helped create a unique experience for her to access science and gain a passion for science.

3. Summary. The eight participants interviewed felt that being part of this program provided unique opportunities that they would not have had were it not for this experience. Angel, Winter, Lilly, Issa, and Valeria provided concrete examples of the unique aspects of their experience in the program. For example, learner-centered opportunities provided a venue for the girls to have the opportunity to pursue an authentic project, to focus learning on what they wanted to learn. The girls developed their own investigations based on topics they wondered about as they became acquainted with the site. Interacting with equipment and tools that scientists use when doing field studies were also unique opportunities as evidence by Lilly's story when Dr. Benedict brought her sound equipment, which also resonated with girls such as Angel and Maya. Issa summed up the uniqueness of the experience of being out in the field conducting her own research project as an opportunity that provided a deviation from her

normal routine. It added an excitement factor that she looked forward to year after year.

4. Importance of experiences. This theme includes findings where the girls acknowledge that were it not for the experiences in this program, they probably would not have the opportunity to experience science and learn about nature.

Angel. Being exposed to professionals for her was really important for Angel. These are experiences Angel would not have had were it not for this program. Angel acknowledges that she enjoys learning about new careers and recognized that at school, she doesn't have the opportunity to do many of the things she did during this program. She expresses the importance of newfound career opportunities saying, “Knowing that I could do something besides something like a teacher something you could do something completely different.” This experience provided exposure to careers that Angel had not thought of. In her science notebook, Angel reflects on how the program helped her become, “[M]ore aware that there’s other thing besides math, reading, and all that.” Angel discovered science as an important component of her education.

Maya. The idea of the program being selective for her was an important experience. Maya was accepted into a program that she thought was selective. For her, this was an amazing opportunity that Maya did not want to waste because she thought that not many kids had the opportunity to do this. Maya felt really special as evidenced by the statement about what the program meant to her, “This program means that I got accepted and I had the opportunity to learn

and succeed." Maya knew that this was an experience that could enhance her college applications for the future.

Lilly. Lilly mentions that taking a risk to join the program was an important experience for her. Lilly wants to be able to make sure Lilly's practicing what scientist do because Lilly knows Lilly's going to be a scientists in the future-- that was important for her. It's keeping this open, whatever these experiences are to make sure that Lilly actually goes throughout and learns more and seeks opportunities to be a continuous learner seemed to be of importance to her.

Lilly talks about her leadership skills and how Lilly was seen as a leader throughout the program and how she was given different charges. All those types of experiences seem to be of importance to her and Lilly wants to make sure she continues doing those things.

Lilly expressed her gratitude for the opportunity she was invited to be a part of. The opportunity to be part of the summer research program meant a lot to her and she recognized the impact she could have on other students as well:

> It means very much because you're [program developers] trying to help students/kids to feel that they can become scientists when they grow up because if they don't believe they could be a scientist and you show them that they can they learn so much and then they just think they can be ready for anything.

For Lilly, knowing that there was somebody who cared about showing students that they can become scientists or be ready for anything was very important. She was grateful for the opportunity to be part of a community where facilitators helped her achieve the goal of planning and conducting her own investigation.

4. Summary. Angel, Maya, and Lilly shared their appreciation for being selected to be part of this program. Angel's identifies being exposed to scientists and to careers in science as something that she had not encountered in school. Angel was very appreciative of the opportunity to learn about different careers. For Maya, being chosen to be part of this program was pivotal. Maya felt proud to be part of this program. Lilly took a risk by joining this community of scientists, but she knew that this was a need not just for her, but for her peers as well. The experiences they had by being part of this program were very important for these girls. Three out of the eight girls felt that this experience was truly important for them.

5. Role of facilitators in the girls' experiences. The facilitators embraced different roles throughout the project that the girls found particularly beneficial for their learning experience. Facilitators included teachers, community leaders, or college students with strong science backgrounds, and whenever possible, local scientists, too. The adults who served as facilitators were all women. There were however, male mentors and invited speakers on occasion. We welcomed anyone willing and able to help us fulfill our mission of advancing girls in science using inquiry through field investigations. Sometimes facilitators took on the role of teachers, other times they were helpers, coaches, interpreters, or field assistants. The facilitators also served as examples of women in science. Many of our facilitators were practicing teachers with degrees in science and identified themselves as having a strong background in science. The facilitators helped Angel narrow down a topic of interest. Facilitators played different roles

for each participant, with many learning moments for both the adults and the girls participating in the field research program.

Angel. Angel acknowledges that Jen and Melissa, two year-four facilitators, helped her figure out how to organize her thoughts. If Angel had a question, facilitators were accessible out in the field. They would help guide Angel to resources where could find answers to her questions. Angel thought it was helpful that they were able to show her different ways she could explore her question. The facilitators served as coaches that could guide her.

Winter and Selena2*.* Winter challenged the facilitators and the program coordinators, but the facilitators did not argue with her and encouraged her to follow her interests; Winter did not know how to handle that. The facilitators came to me on various occasions expressing their concern that they did not know what to do with her. Winter would say she did not understand what she did wrong. “I don't understand why they're trying to get me in trouble.” Not doing anything meant that Winter was not doing the writing that they wanted her to do. Winter was learning without doing the typical things we expect of students.

The facilitators wanted Winter to be able to explore and to utilize their expertise as sources of information rather than distributors of information or as the discipline police. Facilitators who were able to get past that were successful with her: Facilitators who were not had a really hard time working with her. Winter and Selena2 were the only two students who perceived some facilitators as “authority” figures who were out to get them in trouble the majority of the time. Winter and Selena2 challenged adults because they perceived facilitators to be

authority figures; Winter was not a complacent person and Selena2 was a vulnerable bystander. When Winter was asked about her behavior, she always pointed to someone else saying the other girl instigated her. The other girl happened to be Selena2 on most occasions. When Selena2 was by herself or with other girls, her behavior changed. She was a lot quieter in her demeanor. Out in the field, she would sit and listen to her surroundings. This type of experience was not possible for Selena2 when Winter was around.

Winter fueled the facilitators with her behavior. The facilitators classified Winter and Selena2 as being the disruptors and the rebellious ones. Selena2 wrote a letter through an activity we called “PLC mail” to the program coordinator explaining her desire to be near Winter:

> To: program coordinator
>
> From: Selena2
>
> I am frustrated about how I <u>never</u> get to see Winter and you don’t let us adventure in the same group. Winter is the <u>only</u> girl <u>love</u> in this camp (except Adriana, [another participant]) and her and I are into the same things. Why can’t we be together?? I will be good and I will make her be good too.

The facilitators tried separating Winter and Selena2, and the girls rebelled. In the end, the program coordinator and the primary facilitators working with Winter and Selena2 decided to keep them together instead of having them distracting two different groups. Even with all these occurrences, which the adults perceived as distractions, both girls managed to have a presentation ready for the community symposium. This challenged the notion facilitators had that the girls were not engaged in their learning because they were not writing things down in their notebooks or being responsive to what the adults were asking them

to do; however, there was room for improvement in their projects. Indeed, both girls have great potential and they show desire by coming back year after year.

Winter and Selena2 kept coming back year after year. They were both interested in seeing each other, but there was another layer of complexity to their relationship. They both liked being out in the field, wondering around. They liked to experience science together. Ultimately, implications from this particular friendship could be that they support each other as they move along their educational trajectory. This could be an interesting relationship to follow.

Maya. Maya saw facilitators as people who helped her gather materials and helped her gather her data and helped her with her notes. Maya did not see them as authoritative figures that told her what she was supposed to be learning or doing. Maya did not feel they were the watchful eye but rather felt she was free to explore on her own.

Issa. Issa mentions, "…To make up your own question," was hard for her so the facilitators being there to help Issa with that part was an integral component of her experience. Issa talks about the facilitators helping with the different activities. One facilitator who worked with Issa for two consecutive years expressed how impressed she was to see Issa's development and growth since her first year. Issa joined the program as an exiting 4th grader.

Valeria. Facilitators were extremely important for Valeria's experience. The facilitators "*me ayudaron a mi* [they helped me]." Having bilingual staff helped Valeria be an active participant in this community. There was always a bilingual volunteer or facilitator who could help explain things using language

Valeria was able to understand. On a few occasions, her team members helped her understand what was happening. We tried placing her with at least one other girl who spoke Spanish but in some activities, her team was all English Speakers. In these occasions, we tried to have a bilingual volunteer available to help Valeria if she requested help.

Valeria's first year in the program was a cultural experience for both the facilitators and for Valeria. The tadpoles and the frogs fascinated her. The poetic representation seen in Table 6 highlights the facilitator's experience who was working with Valeria's as well as the experience of other facilitators as they interacted with the girls. The facilitators working with Valeria the first year could not believe that she was kissing the toads!

Valeria returned for a second year. It was fascinating to hear the stories Valeria told. Valeria shared that when she returned to her home school, she told everyone about the million toads she saw; and to the researcher's surprise, Valeria actually kept one as a pet, which we did not encourage, but she managed to make it happen.

There were many toads at the site that year. The flooding form the river almost reached the 100-year mark. Valeria returned home and talked about how special that moment was. Valeria was very disappointed the following year because there were no toads because the extreme opposite occurred, a drought. However, Valeria was on a mission to find out what happened to the toads.

This desire to seek knowledge inspired Valeria to pursue a career in science teaching. Valeria loved helping other students. During the school year,

Mrs. B, the community liaison and outreach worker shared that Valeria showed an interest in tutoring recent immigrants to teach them the things she had learned the previous year. Valeria became a sort of “helper” for the outreach worker (the person who helped recruit her to the program) and tutored younger students. Valeria sees herself as a scientist and an educator. For Valeria, the facilitators created a space where Valeria could learn at her own pace.

5. Summary. The facilitators helped create authentic learning experiences that were different than school learning for four of the participants: Angel, Maya, Issa, and Valeria. The facilitators helped the girls make their own decisions and helped them examine their choices for topics to investigate. The key to doing this successfully was having a facilitator that felt comfortable guiding the girls and provided them with a balance of structure and freedom to test ideas, experience failures, and struggle through the process.

The facilitators experienced different emotions working with the girls. As seen in Table 7, and presented in the form of a poem, the lasting impressions from the facilitators’ interactions with the girls ranged from fascination, to challenging moments, to risk-taking on behalf of the girls, to transformation of experience in the end. The girls came “pretty” and left knowing that it’s okay to be pretty, and it’s okay for them to do science and to get down and dirty. It is all part of the experience. Facilitators really strived to build personal relationships with the girls to guide them individually or in small group settings; however, the facilitators were not always successful in reaching every girl as evident in two of the girls’ experiences: Winter and Selena2.

Table 7

Poetic Representation Using Data from Facilitators Debriefs Describing their Experience Working with the Girls

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Kissing Toads

I guess I never thought toads were cute
And they were kissing toads…
That was quite an experience!

I thought you liked being outdoors
I only like certain types of outdoors

And one was in a skirt –Oh, Winter!—
and she was in the water
Gossiping about boys
but yet, still there, playing with the frogs

I knew Mia was a thinker
And she has a lot to share
But she is random, all over the place
And channeling that was difficult

Working with middle school girls.
It's okay to get dirty.
It's okay to be pretty,
but it's even better if you're pretty
and you're smart.

This program allows them
to come pretty
and you may not leave
how you came.
You're collecting data,
you're going to get dirty in the field,
and that is OK.

Often times in today's classrooms students are not given the opportunity to explore a topic of their choice and design a way to test an idea or develop their own scientific studies. Students rarely get to meet and interact with scientists

from their local communities. Collaborations among facilitators, scientists, and community organizations helped make this program opportunity for participants truly unique. However, while this opportunity was unique because of place and time, it is also a design that can be used and adapted by other communities to provide a place for their young women to experience science in a whole new way. Facilitators also guided their team in determining how they want to present their research at the symposium.

Mentors. This community was in great need of opportunities in science and engineering for girls to explore different realms of science, especially girls from historically underrepresented populations. There was also a need to connect women role models and leaders in STEM disciplines for the participants to see that science is something that happens in their backyard. This intervention gave girls from all walks of life the opportunity to be apprentice researchers and to work with scientists and science educators from the local community as evidenced by the visit by Dr. Susan Keenan, the biological scientist who studies malaria. For Selena, Dr. Keenan was an inspiration for Selena, “She told us about malaria and how to stop it and that seemed interesting, I was interested in that and she just kept talking about it and I was like that’s cool”.

Schmidt & Nixon (1996) expressed the need for learning opportunities to occur through active participation to affect learning. In particular, their study focused on understanding factors that could improve girls’ attitudes towards science, with an emphasis on experiences that were for girls only. A unique characteristic of their intervention was that they were open to the inclusion of

male volunteers in years 1 and 2 who showed commitment to encourage participation in science for girls (Schmidt & Nixon, 1996). Learning in an all-girl environment, even with a few male role models present, served as a useful strategy towards increasing the participation of underrepresented girls in field ecology. Selena2 shares her concern over having boys in the program, “I think it’d be cool to have boys there, but yet distracting.” If Selena2 was already distracted with Winter being there, adding boys to the equation might have been counterproductive.

Speakers. The girls showed a deep interest in learning from the speakers. We had three speakers in year 4. The ornithologist and the chiropterologist made a lasting impression on the girls. The first scientist speaker was an ornithologist from the local university, Dr. Lauryn Benedict. Dr. Benedict brought her sound equipment, her field equipment and we split the group of 30 girls into two groups; one group learned to use binoculars and spotting scopes while the other group learned to use the sound equipment. Since the sound equipment was very expensive, it was explained to the girls that they would not be able to use this type of equipment for their field studies later that week; regardless, they were exposed to this sophisticated equipment and they understood the potential for exploring research questions using that equipment in the future. In journal reflections, seven girls indicated they wanted to be ornithologists if they ever chose to be scientists.

The second scientist was a doctoral student in the Chiropteran Lab, Laura Heiker. Being directly exposed to experiences helped the girls expand their

career opportunities because they saw the different faces of science and were able to identity with scientists or science educators in the program.

The girls met women in the sciences as well as women leaders from the community who were non-scientists because it was important for girls from underrepresented groups to see women leaders who represented their cultural backgrounds. There was difficulty in finding women scientists who were from the underrepresented cultural groups the girls represented: Latina, Native American, and African/African American.

The list of scientists the girls met varied year to year, depending on the scientists' availability. Exposure time also varied. Some scientists spent the day with the girls; others spent half a day. For many of the scientists, 90 minutes was all they could do. In this short period of time, they presented a 15-minute overview of what their interests were and for the remaining time the girls experienced what the scientists did.

Even though the girls were exposed to scientists throughout the week, there were a couple of participants who could not name any of the scientists or science careers they experienced during the program. This was an interesting finding and highlighted the importance of being explicit in introducing the visitors and their professions. Also, we recognized that listing the scientists by discipline and by name was probably not the best way to assess if the girls learned anything from them or their professions. Thus, a more creative way to assess learning may be through a mini evaluation after every presentation to help the girls reflect on the role of the visitors and what they meant to them and their

experiences. Also, validating that the visitors were scientists may be a necessary step for the girls to recognize them as such, rather than assuming the girls will make the connections on their own.

Table 8

Academic, Career, and Cross-cultural Goals and Objectives

Academic	Career	Cross-cultural
By the end of the intervention, students will:		
Design, set up, and implement an inquiry-based, interdisciplinary investigation.	Be exposed to at least 5 careers that involve research in STEM disciplines.	Meet professional women from various cultural groups and various STEM disciplines.
Engage in using at least five scientific protocols in a variety of settings.	Meet at least 5 women professionals in STEM fields that incorporate research as part of their professional duties.	Be exposed to experiences to create cultural awareness and understanding of other for different points of view.
Communicate findings to fellow researchers and community members.	Build an understanding of the differences in community college, four-year college/university, and a professional school.	Experience intercultural communication.
Develop greater environmental awareness through meaningful outdoor experiences to learn about their place.	Understand what the word “major” refers to when deciding on a career path.	Build a greater tolerance to respect diverse points of view.
Understand that research is a dynamic process, not a linear way of finding an answer.		
Make scientifically informed decisions.		

Table 8 summarizes the original program goals. Participants were exposed to academic, career, and cross-cultural experiences. Individual goals and objectives were accomplished at different levels throughout the program.

Some objectives were more straightforward than others. For example, we can clearly document that all girls were exposed to at least five STEM careers; while, "*Develop greater environmental awareness through meaningful outdoor experiences to learn about their place"* was more challenging to document. Two goals that we clearly did not met because of lack of resources necessary to expand the program were, "*Build an understanding of the differences in community college,"* and *"Understand what the word "major" refers to when deciding on a career path four-year college/university, and a professional school."*

Although we did not create goals specific to content knowledge, the second part of this study was an exploration of the ecological knowledge as its role in the development of the girls' science competence. The next research question will focus on specific ecology knowledge, on the science practices the girls applied towards learning these concepts, and the reflective process they showed as they explained the concepts they learned.

Ecological Knowledge as a Component of Scientific Literacy—Building Science Competence

Q2 Ecological Knowledge as a Component of Scientific Literacy. What ecological knowledge did middle school girls have before and after the intervention?

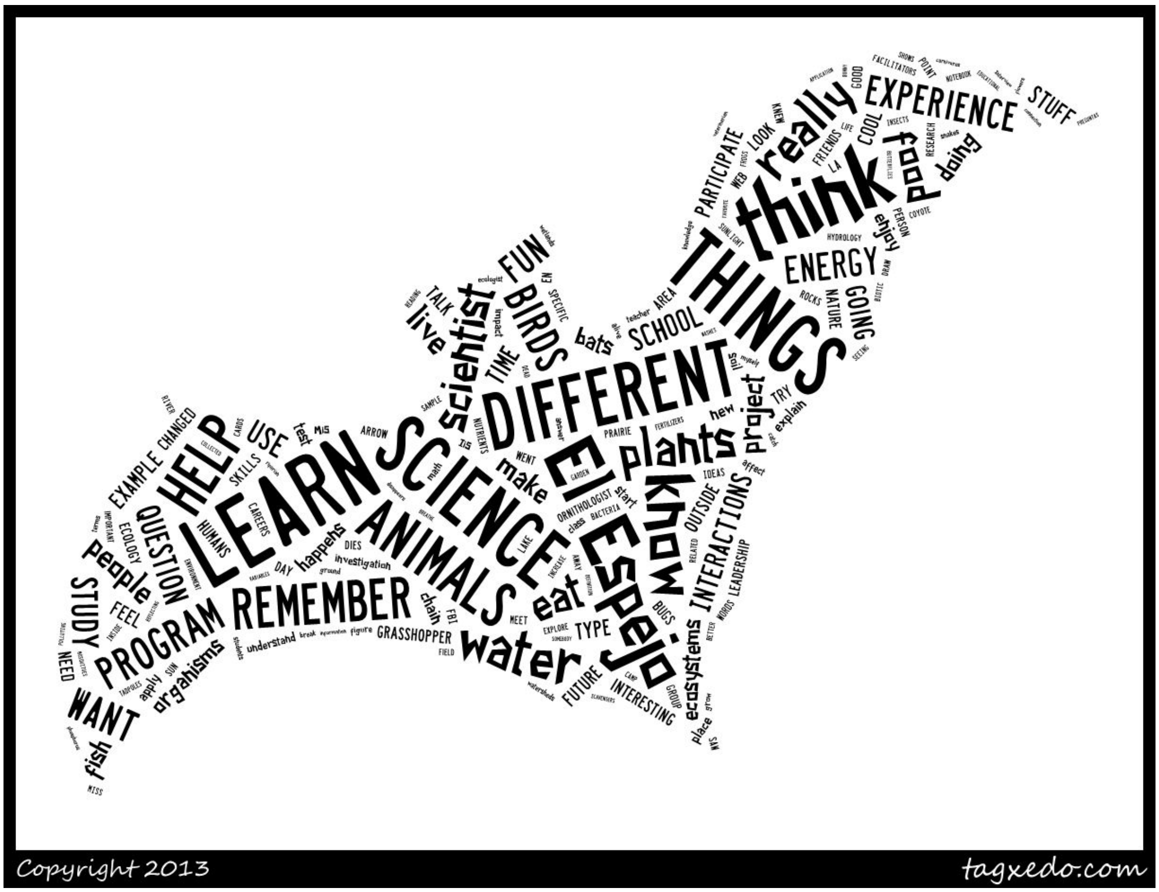

Figure 4. A Tagxedo diagram representing the most commonly used words in the interviews and in the girl's responses in the ecology knowledge tool and in the attitudes and perceptions survey written responses.

6. Learning ecology. This theme explains the girls existing knowledge or new learning of ecology principles. The importance of knowing and learning science in different ways was evident in the analysis of the data set that sought

the most common words the girls used to describe their experience (see Figure 4). The top five words were: 1) different, 2) learn, 3) science, 4) things, and 5) think.

The theme, “Learning ecology” was also inclusive of all the ecological principles that made up the ecology content knowledge test: 1) the earth as a biosphere, 2) ecological energetics, 3) ecosystem succession, 4) biotic interactions, and 5) materials cycling (Morrone et al., 2001). This theme also summarized experiences or moments where the girls showed evidence of learning any of the principles listed above. Any explanation that helps the reader understand the experience with the ecology concepts the girls learned and experienced throughout the intervention were also included in this section of the analyses.

To get an overview of the knowledge the participants had pertaining to ecology, all participants present on the first day took the pre-ecology knowledge test (Appendix H, I). Even though the tool was adapted form an existing tool (Morrone et al., 2001), a Cronbach’s alpha, α=0.656, indicated the responses to the questions in the tool had moderate reliability. The reliability may indicate that the test may have been getting at multiple constructs, which is logical, considering there were several ecology principles under investigation; however the small sample size (N=26) limited the researcher to run an exploratory factor analysis.

The ecology principles tool itself did not capture the main understandings the girls had about the ecology principles of interest. The tool only captured what

the girls remembered at that moment in time, either during the pre-test or the post-test. With this limitation in mind, the researcher conducted a Wilcoxon test, which evaluated the difference between medians for pre-test and post-test for ecology content knowledge (Green & Salkind, 2008). The results indicated no significant difference, $z= -1.294, p<.05$. The Wilcoxon test was conducted because it is the equivalent to a student's t-test but does not need a large sample size; it's a non-parametric test that can be used with a sample size of 26 usable scores (Green & Salkind, 2008). Even though 33 girls were part of the total group, not all the girls were present during either the pre or the post-test. There were three tests that could not be used because the participants selected the same response for all questions or did not answer any questions, and four tests that were missing either the pre or the post-test score. The mean of the pre-test (N=26) was 5 out of 11 and the mean for the post-test was 6 out of 11 (N=26). These eleven questions reflected only the questions that could be coded binomially. Based on these findings, the intervention did not have an impact on the outcome of the ecology knowledge scores form pre to post. With these constraints in mind, the information from this test was used as it pertains to the stories of the individual participants interviewed. The data will be presented through individual stories that connect to this broader theme of learning ecology.

The second part of the ecology knowledge test was open response so it was not included using binomial scores. There were a range or responses, some were left blank, and others included novice responses or responses that were not well articulated. There were a handful of girls whose responses reflected what

they knew about the concepts. For Angel and Lilly, the responses on the post-test did not show mastery of the concepts being addressed in the question, but they were better able to articulate their responses in their interviews.

Angel. Angel scored 5 out of 11 on both he pre and post ecology content knowledge test. Two questions she scored right in her pre-test were changed for her post-test and two new questions were answered correctly on her post-test that were incorrect on the pre-test. There were four questions where Angel marked, "I don't understand the question" for both her pre and post-test. Angel explained a lot more during her interview than what was captured in her pre/post test score.

For the second half of the test, Angel’s responses reflected a novice understanding of food webs, decomposition, and nutrient cycling. A deeper dive in the interview, demonstrated that Angel was able to convey a more sophisticated understanding. For example, Angel explained the food web diagram she drew on her post-test to the researcher. Angel realized that what she was saying did not match the diagram she drew so she changed her arrows to show the flow of energy between the organisms, rather than the arrows pointing to the organism being eaten. Angel explained, “The arrows mean stuff that the bunny, the grasshopper, the bird would eat and the bunny would eat stuff like plants and grasshoppers and insects.” Angel then talks about energy flow in a food chain, “The energy would go from the plant it would give energy to the bunny and then the bunny would eat insects to get energy.” Angel’s answer demonstrates a “proficient” knowledge in the knowledge proficiency standards

established by Hogan (1994) in the Eco-Inquiry curriculum used in the program (see Appendix F). Angel understands, "The flow of food from producers to all types of consumers is called a food chain (Hogan, 1994, p. 29)." Angel also understands, "A food web is chain is the connection among everything animals and microbes in a location eat and are eaten by (Hogan, 1994, p. 29), which is a more sophisticated, or advanced understanding of food webs. Angel defines a food web as "something that shows how all organisms are connected," and goes on to share that animals may have more than one food source and that animals interact in many different ways not only to get food, but in selecting suitable habitat as well.

When the researcher asked Angel about interactions in ecosystems in her interview, she talked about the prairie and how it was really dry and as she walked into to the wetland she felt a rush of humidity as described in the following excerpt from her interview:

> Angel: One of the ecosystems was the prairie and how it was really dry and then once you walked down you saw the wetlands which is right when you walk there you get a sudden rush of humidity because when we had heat so and plus there's water there, heat and water humidity and when you walk towards you got kind of cool so the different parts of the ecosystem was like different from one spot you're dying of heat to getting really hot and humid to just cool.
>
> Researcher: Did you notice the differences or similarities in the organisms that live in the different ecosystems?
>
> Angel: In the prairie there wasn't much life there, mostly those flowers and just prairie dogs and once you got the wetland you didn't see those flowers anymore maybe because of the water and they don't like water and then you saw more birds and life there than you did in the prairie land and once you got to the water you saw a lot of life.

> Researcher: How where the plants different in the wetlands than in the prairie?
>
> Angel: The wetlands you saw more plants and stuff that you would see and stuff you would see in the water like those, what was that?
>
> …
>
> Angel: The cattails, and you didn't see any cattails in the prairie. All you saw were those pretty flowers but they were weeds I guess

Angel acknowledges that variation in humidity was a characteristic that differentiated microclimates within the PLC and influenced the diversity of life she was able to see. The post-test responses did not indicate this type of understanding. Angel's journal included descriptions of interactions occurring between the abiotic and biotic environmental components.

To explore what Angel knew about decomposition the interviewer asked her what would happen if an animal died. She said, "The body would start to break apart and the organisms will start to get eating it away." Angel described the decomposition process as follows:

> Decomposition is when insects and stuff start to eat away at the bone and cartilage and then the body starts to became less, it would start off looking like a coyote but as time goes on it would look like something completely different it wouldn't even look like it, you would just see pieces of it somewhere and you wouldn't know what it was.

The depth of Angel's response was not reflected in her pre/post test. Her answer on the post-test to what happens when an organism dies, she wrote, "When organism die, others die." The quotation above shows Angels understanding, "Some dead things get eaten by bugs, but dead things also

decompose because of physical conditions (Hogan, 1994, p. 30).” In her pre/post-test, Angel was not able to explain the concepts of food chains, food webs and energy flow, and decomposition whereas in the interview she was able to talk it through and make sense out of what she was thinking.

Lilly. Lilly made references to her notebook to help her answer the questions I was asking because she saw the science journal as a book that helps scientists remember what they have done:

> I think it’s important for a scientist to have a science notebook because if they forget they could always look back to see what they captured because if they needed something very important to do for their experiment and if they forget it they have to look back but If they don’t have it they have to do it all over again.

Lilly applied the same principle to science learning. If she wrote it down, she could easily go back and look it up. Lilly referenced her journal when I asked her ecology content knowledge during her interview. Referencing her journal helped her develop in-depth explanations. An example of when Lilly used reflective thinking for the learning of ecology was when Lilly realized that her explanation of energy flow in a food web was inaccurate. When given the opportunity to process the information more extensively, she corrected herself by saying, “I mean that the energy is being transferred from one organism to another.” This was consistent with Angel's reaction. Both girls explained the diagram to the researcher and realized that what they were saying did not match the diagram they drew. Both Angel and Lilly changed the direction of the arrows to represent energy flow rather than keeping the arrow pointed to the animal that is being eaten, a common misconception regarding the use of arrows to

represent the direction of energy flow (Northeast Independent School District, 2013)

Another example of Lilly's ecological learning pertains to bats. This unique experience impressed her:

> Lilly: Yeah, I was really impressed with the program could make me learn more about what when we learned about bats I never knew that some bats could eat fish because they're slippery so how can they get it but then it's with their big feet or claws or something like that.
>
> Researcher: Do you remember what types of animals bats are?
>
> Lilly: Mammals which means…they have warm blood, they produce milk for their babies and yeah that's mostly.
>
> …
>
> Lilly: What I learned with Laura is that big bats are called megachiroptera and then the little ones are microchiroptera.

Lilly was the only participant that mentioned specific facts she learned about bats and showed an interest in learning about their habitats. She's looking forward to working with Laura, the chiropterologist, next summer to learn more about bats and their role in the ecosystems at the PLC. Lilly's interest on this topic can be a venue that can be further expanded to keep her inspired. Inspiration played an important role for Selena's learning of ecological principles.

Selena. Selena scored a 5 out of 11 in her pre-test and an 8 out of 11 on her post-test. Selena expanded on plants soaking up energy and how that energy is transferred to other organisms that eat the plant:

> Their energy would go into the animal or the organism so I would think the sun the energy would go into the plants, then the plants energy goes into the animals and then I would think since the animals have the plants energy, it digests it and goes back into the

> soil and then it would somehow go back into the plant, I'm not sure how.

Selena exhibits knowledge of energy flow and is "a little confident" about her response to the question pertaining to energy flow; however, she is not sure how nutrients are released so plants can utilize them. Selena talked about producers and decomposition and how the FBI (Fungi, bacteria, invertebrates) are in charge of breaking up dead organisms, "I think decomposition is the breaking down of the animal. The FBI (fungi, bacteria and invertebrates) help breaks down the animal so I'm pretty sure maggots are the invertebrates that eat the inside of the animal." On her post-test, Selena described the process of decomposition, "I think once a fish dies their nutrients get sucked into the ground. Then layers of rocks cover the dead animals and it becomes a fossil." The two different responses to the question "What happens when an organism dies?" were drastic. Her pre/post-test focused on the process of fossilization, while her interview response focused on describing the process of decomposition. In her interview, Selena also described how changing environmental conditions an alter the rate of decomposition, "Scavengers…they would help break down plants and animals and sunlight would also help with the increase in temperature." Selena was able to produce more sophisticated responses that placed her at a proficient level in the Knowledge Proficiency continuum (Hogan, 1994) (see Appendix K) in her interview and in her science journal, but her post-test also did not fully capture her knowledge on decomposition.

Selena understands, "A foodweb is the connection among everything animals and microbes in a location eat and are eaten by (Hogan, 1994, p. 29)."

Her diagram in the post-test adequately shows the flow of energy from producers to consumers and she even included decomposers and the sun as components of the ecosystem that were missing in the original diagram.

Valeria. It was difficult for Valeria to explain her responses in English with the limited English vocabulary Valeria she had acquired. Her learning was taking place in English, and she chose to use the Spanish pre/post test to help her answer the questions in English. She scored a 5 out of 11 on her pre-test and a 6 out of 11 on her post-test.

During her interview, we asked Valeria the questions in English, but she could not understand some of the terms we were using so it was difficult for her to formulate an answer. If we translated the question to Spanish, Valeria still did not understand it because there were words Valeria had never heard of in Spanish because she was exposed to those terms in English when she potentially learned them. It was difficult to get to what Valeria actually knew with the tools we had to gage her level of ecology knowledge. Research shows that it may take 5-7 years for English language learners to master academic language (Hakuta, Butler, & Witt, 2000).

Valeria mentioned learning about animals and the animals that live in the river and in different habitats. Valeria remembers specific details about what she studied out in the river. Valeria shared, "I found boatman and *de esas cosas como se llaman*? [those things, what are they called?] The water spider, *no era* [no, it was] fishing spider *y también* [and also] crayfish, scud, mayfish [mayfly larva], and daphnia." Macroinvertebrates was something that really interested

Valeria when it came to science learning because she enjoyed spending time at the river. Like Valeria, Selena2 enjoyed spending time near the water and noticed changes over the years.

Selena2. Selena2 was a 3-year participant and she talked about systems changing at the PLC. Selena2 noticed variations in the level of the water. The first year Selena2 was there, the PLC was completely flooded. In her third year journal she wrote, “Where did all the water go?” Selena2 was able to see variations in the ecosystems at the PLC from year to year. She noticed changes in the groundwater level and in the organisms present at the site, “There wasn’t as much water anymore. Things were, there was different bugs, too. There wasn’t as many mosquitoes this time there was[sic] more grasshoppers.” Selena2 also spoke of the interactions between different organisms and the environments where they live. Selena2 shared that if you sample different areas, you get, “Different animals and different plants and different temperatures and all” which highlighted the biodiversity at the PLC. Selena2 learned that some organisms can only be found in certain areas and their survival also depends on environmental conditions. For example, she noticed the tadpoles were gone year 4. There was a drought at the PLC that year. The previous year, the water level almost reached the 100-year mark. These place-based, hands-on experiences made learning meaningful and contextual for Selena2. Experiential learning played an important role for Selena and for all the participants interviewed.

6. Summary. Experiential learning called for the intervention to be analyzed as “a process rather as specific outcomes” (Kolb, 1984b, p. 25-38).

Focusing on a specific outcome and not understanding the process that the girls took to get to an outcome limits the potential for intervention if the girls happened to “guess” and get the question “right.” The creation of the content knowledge instrument included an “I don’t know” and an “I don’t understand the question” so the girls could create an awareness that they don’t have to guess if they don’t know. And, they could learn what they didn’t know, becoming more metacognitive thinkers. Ideally, the girls should have kept the content knowledge tool to be able to reflect on the process and how they gained new knowledge. Although they had their notebooks to reflect along the way, both on process, content and experiences, they did not know if they actually had mastered any of the ecological principles because they did not have the pre-test questions from which to build.

The ecology principles tool itself did not capture what the girls knew about the ecology principles of interest. Even though the tool was adapted from an existing tool (Morrone et al., 2001), a low Cronbach’s alpha indicated it was not reliable for this population. Modifying the tool, sampling more participants, or exploring if the tool is getting at multiple constructs may be possible directions for future study. While an overall analysis of the group demonstrated that there was no significant difference in per ecology knowledge compared to post, the participants interviewed were able to articulate knowledge that could not be captured by the tool. Four out of the eight girls interviewed showed they learned ecological principles in their interviews but their responses were not evident in the pre/post-test. It was difficult to gage Valeria’s learning of ecological principles.

7. Learning science practices. This theme is composed of findings that exemplify practices that a scientist would normally exhibit if she were conducting research out in the field/lab. Science practices have been defined by the National Research Council (2012) and include: asking your own questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, obtaining, evaluating, and communicating information. Angel's science practices focus on question development and defining the problem her team wanted to study.

Angel. By collecting data, Angel learned that new questions can arise from the initial study questions developed. Her team's original question was to try to figure out to which calls redwing black birds respond to. Her team found that the birds would only respond to a call from the same species. Sometimes they responded to calls that threatened them. Angel's team wondered, "What if we create a new call, would the redwing black bird respond to it?" Angel gained an appreciation for expanding her research question and gained an appreciation for what ornithologists need to know.

Angel learned to use tools that scientists use (e.g., binoculars, camera, sound recording equipment) and learned to record her results in her science journal. Angel remembers using the microphone to listen to the birds during the visit from the ornithologist. From this experience, Angel shared, "People don't have really good hearing. Most animals have enhanced hearing than we do so

we should be a little more quiet to respect their privacy and so we won't hurt them in any way." She concluded that people have to respect the birds' privacy by keeping their noise level down. Angel also learned to use the equipment to assist her in collecting data to answers her scientific questions.

Maya. Maya had the opportunity to develop her own study question, which exemplified what scientists do. Maya learned about documenting her findings, developing a study question, learning protocols such as measurement, etc. and doing research to improve her design. All of these science practices enhanced her ability to experience science out in the field.

> I would go out every morning and I put bird feeders in different spots and then I'd go back inside and I'd do research on birds and at lunch I'd go out and get what I needed. Before I would set it up I'd weigh it and I'd record what I weigh and then I'd bring it back inside I would weigh it then I'd take it back out and I'd wait till the end of the day and then I'd take it out again and then at the end of the day, I mean at separate times I'd see when and where they'd eat most.

In her journal, Maya documented detailed notes which informed the creation of the poetic representation in Table 9 which was written by the researcher. This poem has been formatted from the journal notes Maya took during an outdoor observation activity on the first day of the program. Her notes, written in the form of a poem, captured the essence of what Maya felt being outdoors using her senses. Her observations led to queries of things she wondered about.

Table 9

Poetic Representation of Data Collected from Maya's Science Journal

My Place Outdoors

I smell wet grass.
……………..Nature.
……..…….Flowers.

I see meadows where prairie dogs live.
I see grass and flowers.
I touch rough rocks.
…………..Smooth flowers with holes in them
I hear the sound of crickets.

Bees buzzing into flowers,
Pollinating.

I wonder…
There might be a nest over there.

I see a hole.

I wonder…
Do eagles come at night when we don't?

I wonder.

Note: The series of queries were written in response to the observations she noted using all her senses when sitting in the middle of the prairie.

Winter. Winter really enjoyed communicating her findings with her peers and the general public. This was one of Winter's strengths as a participant in this experience. Sharing her findings helped reinforce that science is something Winter could do, but she refused to physically write in her journal as a way to document the evidence to back up her findings. Winter enjoyed speaking about what she was doing and discovering. Even though she participated multiple

years, she struggled with this aspect of research—writing down notes and data she collected to adequately represent and back up the conclusions she was making.

Lilly. Unlike Winter, Lilly kept copious notes in her science journal to document her every move. As noted in the learning ecology section, Lilly actively used her science notebooks to create new understandings about ecological principles. Lilly wanted to make sure Lilly wrote everything down, not only because we encouraged her to do so, but because Lilly was interested in tracking her experiences as well. In her notebook, Lilly documented grasshopper behavior because she was interested in seeing how grasshoppers behaved around each other in a contained space. In her journal she documented behaviors such as “A grasshopper ate one of the little ones.” The following quotation summarized her findings:

> What I found out is that the little ones stay away, they were afraid, the little ones so maybe they didn’t want to be eaten or something and the bigger ones, they wanted to be more alone and sometimes they would get near the little ones and they little ones just cocked away, they really show a lot of territoriality when they stay away. Yeah the big ones with their feet they tried to push the other ones away or with their body.

Being out in the field when collecting grasshoppers, documenting her experience was a science practice that helped Lilly feel like a scientist and learn the practices used in science (National Research Council, 2012).

Lilly also made references to her notebook to help her answer the questions the interviewer was asking because she saw the science journal as a book that helps scientists remember what they have done:

> I think it's important for a scientist to have a science notebook because if they forget they could always look back to see what they captured because if they needed something very important to do for their experiment and if they forget it they have to look back but If they don't have it they have to do it all over again.

Lilly applied the same principle to science learning. If she wrote it down, she could easily go back and look it up. Lilly referenced her journal when I asked her questions about ecology content knowledge during her interview. Referencing her journal helped her think in-depth. An example of a contradictory thought occurred when Lilly realizes that her explanation of energy flow in a food web was inaccurate. When Lilly was saying it out loud, "I mean that the energy is being transferred from one organism to another." This was consistent with Angel's reaction when Lilly explained that diagram to the researcher. They both changed the direction of the arrows to represent energy flow.

Learning about bats being mammals was unique when it came to the knowledge Lilly experienced:

> Lilly: Yeah, I was really impressed with the program could make me learn more about what when we learned about bats I never knew that some bats could eat fish because they're slippery so how can they get it but then it's with their big feet or claws or something like that.
>
> Researcher: Do you remember what types of animals bats are?
>
> Lilly: Mammals, which means…they have warm blood, they produce milk for their babies and yeah that's mostly.
> …
> Lilly: What I learned with Laura is that big bats are called megachiroptera and then the little ones are microchiroptera.

Lilly was the only participant who mentioned specific facts she learned about bats and showed an interest in learning about their habitats. She's looking forward to working with the chiropterologist next summer to learn more about bats and their role in the ecosystems at the PLC.

Selena. Selena expanded on plants soaking up energy and how that energy is transferred to other organisms that eat the plant:

> Their energy would go into the animal or the organism so I would think the sun the energy would go into the plants, then the plants energy goes into the animals and then I would think since the animals have the plants energy, it digests it and goes back into the soil and then it would somehow go back into the plant, I'm not sure how.

Selena exhibits knowledge of energy flow, but is not quite sure what happens to release nutrients so plants can utilize them. Selena talked about producers and decomposition and how the FBI (Fungi, bacteria, invertebrates) are in charge of breaking up dead organisms, "I think decomposition is the breaking down of the animal. The FBI (fungi, bacteria and invertebrates) help break down the animal, so I'm pretty sure maggots are the invertebrates that eat the inside of the animal." On her post-test, Selena described the process of decomposition as follows; "I think once a fish dies their nutrients get sucked into the ground. Then layers of rocks cover the dead animals and it becomes a fossil." The two different responses to the question "What happens when an organism dies?" were drastic. Her pre/post test focused on the process of fossilization, while her interview response focused on describing the process of decomposition. In her interview, Selena also described how changing environmental conditions can alter the rate of decomposition, "Scavengers…they

would help break down plants and animals and sunlight would also help with the increase in temperature.” Selena was able to produce more sophisticated responses in her interview and on her journal, but her post-test also did not capture her knowledge of the ecology principles she learned. She scored a 5 out of 11 in her pre-test and an 8 out of 11 on her post-test.

Valeria. It was a challenge for Valeria to explain her responses in English with the limited English vocabulary Valeria she had acquired. Her learning was taking place in English, and she chose to use the Spanish pre/post test to help her answer the questions in English. She scored a 5/11 on her pre-test and a 6/11 on her post-test. Valeria enjoyed learning about biodiversity. She learned that organisms are classified based on traits and different traits may be expressed at different times depending on the organisms’ life stage. For example, Valeria was fascinated by macroinvertebrates. Her understanding that some organisms thrive in water as larva and have the ability to live on land as adults was insightful. Valeria mentions learning about animals and the animals that live in the river and in different habitats and that she enjoyed learning about that. Valeria also mentions she learned how animals communicate. Valeria remembers specific details about what she studied out in the river. Valeria shared, “I found boatman and *de esas cosas como se llaman*? [those things, what are they called?] The water spider, *no era* [no, it was] fishing spider *y también* [and also] crayfish, scud, mayfish [mayfly larva], and daphnia.” Macroinvertebrates was something that really interested her when it came to science learning because she enjoyed spending time at the river and the lake.

The researcher's field notes include at least 10 instances of Valeria walking along the riverbank and along the lake to sample what organisms lived there and what made it possible for such organisms to live there. Her desire to learn more about the habitat as well as the organisms may lead her to pursue this newfound interest in the future. At this time, we do not have a way to track her development long-term, but her inspiration was evident. It was very difficult, however, to capture what Valeria knew using the ecology tool.

During Valeria's interview, when we asked her the questions in English, she could not understand some of the terms we were using so it was difficult for her to formulate an answer. When we translated the question to Spanish, Valeria still did not understand because these were words Valeria had never heard of in Spanish either. The challenge was Valeria was exposed to those terms in English when she potentially learned them, yet still had difficulty with the English language. It was a challenge to gage what Valeria specifically knew and understood with the tools we had to gage her level of ecology knowledge.

Selena2. Selena2 was a 3-year participant and she talked about systems changing at the PLC. Selena2 noticed variations in the level of the water. The first year Selena2 was there, the PLC was completely flooded. In her third year journal she wrote, "Where did all the water go?" Selena2 was able to see how the ecosystems varied from year to year in terms of the organisms present in different areas, "There wasn't as much water anymore. Things were [different], there was different bugs, too. There wasn't as many mosquitoes this time there was more grasshoppers." Selena2 also talked about interactions between

different organisms and the environments where they live. Selena2 shares that if you sample different areas, you get “different animals and different plants and different temperatures and all.” She learned that some organisms can only be found in certain areas and their survival also depends on environmental conditions. For example, she noticed the tadpoles were gone year 4. There was a drought at the PLC that year.

7. Summary. The science practices the participants learned included asking their own questions, defining their own problems, analyzing and interpreting data, and obtaining, evaluating, and communicating information. Seven of the eight participants interviewed showed evidence of science practices. Angel enjoyed being able to expand or modify her question once her team was able to answer their original question. Angel also enjoyed using the tools that scientists, such as the ornithologist, used to see how data is gathered when studying birds. Lilly and Maya’s science journal contained copious notes that the girls referred to as they pursued her project. Both girls also referred to their notebook during the interview. Winter practiced her communication skills but refused to work on science practices such as keeping an up-to-date science journal. For Selena2, documenting differences she observed at the site on different years indicated that this information was important enough to write it down to see how the site would change in years to come.

8. Applying reflective practices. Reflective thinking, the ability for the participants to think about what they knew and did not know, or their metacognitive practices were summarized through this theme. This included the

girls making suggestions for program improvement. This theme also included what the girls were thinking at the time the data were generated or if they corrected themselves because what they were saying was inaccurate; they caught the inaccuracies, and corrected their train of thought. This theme summarized reflective practices participants used as they explained their learning.

Angel. Angel was curious to learn new things, and because of this program, she now had the tools to find answers and to continue studying topics of interest. "Stuff that I learned in EE [*El Espejo*] can help me at school and apply it to my everyday life. If I see something I can be like, Oh. I learned it at *El Espejo.* I could probably research that and find out more about it." Angel has been empowered where now the opportunity for her to seek new information is there where it may have not been there before. This evidence shows that Angel acknowledges that these skills are something she will keep forever. Angel is being reflective and thinking about what she knows and where she needs to go. Angel is acknowledging that she has enhanced her research abilities and desire to seek new information because of this experience.

Issa. When Issa wrote the letter to the board that detailed the potential benefits of having an overnight stay, not only for herself, but also for the *El Espejo* community:

> Dear Board of Education,
>
> Us *El Espejo* want to be here overnight and experience being outdoors. To see animals in the evening and see what they do or learn about the animals if we don't know what it is. So we can learn more or just be in class listening to the teacher and not learn much just hear and listening? Also if we are learning things and need

> more time we can collect the data we need for the overnight. We can be without new friend and fun too. Please let us have an overnight at *El Espejo.* Thank you for reading my letter.
>
> From: Issa

Issa was reflective when she spoke of the experiences that would benefit the community and not just herself. Adding camping to her experience would not only benefit her, but girls who have never had that opportunity to learn in this environment would benefit from the experience, too. While Issa shows reflective thinking in communicating to the school board, her journal does not show the same type of reflective thinking.

Issa's notebook on the other hand, does not show reflective practice. She is very much to the point. Issa does not demonstrate the ability to expand on her notes. Issa just wrote what was on the board or what someone else told her. Issa cannot connect what the notes mean for her project. Her metacognitive abilities are still emerging. This is important for facilitators to be aware of to help her work on advancing those skills if Issa returns the following year.

Selena. Selena was a multiple-year participant. Selena was part of the project from the beginning. During year four, one of the facilitators presented the linear "Scientific Method" than the more dynamic process of science. In traditional science classes, students are taught a 5 or a 7 step method that scientist use to plan and conduct experiments. Science is perceived as a linear method where one step must follow the other. This is the typical "cookbook" method of doing science. However, science is more complex and rarely relies on a set number of steps (University of California Museum of Paleontology, 2012). Different types of scientists have different "methods of science" for conducting

investigations and experiments and require problem-solving skills. Previous year participants had been exposed to a more dynamic scientific process so Selena shared the following regarding her experience:

> Selena: [The facilitator] was the one that was teaching us about experimental probability or it was forming an experiment and she taught us what a control experiment is and how to set up one if we had to compare an experiment from another to see which one would work better or would do anything so she taught us that we needed five things for an experiment. We needed a question, a hypothesis, our data, a conclusion and a fair test and all that would tie into forming an experiment.
> …
>
> S: I think it would help to do it in that order and do it that way but I think there would be another way that you could do this just not in this order or this way that [I] have here.

Selena recognized that the “five step” method was one way of studying science but there was another more dynamic way too. Selena also questioned if it was always necessary to do a fair test to study science. This was reflective practice on her part. Selena acknowledges that her study was not a fair test rather; her study was a comparative in nature. Selena shows critical thinking and metacognition in this example.

8. Summary. The ability to apply reflective practices added to the girls experience as they learned ecology, as they learned science practices in general. Three girls indicated applying reflective practices: Angel, Issa, and Selena. Being able to identify what they know, what they need to know, and how to research what they want to know are lifelong skills that students, such as Angel, saw as imperative in their future. Issa learned that being reflective can lead to action. Issa decided to take a stand and write a letter that provided a

compelling argument for the girls to have an overnight experience at the PLC. Selena recognized that there are multiple ways of knowing and multiple processes that scientists use to do investigations. Ultimately, applying reflective practices will help the girls in any path they choose.

Understanding Science Identity Formation as an Integrated Process — Building Science Confidence

> Q3 How did girls' science identities emerge or change over the course of the program? In what ways did being part of a "system" help or hinder the girls' science identity formation?

Over the course of the program, the participants had experiences that helped them enter a community of science, become part of that community, and embrace identities where they saw themselves as scientists. While many of the 13 themes can also be included in to address this question, the five themes that will be presented include: 1) entering a science community, 2) joining a science community, 3) creating science identities, 4) how others view me and 5) my interest in science was maintained or ignited. A representation of each girl's social system and how they interacted with the ecological system will also be depicted in this section.

9. Entering a science community. Peripheral refers to a girl being "on the skirts" as opposed to being a "central" member in an experience. This is when the girls participated in science practices, talked about the experience as something they yearned to do, but did not take an active or central role in the experience. The whole group did an icebreaker activity during year 4. The girls were provided with a box of prototypical science tools and equipment. They were

asked to select a team member that would represent their “model of a scientist.” The directions were explicit in saying that they could use the props if the wanted to, but it was not mandatory. All of the teams dressed their scientist with lab coats, eye protection, and made the “models” look like males using props such as hats, as evidenced in figure 5, or had crazy hair.

Figure 5. From peripheral to central participants in a science community. The dress-a-scientist activity showed the girls perceptions of what a scientist should look like: a lab-coat wearing, male with crazy hair. By the end of the program, many of the participants embraced a central role where the girls were the experts. They moved from perceiving science as something “others” do, not people who look like me to, “I feel like a scientist when I’m out in the field.” (Selena)

The girls demonstrated shifts in their perceptions of who does science and what “doing science means.” Figure 5 shows pictures of the “Dress like a scientist” experience. The shift by the end of the program showed that the girls themselves are the practicing junior scientists and they do not look like the prototypical male, crazy haired scientist wearing a lab coat. The experiences

during *El Espejo* challenged the girls to move beyond the lab-wearing, crazy hair and goggles idea of a scientist typical of the Draw-A-Scientist Test (Steinke et al., 2007).This realization had huge impacts on their identity as scientists. Throughout the week, there were other examples of participants feeling or being part of the outskirts rather than being central participants in the experiences.

Lilly. Lilly was really interested and captivated by other girls' questions. Lilly was a peripheral participant in those instances, “Well other people were investigating, like there’s this person investigating different types of rocks and I think that was kind of cool because no one really pays attention to rocks so I wanted to do that but I just got stuck with the grasshoppers.” Lilly perceived herself to be on the outskirts because she realized that studying rocks seemed more interesting than her project on grasshopper behavior. If she participates in the program again, she will have a better idea of the possibility of developing a project that truly captures her attention instead of being “Stuck with the grasshoppers.”

Another example of Lilly standing at the periphery was when she expressed a yearning to try something new next year. She saw herself looking in and admiring what Laura, the chiropterologist studied. Next year “I would want to do, to try…well when Laura came to tell us about the devices that she used for the bats I really want to use it and know more about how the bats, where they live and what they get around that area to eat.” Even though Lilly is standing in the periphery of this potential opportunity, she is looking forward to having Laura come back with her equipment to capture and study bats at the PLC.

Issa. In science class at her home school, Issa sees herself as a peripheral participant of science, "When you're inside a class you're just sitting down and the teacher just keeps talking. In *El Espejo* it's different because you go outside and talk about things and it's different than class." In class, science is something others do or others talk about. Issa does not see herself taking on a central role in her science class, but in *El Espejo*, it’s different. She feels like a scientist, "It makes me feel like that because you're going outside and doing different things and seeing what they do."

Selena. Selena’s dual identity mentioned earlier is also an example of peripheral participation. Depending on the time and place Selena can either be a participant or be an outsider. When Selena is at home, she sees herself as an outsider (see Figure 6).

> Researcher: Do you see yourself as a person who does and enjoys science?
>
> Selena: It’s off and on, like when I’m at *El Espejo* I do see myself a little bit more than I do now because I’m not doing anything and I’m not sure.
>
> Researcher: Do you enjoy doing science?
>
> Selena: I do if there is an interaction with what you’re doing and I do if it’s a topic I like or something.

When Selena is at *El Espejo*, she takes on the role of a peripheral member and if she really enjoys what she’s doing, this role becomes central in her experience (Lave & Wenger, 1991; Tan & Barton, 2008).

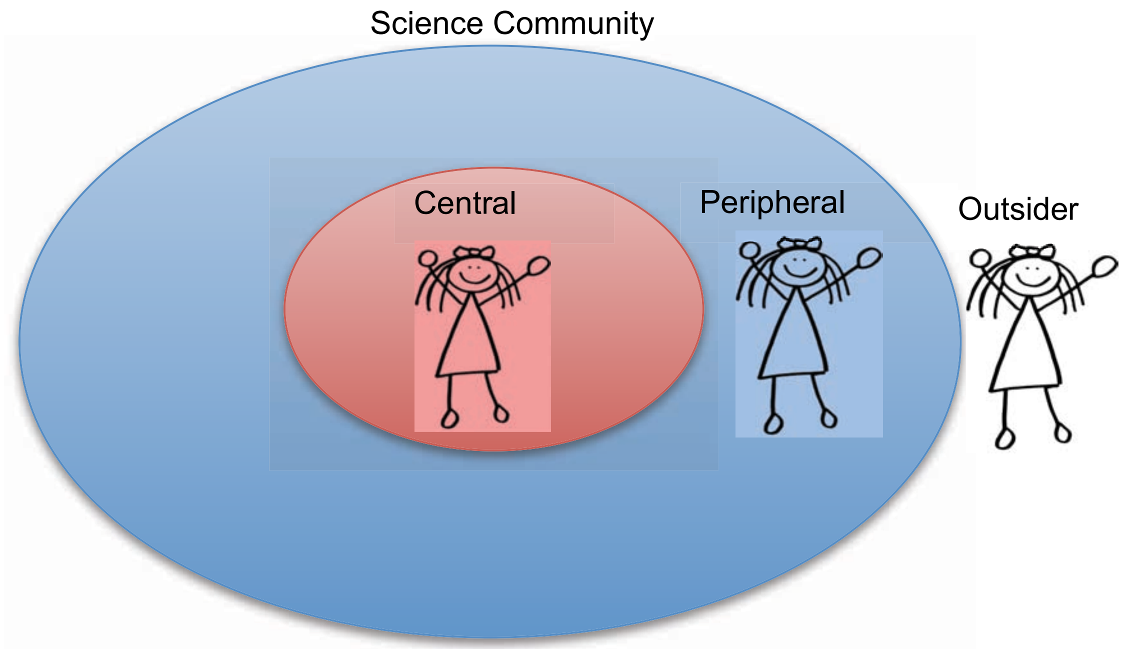

Figure 6. Roles in science community. Participants began as outsiders entering a new community and moved into the periphery or to a central role within the community.

Selena took on the role of a central participant when she took the risk of conducting her own study. She had worked with her cousin in previous years, but this year, they decided to part ways and do individual projects, “For me, mine was an individual project, so it was a new experience to do it by myself instead of with someone else.” Moving from an area of comfort where her cousin was there to help her and taking the risk of doing her own project created a space for Selena to study something new. She opted to continue working on insects, her topic of interest for the past three years.

Valeria. Valeria did not demonstrate a high confidence in her ability to do science so she saw herself at the periphery in terms of her ability to pursue science as a career as evidenced by the following statement, “*Si un poco nomas*

que necesito estudiar más para poder ser una buena scientist *y poder enseñar muy muy [sic] bien.* [Yes, a little, but I need to study more to be a good scientist and to be able to teach very very well.]" Valeria feels learning more science will help her feel more confident so someday Valeria can help kids learn science "Yo *iba a aprender más y [espero] que algún día podría enseñar a niños lo que yo aprendí ahí*. [I came to learn more and I hope that someday I can teach kids what I learned there]." The potential she sees to enter this central role is important, but her confidence in science has to increase to make this a reality. Valeria perceives she needs to "*participar, colaborar y echarle todas las ganas para aprender más* [participate, collaborate, and give it all she's got to learn more]." This notion of "*ganas*" or "will-power" is how Valeria plants to become the science teacher she dreams of being.

9. Summary. Four girls, Lilly, Issa, Selena, and Valeria, provide examples of peripheral participation of the girls in this science community. All of the participants decided at some point that they wanted to enter this community of science, but not all stayed or fully joined the community. We had one participant who came the third day and did not return after that. The participants who took the risk of entering this community came with preconceived notions of what it meant to be a scientist, as evidenced by the "Dress-a-scientist" activity. The girls stood at the periphery in some instances, yearning to experience what it would be like to catch bats, like Lilly mentions, or when she was curious to learn about what other girls were doing and thought their projects were much more interesting. Issa mentions how entering this science community gives her an

experience so different than her school science experience. For Selena, having this science community was critical. This was the only place where she felt she could be a scientist. For some participants, entering the community of science happened right away; it took a couple of days for many of the participants to actually join this community to the point where they were fully immersed in the experience.

10. Joining a science community. Participants noted a meaningful connection to the *El Espejo* community. This theme included certain instances when the girls felt part of this group because they shared a common vision or a common goal for learning. This exemplified being members of a science community.

Angel. Angel felt part of this community we call *El Espejo.* When Angel was asked about what she did during the week, she always spoke of "we" and of the importance of working closely with her team. Angel put herself in the moment, in the situation as evidenced in her long description of the program earlier in this chapter. Angel describes her participation when designing her study, “We recorded them [bird calls] through this website about birds off my phone and then we would replay them out there and it seemed to be the actual real call…We tried doing a bird call by ourselves.” Angel’s engagement showed that she was an active participant in her learning and also being a participant in her science community. Figure 7 represents Angel’s system in this community of science.

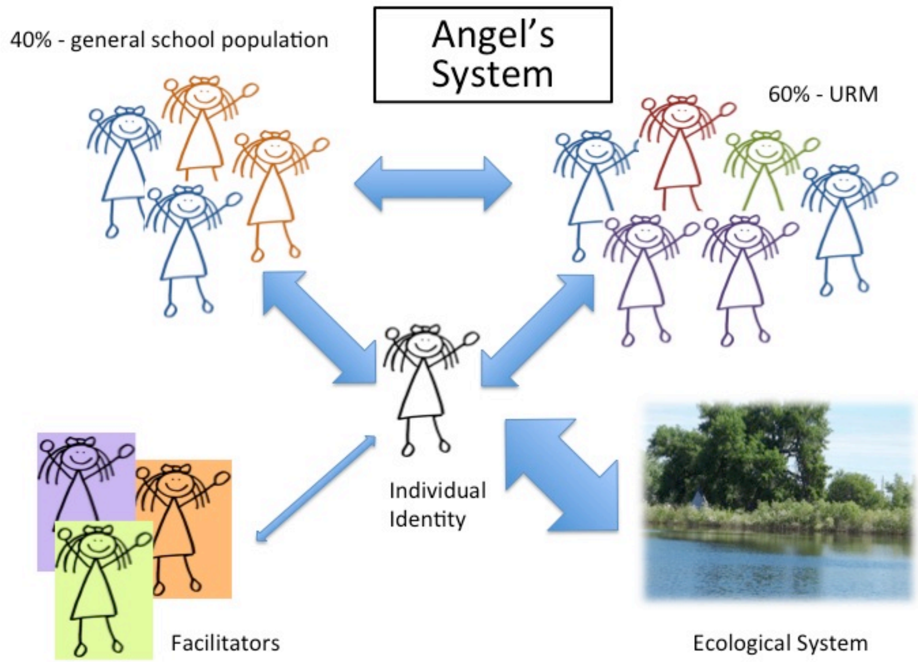

Figure 7. Diagram representing Angel's system as part of this experience. Interactions with all participants were evident and respect for diversity of participants was evident in her experience. Science confidence and experience of place make the arrow leading to ecological system wide. Angel did not interact with facilitators in a way that had a huge effect on her experience.

Angel's team did their study on bird calls. They were using different birdcalls to see if birds responded to different calls. With her team, Angel mentions that they tried doing a birdcall by themselves. Angel is moving to a new level of exploration Her team had a recording but now they are working together to create a new one as a team. Angel exemplifies team cohesion and how the team came together to figure out new ways to collect data to answer questions that emerged as they tried new procedures in the field. Angel saw herself as a critical component, or member of this team of scientists.

Angel also felt she was not alone in her team, “Yeah, Mayra [another student] she helped me to understand different things that I didn’t understand, that I didn’t know.” Angel was saying that there was somebody there who did not just leave her to fend for herself, as an outsider. Angel was actually saying that another participant was willing to help her get to where she needed to be. This created a community where she was welcomed and where she belonged as a learner and a participant.

Angel also recognized that learning from other girls was equally important. During the interview the researcher asked her what Angel thought about having girls from diverse backgrounds in the program. Angel responded:

> Researcher: What did you think about having other girls who were from diverse backgrounds in the program?
>
> Angel: that you’re not the only one who cares about certain stuff and you’re not different from anybody else they’re just like you but from different backgrounds and they do experience different things.

These cultural interactions shaped her identity as a member of this science community. This was a place where girls from all walks of life were welcomed. Angel recognizes that even though the girls may look different, there are shared experiences that connect them to one another.

Maya. Maya created a community that welcomed all students no matter what their English ability was. Maya shares that she would tell other girls who wanted to participate in future programs that they can be part of a community that is welcoming, “I would tell them that it’s really fun and it helps them learn and they can be part of something that they can never imagine if they just put their

heart into it”. Maya is a part of this community of science (Figure 8). Maya wants to tell other girls that they are welcomed in this community. Maya also talks about her leadership skills in the program and how she helped other kids with their project.

Maya had opportunities to lead. Her ability to help other kids created a community where people help each other to do science as evidenced by the following quote:

> I had the ability to help other kids with their projects…I felt responsible because I was helping other kids that didn’t know English and I helped translate and, well they did know English but they didn’t know that well so I helped some girls and we just became friends.

When Maya was caught up she was also able to get help from other people. In this community Maya felt she could ask for help if she needed to, “most of the people helped me gather the materials and they helped me go set out and helped me collect my notes.”

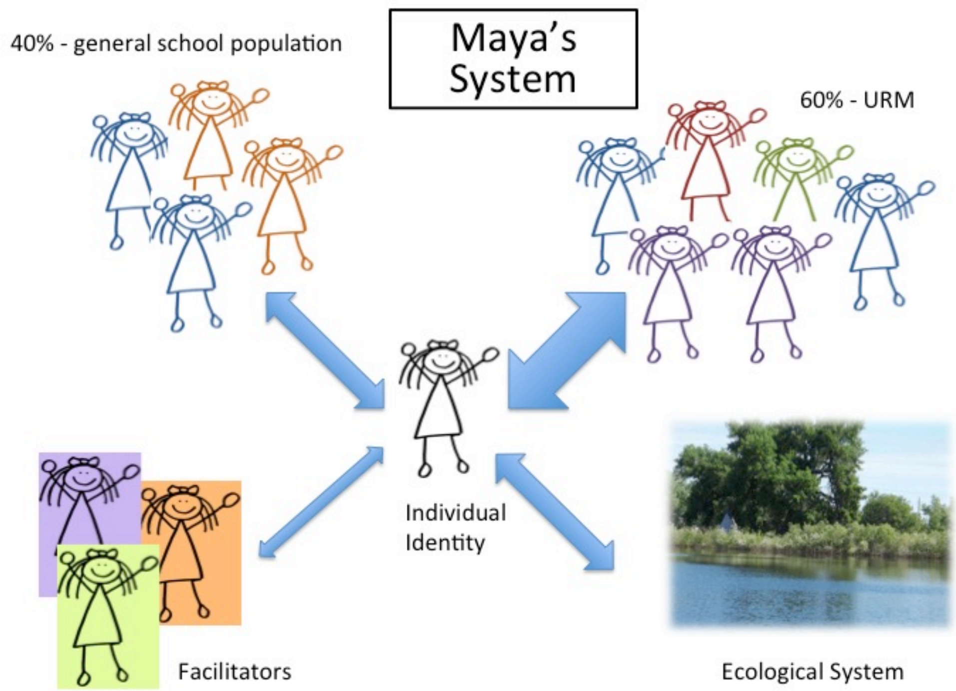

Figure 8. Diagram representing Maya's system as part of the program intervention. Interactions with participants who needed her help and support were more evident than with participants fluent in English. Science confidence and experience of place make the arrow leading to ecological system wide. Maya did not interact with facilitators in a way that had a huge effect on her experience.

Winter. This idea of community was exemplified in the leadership skills Winter was able to apply, "I got to show other girls things that I had strengthened as well as people got to show me, it was teamwork, but at one point or another everyone was leading the group." Being able to apply leadership skills such as showing new girls skills that Winter had learned and strengthen over the years as well as opportunities for other girls to show her new things were important for Winter's system. Winter said at one point or another everyone had the opportunity to lead the group. That was a neat opportunity to say that I wasn't the sole leader, it was a matter of seeing what everybody's strengths were and how

those came out at different times and at different places. One of her roles was as a veteran participant, an expert as evidenced when she explains her greatest strength as a participant in the program: "probably things like explaining things that in a way that people can understand and showing them that everything, you can put it down to simple steps, which make it a lot easier." Winter explained how things worked and simplified things for people in her group to be able to follow easily.

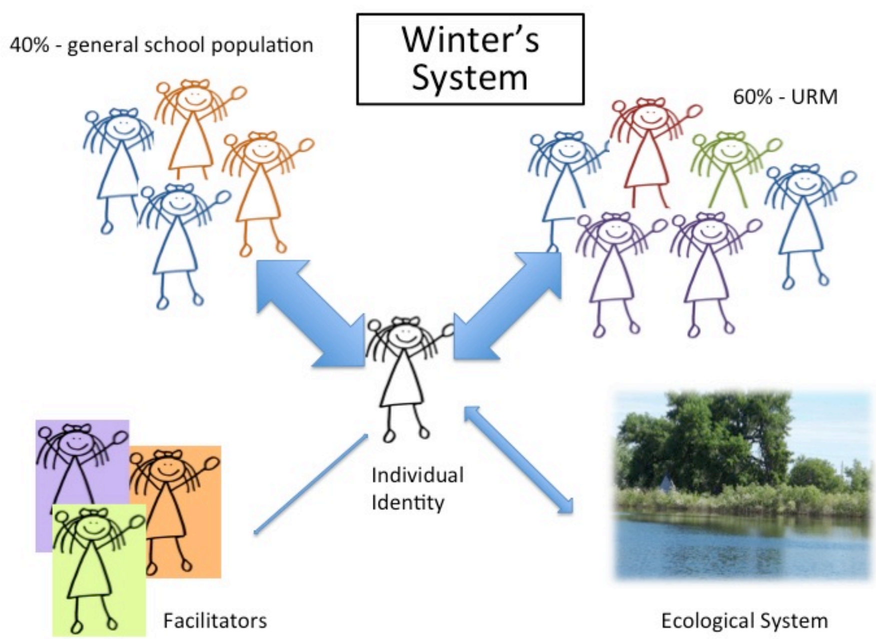

Figure 9. Diagram representing Winter's system as part of this experience. Interactions with all participants were dominant in the experience. She exhibits some content knowledge and has a difficult time getting along with the facilitators. Winter did not interact with facilitators in a way that had an effect on her experience.

When we asked about why she kept coming back, Winter reiterated that the program was a lot of fun so this community that she joined was a lot of fun

and she looked forward to learning about new things. Winter's system is dominated by the interactions between the participants (Figure 9). While she saw science as being an important component in her future endeavors, she came back year after year because she enjoyed meeting new girls.

Winter's system included constant struggle with the facilitators. She did not feel she had a good working relationship with the facilitators because she felt a disconnect or felt the need to rebel against authority figures. In her words, "They [the facilitators] were always trying to get me in trouble." Winter and Selena2 were the two participants that posed the greatest challenge for facilitators because the girls wanted to explore on their own terms. This was a learning experience for facilitators who were used to telling students exactly what to do. This direct method of instruction did not work for Winter and Selena2 because they did not want to be told what to do. Winter and Selena2 benefited from the learner-centered model even though this took away a lot of power from the adults. The limit to the learner-centered approach came with the girls' inability to listen to suggestions or when there were opportunities to learn concepts in-depth rather than superficially. Winter had the potential to investigate concepts more in-depth but felt she was "done" after she collected her data and drew her conclusions. There was no intrinsic motivation to find out more about the topic she was studying.

Lilly. Lilly felt her immersion into a community of science when she sees herself as an important member who can help other girls collect data to make progress on their projects, "Some of my friends were studying other bugs so we

helped each other to help them catch them so we could have fun together catching the bugs." Lilly not only worked on her own project, but she also was a part of this larger community where people helped each other complete the project within the given time frame. Figure 10 shows the interactions occurring in Lilly's system between the girls, the facilitators and the ecological systems. The thickness of the arrows depicts the strength of the relationships.

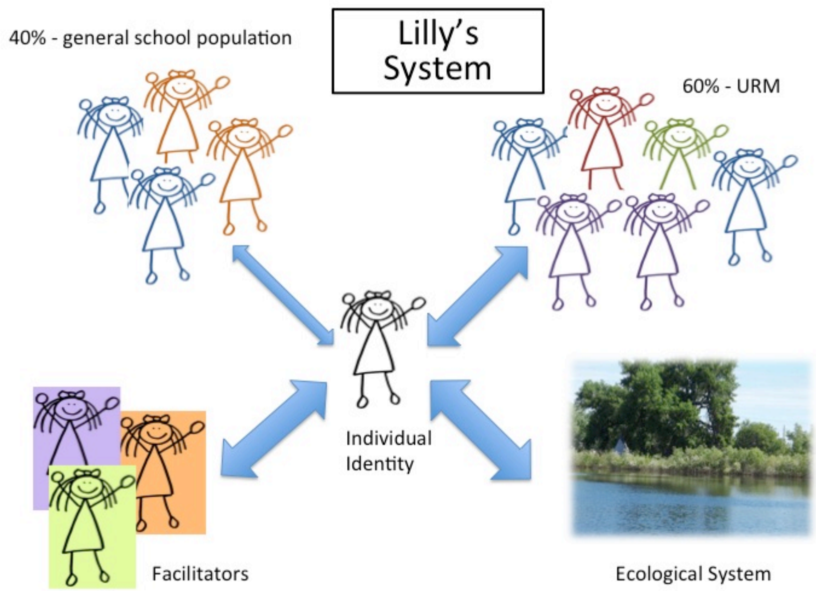

Figure 10. Diagram representing Lilly's system as part of this experience. Interactions with all participants were evident in Lilly's system and leaned more towards friendships with girls, who were of similar background, especially girls who attended her same school. Lilly showed confidence in her science ability and interacted well with facilitators.

Lilly's ecological system exhibited a strong connection because she felt that learning outdoors was important for her, "To learn more about nature and the outdoors and see… to discover what's out there to discover and pay attention that what might you not see and it's there [but you may not see it with the

unaided eye].” Gaining a deep appreciation for this place required a close look for Lilly, not simply a superficial glance to learn more about the system she was seeing. The ecological system contributed to Lilly’s sense of place, which was something that was important for her system.

Issa. Issa felt like she was part of a community where she got to do activities that were not typically done in her school science class. This experience, “It’s different because you’re inside a class just sitting down and the teacher just keeps talking and the one in *El Espejo* is different because you go outside and talk about things—that’s different than class.” This community included a venue for her to experience a strong connection to the outdoors, to the environment.

When the program was denied the permit to camp out, Issa’s letter to the school board started by saying "Us *El Espejo* need to camp out because many of us have never experienced what it's like." Our community needs to have this experience. Only Issa and Valeria expressed the need for the community to have an experience that has not been afforded to them yet. The letter showed unity in terms of understanding what it means for the whole rather than just for her.

For Issa’s experience, having facilitators who could help her was a critical component of her system (Figure 10), “They would show me examples about the questions, like examples [of what she could do].” Issa had a strong connection to the facilitators, to the site and to the girls in the program. The friends she made also played an important role, “Yeah, like the friends that help you out and the groups,” were seen as important components of Issa’s system.

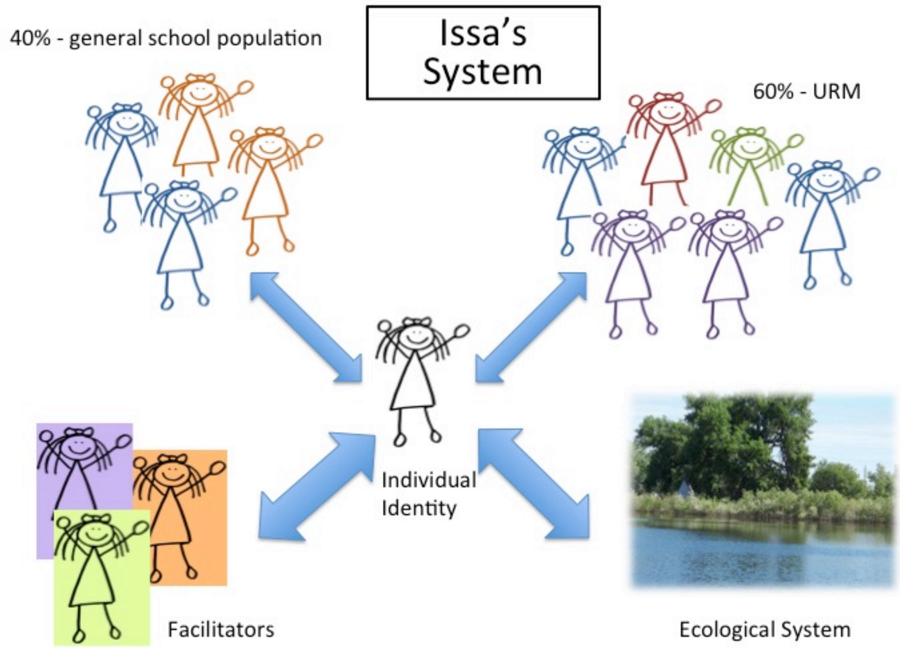

Figure 11. Diagram representing Issa's system as part of this experience. Interactions with the facilitators and the ecological system were strong. Issa expressed her interaction with the other girls as being important, but chose to work by herself every year.

Selena. Selena also talked about her cousin being part of the community as an important component for her system. Selena says Selena looks forward to meeting new girls but Selena also liked having someone there that Selena knew. Even if they are part of this larger community they can still be individuals in this larger community. Selena shares she enjoyed meeting new girls and being with her cousin:

> Selena: Mostly meeting new girls and doing it with my cousin, because she's done it with me like 4 times.
>
> V- but this year was the first year you two were separated you know for the most part in your own projects, what did you think about that?

> S- I was like oh we're going to have so much fun we're gonna do it together and then I was like ok I'm doing this and she was like oh I'm doing this so I was like ok.

Selena was able to interact with new girls and worked with facilitators when necessary, but the largest connection she had was to the place, the ecological systems at the PLC (Figure 11). She felt like a scientist out there, but nowhere else:

> It's funny because when I'm not there I wouldn't see myself as a scientist but when I am there it's like I can see myself being one. You know I research bugs the whole time I was there and I didn't like bugs at all but when I'm there it doesn't matter. I don't know why but it switches around.

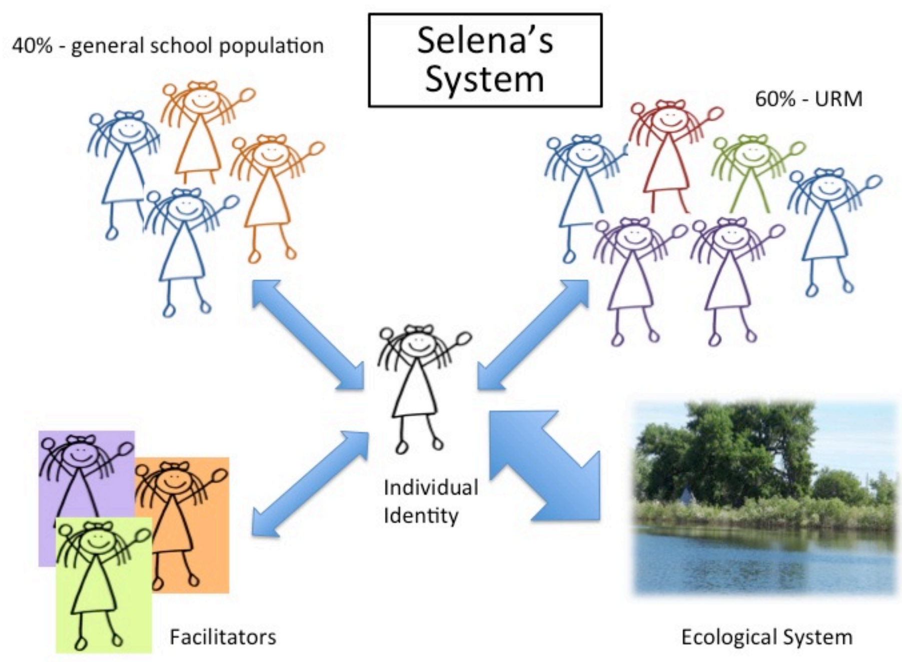

Figure 12. Diagram representing Selena's system as part of this experience. Interactions with all participants were evident. There was a strong connection to the ecological system when she was at the site, but not when she was away from the site.

Selena felt it was very important for her to be able to go outside to do science. This idea of moving away from just reading about science but actually experiencing science in a different way was important especially because being out at the PLC was the only place where she felt like a scientist. The thickness of the arrow connecting Selena to the ecological system is important because this is the only place where Selena feels like a scientists; therefore, it is important to keep exposing her to this place.

Valeria. Valeria felt Valeria belonged to a community that was accepting of who Valeria was as a person, as a Spanish speaker, and as an emerging English speaker. Figure 12 shows Valeria's system. Valeria felt she had the right support to be successful and missed the support during the school year, "*me hizo mucha falta* [I missed the program]." Valeria felt well supported during the program. At the same time, Valeria recognized that she does not have that support in her every day school classroom and feels she would learn a lot more.

Valeria wrote the following letter to the school board after we were denied permission to camp overnight at the PLC:

> Dear Board of Education,
> We would like to tell [you about] the importance of having overnight camping on the *El Espejo* Project.
> We would like to experience over night research to learn more about outdoor activities.
> I never experienced to sleep in a tent or a sleeping bag.
> I never seen an eagle in he's natural habitat.
> I hope you can at least listen to us.
> Thank you,
>
> Valeria

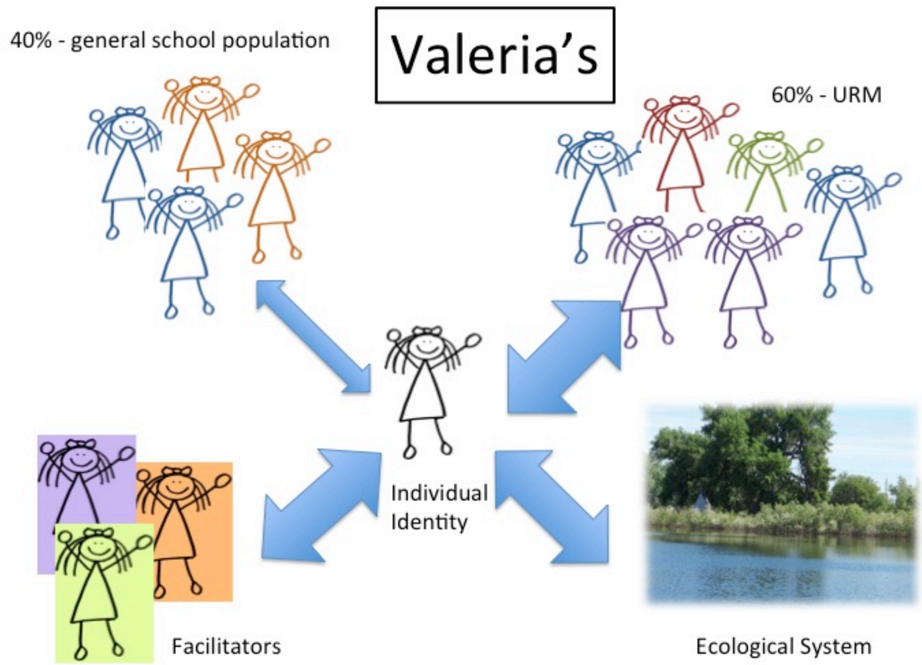

Figure 13. Diagram representing Valeria's system as part of this experience. Interactions with facilitators were extremely important for Valeria's system. Although Valeria's science competence and confidence were limited, Valeria felt a deep connection to the place and looked forward to learning more about organisms at the site and looks forward to the opportunity to camp and sleep in a tent.

Valeria talks about the needs of her community of science in her letter by explicitly stating the need to be outdoors. In our community, we would like to be able to learn these things. Then, Valeria addressed her personal needs and how she's never camped out before. Asking the board for that opportunity was an empowerment piece for Valeria. She learned that she has to be an advocate for her needs and the needs of her community. Valeria was able to convey her message to let the school board know that these experiences are important for girls like her who have not been exposed to such opportunities. She conveys the message that this would be an opportunity for her to learn more about this place

to deepen her connection to the site and to experience something she has not experienced yet, camping out, and sleeping in a tent.

Selena2. The *El Espejo* community was a community where Selena2 made a lot of friends. Selena2 was an active participant in this community. Like Winter, Selena2's motivation to return year after year was to meet new girls and build new friendships with girls who had similar science interests. Figure 14 shows the strong relationship Selena2 had with the girls and the ecological system and a weak relationship with the facilitators, whom she perceived as adversaries.

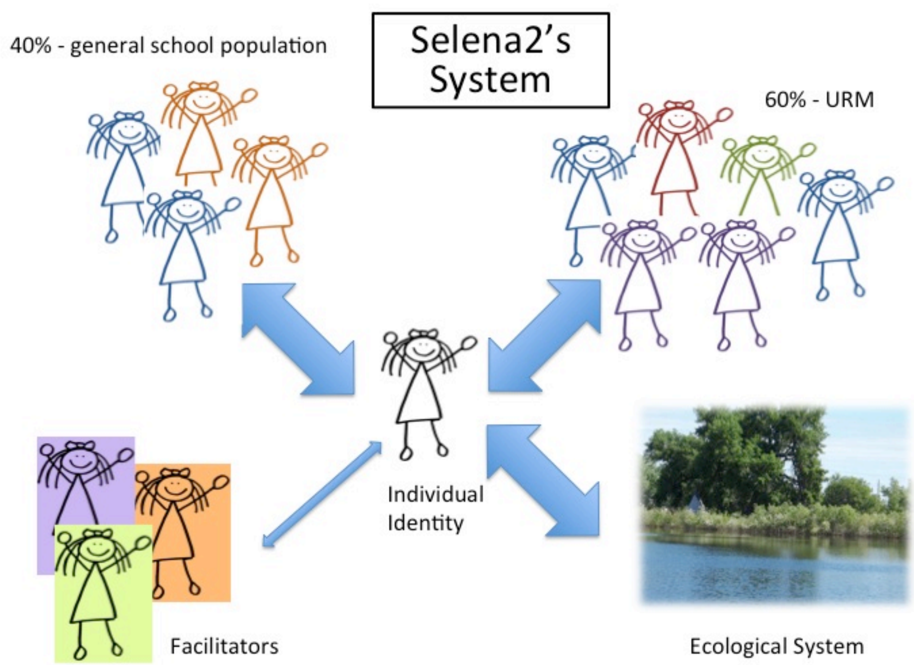

Figure 14. Diagram representing Selena2's system as part of this experience. Interactions with all participants were especially important for Selena2, while interactions with facilitators were adversarial.

Selena2 felt "Sharing your ideas not just keeping it to yourself" was an important component in her system. That was something that was a defining

characteristic of this community of science where people help each other out rather than compete. For Selena2, it was important to have an audience who was willing to listen to her stories and what she was learning. This validated her experience as something that was important not just to her, but to her peer group as well.

10. Summary. All eight girls showed varying degrees of joining the *El Espejo* science community. Angel's close involvement with her team exemplified the unity she experienced as she joined this community of science. Maya's full immersion came as she helped girls access the experience fully. Maya served as a helper and in turn, she became more immersed in the experience because now, it was not just her experience, but two other girls' experience that were meaningful and part of this community of science. For Winter and Selena2, having the social component made all the difference for her immersion in this community. Lilly, like Maya, took on a leadership role to help other members of this community fully access the experience. Lilly helped her peers collect data and get them up to speed so all of them could succeed together. Issa gained tools of empowerment as she immersed herself in this community. Issa no longer saw issues that were relevant to her experience as issues that only pertained to her, but such issues now pertained to the entire community. She became an advocate for students who have been deprived of opportunities such as camping out and studying about nature at all hours of the day. For Selena, being at the PLC was reason enough to join this community of science. This was the only place she felt like a scientist. Finally, for Valeria, joining this community was

important in recognizing and valuing who she is as a person, as an English language learner, and as a future science teacher.

11. Creating science identities. This theme refers to when the girls alluded to feeling like a scientist or embracing a science identity where they saw science and a part of who they are as individuals. For example, taking on the role of scientists in action collecting data or putting protocols into action and saying they felt like scientists in the process. They were doing science first-hand, getting involved and becoming one with the experience.

This theme was also informed by the attitudes and perceptions towards science instrument data. The items were analyzed under the assumption that they were all one construct: perception of science. However, the items may have been getting at multiple constructs. The researcher wanted to see the reliability of this instrument given this particular sample. This analysis was conducted post-hoc so there was no opportunity to modify or improve the items. Even with the reverse coding, the reliability of the instrument for this tool was low with a Cronbach's alpha of 0.446. For future work an exploratory factor analysis would help determine how many factors should be added to the broader category of perceptions. The biggest limitation towards any type of modification was the small sample size of 26 students who completed both pre and post surveys.

Table 10 lists the seven items that were deleted because they were redundant. After removing these items, the reliability was still low. This means that using these items poses a limitation for this particular sample. With this limitation in mind, The researcher conducted a Wilcoxon test, which evaluated

the difference between medians for pre-test and post-test for attitudes and perceptions instrument (Green & Salkind, 2008). The results indicated no significant difference, *z= -2.707, p<.05* in scores from pre to post-test. Based on these findings, the intervention did not have an impact on the outcome of the girls' attitudes and perceptions towards science form pre to post-test. Next steps for further develop and enhance this instrument are to cross validate it to see if it works for another sample or to increase the sample size, but this is beyond the scope of this dissertation. The sample that was tested was a small sample, which included at least two distinct subgroups: underrepresented students, and students not underrepresented in the sciences. The results could be different if the instrument was used to test another sample.

Table 10

Items Deleted Due to Redundancy with Already Existing Items

Deleted item due to redundancy	Item kept
I do not know how to design an experimental study.	I am able to design my own experimental study.
Other people do not see me as a science person.	Other people think of me as a science person.
I do not know how to design an experimental study.	I have confidence in my ability to learn to design an experiment.
Human actions do not impact nature.	Humans can have an impact on nature
I have not had good science teachers.	I have had at least one good science teacher.
I prefer not to read about science.	I enjoy reading about science.
Girls are not good at science.	Girls can do science.

The data from this instrument was used to get a qualitative picture of what the girls thought of themselves as scientists and their attitudes towards science and science activities. All the girls indicated a strong belief that “Girls can do science.” Survey items that had overall low rankings included, “I study about nature on my own,” and “My parents do not like science.” The item that talks about nature shows a positive shift in perception for most participants. This item would have to be further sampled with a larger participant population to demonstrate statistical significance.

Science identities were enhanced, and in some instances, discovered by the girls as they went through the program. Most girls came in with the notion that “Girls can do science,” but some girls did not see themselves as scientists until the experiences started bringing out attributes that constituted science practices and affirmations that they were capable of doing science. The perceptions of what it meant to “do science” or to “conduct scientific investigations” was also something that the girls found compelling since they realized that a lot of their natural curiosity is closely linked to the process of critical thinking and scientific inquiry.

Angel. Before attending the program, Angel did not acknowledge having a strong science identity, “Before I participated in the program I wasn’t a big fan about science but I liked it a lot and then when I started doing *El Espejo* I thought, ‘Oh! Science could be really really [*sic*] fun and it doesn’t have to be boring.’” This evidence supports that Angel was curious and interested in the science because now she sees that science can be something she enjoys rather

than being boring. Angel came in with a perception that this could be interesting so she was open to the experience. This positive attitude opened up the opportunity for her to experience opportunities that she normally would not be exposed to her in everyday life.

On her program application, Angel wrote that she wanted to participate in the program because, “I want to be a doctor because I wants to learn about orginizems [*sic*].” When asked after the program what type of scientist she would be if she could become one Angel does not mention being a doctor, but she claimed she wanted to be a scientist who studies rocks, igneous rocks. There are several science identities that Angel can relate to or that she finds intriguing. She saw herself as a doctor before participating in the program “I want to be a doctor so I can learn about orginizems [*sic*].” Her career options were limited to becoming a doctor. In her post-interview she shares that she also wants to study how science and things work in the world. Angel saw herself as a geologist after participating in the program. Her interest in rocks emerged from the experience as a career path that was possible for her. Angel felt an increased confidence in sharing that she wanted to pursue a career that is not common when people talk about future careers, with doctors, teachers, lawyers being very common answers.

When Angel talked about the experience with the speakers she thought “Both [men and women are important to have as speakers] to show that men do it [study science] but women can also do it [study science].” She learned that “science careers are really different” and now wants to be “a scientist who

studies igneous rocks because rocks are pretty cool how you could find a rock that's really, really [sic]] smooth and tell the difference and how it formed and see like do projects with rocks." Even though we did not learn about rocks explicitly during the program, Angel felt she was able to express a different desire that may have been perceived as strange in another setting. Her confidence in sharing what she truly loves emerged from her participation in this program. Angel is aware that there is an opportunity to be a scientist if she wants to but she is not sure yet. Angel has multiple science identities and different ones come to the forefront based on the setting or the experience.

Maya. Maya gained tools of empowerment when she conducted her own project. This experience being different than school learning was expressed when she said, "I can do the project. It's different because I can gather materials by myself and I can explore when nobody else is around me and I can use what I need, like materials and those things." She was able to conduct her project out in the field where she could explore and nobody else was around her. Experiencing this opportunity was empowering for her. Maya did not feel as if people were watching her and being judgmental. Maya felt she could go out there and do her thing, even though there were plenty of people around her all the time.

Maya had the ability to be a scientist out in the field and did not feel others were judging her. Maya learned, "We can do anything! We could be scientists, archeologists and a lot of other things". Being out in the field made her feel like "I can do something, I can make something, I don't know how to explain it, but I can

make the world, I can be part of the world, I can change the world." Maya wants to be a nurse because she wants to help people. Maya's sense of identity includes doing something good for the world and she sees science as being part of that picture. Maya is the scientist who wants to do "good" for the world.

Issa. Issa showed an appreciation for science initially and the program reinforced her original science identity. Consistently for three years, Issa has shared through her science journal, and interview that she wants to be "a doctor or a pharmacist doctor - like the plants, what kind of plants we can use as medicine, a pharmacist or a scientist." On her year 1 application, Issa shared, "I like science because I like learning about plants…I also [want] to learn more about nature. I think animals and plants are very interesting."

Issa was one of the students who participated multiple years. This past summer was her third year participating in the program. Issa started the program as a fourth grader. Issa felt that *El Espejo* helped foster the idea that science is something she can use in her everyday life and science is a career that Issa can pursue and has expressed multiple ideas on what she could possibly do as evidenced by the first quote in this Issa section. Her first year, as a fourth grader, she questioned if there were "things" inside plants that she could take out and do something with. Her first year project "was about getting a piece of cloth and seeing if the plants would stain the cloth, rot, or if they would disappear." Issa gathered various plants from the PLC, and she brought in strawberries, blueberries and blackberries from home. She extracted the pigments from the various plants and tested which of the plants could stain the fabric best. As a

fourth grader, she realized there were "things" inside plants that she could extract and use. Combining the research aspect with the medical aspect was an interesting realization for Issa.

Issa was able to experience how research could inform a career that she was already curious about. Her science identity included a curiosity to find more about how plants can help in drug development; however, her insecurity "I think" was evident in various places. When she completed the pre-post science perceptions survey, she wrote on the margins "I think" when responding to the four-item Likert-scale survey item that stated, "I see myself as a scientist." She also wrote on the margins she, "Doesn't really ask questions" and wrote, "kinda" next to the statement "I believe everything my teacher says." Issa does not have the confidence to question what her teacher says, but during *El Espejo* Issa was able to ask all sorts of questions. Issa's self-doubt hinders her ability to see science as something she is good at and to see science as a discipline where she could make a contribution.

Selena. Selena only felt like a scientist and her science identity truly came out when Selena was out at the PLC during *El Espejo*. This experience is unique to her:

> It's funny because when I'm not there, I wouldn't see myself as a scientist, but when I am there it's like I can see myself being one. You know I research bugs the whole time I was there and I didn't like bugs at all, but when I'm there it doesn't matter. I don't know why, but it switches around.

Selena talks about this split identity that her physically positioning herself at the PLC gives her an identity that she normally doesn't relate to outside of that

place. No other participant expressed an experience like Selena's. Selena expands on how she sees herself as a science person when Selena's at the *El Espejo* compared to when Selena's at home not doing anything. Selena feels she needs to be out there doing science in order for that identity to come to the forefront.

Valeria. Valeria came into the program knowing that she wants to be a teacher. From year 1 to year 2 Valeria solidified her goal of becoming a teacher, but specifically a science teacher for English Language Learners. She feels that kids who don't speak English yet have the potential to learn science and learn English too. Valeria was really excited to be able to prepare so she could do that someday. Her science identity became that of a future science teacher.

11. Summary. Science identity formation was a manifestation of several components working with one another or against one another, but as part of a larger system nonetheless. The social system that made up the girls' experiences played a pivotal role in their desire to take part in science experiences. The social system also included how others viewed the girls or how the girls *perceived* that others viewed them. Five girls from the eight interviewed demonstrated behaviors consistent with identifying with a "science identity."

12. How others view me. This theme captured experiences that relate to how other people perceived the participant when it came to the participant's ability or desire to do science. For example, did the participant exhibit behaviors that are perceived to define the girl as someone who enjoys science, or someone who is good at science? If the participant made comments such as "My friends

say I’m a science person because I like to ask questions.” Or “my parents think I can be a scientist” were included in this theme.

Angel. Angel talks about her parents seeing her as a person who enjoys science. My parents and teachers at school see me as somebody who studies science. Angel likes to try different things. Others recognize that there is something about her that attracts her to do science.

Winter. Other people perceived Winter as a challenging student. Winter did not come across that way on her interview. Winter comes across as someone who has an interest in science, but she struggles with this identity because other people do not see her as having a science identity. Winter was labeled "rebellious" by many of the adults. The program coordinator documented several instances where facilitators complained that Winter and Selena2 were being disruptive or not engaged in learning. The facilitators felt there was no way that Winter could be learning because of the way she behaved. Her behavior did not fit the adults’ perception of what an “engaged” child looks and acts like. Her behavior also took away from other people's ability to see her as someone who enjoyed science. Winter was perceived as being someone who was distracting for the other participants rather than somebody who had something to contribute. Winter did not fit typical engaged student profile. The bias of the adults in the program of what an engaged child looks like (i.e. pays attention, writes notes, doesn’t challenge authority) perhaps influence this potential for Winter to see and embrace her science identity. From her interview Winter expresses she was actually very engaged and was really excited about the program. The program

coordinator documented 10 instances in her field notes over a three summers where she had to speak to Winter for complaints from Winter "throwing things" to "horsing around." Winter's engagement was documented in photographs where she is seen collecting data out in the middle of the wetlands using technology to measure the differences in temperature, dissolved oxygen, and pH. Winter's poster presentation included all the data she and her team collected, the differences she found between the sites she studied. Winter was eager to share her results with the community: This was a clear sign of engagement.

Lilly. The teacher that recommended Lilly definitely perceived Lilly as a student with potential. Her teacher recommended her because she believed "Lilly is someone who can benefit from this experience" (L. Perrich, personal communication, May 4, 2012). In her interview, Lilly shared, "They always say I'm really smart and I'm always good at math and science so they always encourage me to do it and keep going." Teachers like Mrs. P reinforce this by recommending her for opportunities such as this program or by reiterating that Lilly can do it and by providing support in any way they can to foster her interest in mathematics and science.

Selena2. Selena2 perceives that others do not view her as someone who does science and documented this in her survey, yet Selena2 knows that she wants to be a vet. Like Winter's experience, Selena2 felt that people may not have taken her seriously. The facilitators for example inadvertently may not have seen her as a person who enjoyed science because of her constant need for attention and need to respond to other girls who were distracting her.

When Selena2 was by herself, Selena2 would immerse herself the experience. The program coordinator documented her sitting in the field one day, taking notes and watching the prairie dogs. No one was around her and she was writing, drawing, and documenting everything she saw. When there were other girls who distracted her, she experienced nature in-depth so having Winter and other girls who pulled her attention may have deprived Selena's experience learning science.

12. Summary. The dichotomy in perception of how others viewed certain participants was evident. On one hand, girls such as Angel, and Lilly, were perceived to have potential in science because they are dedicated students who take things seriously. On the other hand, others perceived girls such as Winter and Selena2 as rebellious and unengaged. Four girls showed that how others perceived them affected what they thought of their own abilities which in turn translated to behaviors such as rebellion and aggression in Winter and Lilly. All girls, however, indicated a self-interest or curiosity towards science topics.

13. Interest in science maintained or ignited. This theme included findings that were relevant to exploring participants desire to learn about science or to continue learning about science. This refers to the girls saying things such as "I liked science before, but this program just made me love it even more" or "I didn't really like science before, but now I do." Relevant questions to this theme were: What characteristics of the intervention were necessary to engage the girls in the program? How did girls' science identities change over the course of the program?

Selena. Selena's interest in becoming a biological scientist was ignited by Dr. Susan Keenan, a biologist from the local university.

> Researcher: the questions that said if you wanted to become a scientist what type of scientist would you be and why? And you put "If I was a scientist I would be a biological scientist. This is because I want to study diseases like malaria and try to top them." Tell me more about where you learned that.
>
> Selena: I learned that from when we met the women. I'm not sure what her name was but she told us about malaria and how to stop it and that seemed interesting, I as interested in that and she just kept talking about it and I was like that's cool.
>
> Researcher: Do you remember what she said about it that you thought was cool?
>
> Selena: I was trying to see which, I knew what malaria was but I just didn't understand it. She told me it was the mosquitos' organisms that carry it and if they bite you like mosquitos do it would get into your system, you can die or get really sick or something and that seemed really cool that she was trying to figure out a way to stop it.

Selena's interest in learning something new that she thought was "cool" was important to ignite a new flame for potential learning. Selena is the student who felt like a scientist only when she was out at the PLC. Now that she has another potential interest perhaps learning more about a disease such as malaria could expand her opportunities in science so she can see herself in multiple science roles.

Multiple year participants began to ask questions based on prior observations of the study site. For example, Selena2 wondered, "What happened to the flood over the year?" The prior two years that she participated in the program, the site was flooded. The previous year, the flood came close to hitting

the 100-year mark. Selena2 was able to notice that this year, a year of drought, brought many consequences. She questioned, “Did the flood make the fish move?” The biodiversity at the site had been impacted. She sat for 10 minutes drawing the site in her notebook cautiously looking around, with awe at the lack of water compared to previous years. She noted how hard it was to find tadpoles this year when last year they were abundant. She reflected and documented the following question in her field notebook, “Did the humis [humans] have an impact on the flood?”

The speakers definitely ignited a passion for science in most of the girls. All of the girls interviewed mentioned the experience with the Laura and the Bats or Dr. Benedict, the ornithologists, as being memorable. Angel for example, learned that there are different jobs for scientists that they don't always have to involve chemicals and stuff like that. Angel definitely had a changed perception of science. Before Angel participated in the program she wasn't a big fan of science but she actually likes it a lot now. Science can be really fun and it does not have to be boring.

Lilly*.* Lilly definitely showed an interest in science. Her interest in learning more about bats shows that Lilly has gained a new interest in science. "I enjoyed learning about bats, and there are only a few bats that live here, they live in some trees in *El Espejo* (at the PLC)..." This idea that this is something that I never knew about and I still have questions I want to explore about shows an increased interest in science. “I usually don't like to talk about bats,” shared Lilly, but now she wants to take a risk to learn more about bats and looks forward to Laura’s

continued participation so she can learn more from her. This is something Lilly may have not considered where it not for this experience. Lilly expanded on her newly acquired fascination of bats. Lilly knew about mammals but did not know that bats were mammals. It provided a space for her to learn more about his topic. This was something that increased her interest in science.

Lilly talked about birds and how it was such a cool experience because she likes birds and she had never seen or used the equipment that the ornithologist brought:

> Lilly: we got use the equipment to hear birds and to see more louder and clearer and we rotated to another station where we could spot birds and try to look them up to see hat kind of bird it was.
>
> Researcher: Had you ever done anything like that?
>
> Lilly: No it was a very cool experience for me because I like birds but I had never did that so that was cool.

Lilly's interest in science was not only maintained, but it was also increased through the opportunities offered in the program. The speakers played an important role in her increased interest.

Issa. Issa came with an interest in science. Issa likes asking her own questions and finding out about organisms is conducive to how Issa learns. It sparks that flame, but that flame is slowly turned off during the school year. It needs to be re-ignited every year. It's going to be a challenge in keeping her long-lasting interest in science. The researcher had a personal conversation with her six months after the third year program and Issa talked about how science was so exciting at the beginning of the year in her regular school, but then science becomes boring throughout the year.

The way Issa enjoys learning is not seen as something that's valued in her class. The fact that Issa wants to ask her own questions is not something that is welcomed. The teacher may not know how to facilitate that. By the end of the year, Issa's still interested in science, but Issa's not engaged in science. Issa feels bored. *El Espejo* servers as a way to re-ignite her flame every year. The question is what will be of her when the program ends, when Issa is no longer able to participate? Issa’s interest in becoming a scientist doctor is consistent.

> Researcher: What do you want to be when you grow up?
>
> Issa: A doctor or a pharmacist doctor like the plants, what kind of plants we can use as medicine, a pharmacist or a scientist
>
> R: Do you think *El Espejo* helped you in deciding that?
>
> I: Yeah

Being a scientist is something Issa can do and wants to do, but she is not sure how she’s going to get there.

Valeria. The program increased her interest in science. Valeria really did not know what the program was about before coming. Valeria did not come with a preconceived idea that she would be learning science. Valeria was recruited through one of the outreach workers who help recent immigrants. We asked Mrs. Guzman to find families who had children who would want to participate in the program and Valeria was found that way. Her interest in science is now evident; as Valeria has identified that she Valeria now wants to be a science teacher for English language learners, not just any type of teacher, but a science teacher.

Valeria is looking forward to future *El Espejo* because she wants to learn more about science so she can teach other kids science in the future. This sense of longing for the program during the school year is also evidence that Valeria looks forward to participating in the program again because of the way it works and the support she is able to get from the program. Valeria talks about the need to study a little more to be able to learn more so she can teach science in the future. The program means a place where Valeria can participate, collaborate, and learn. She is determined to give her all to be able to learn more. We see an interest in her willingness to be part of the program because Valeria has an increased interest in learning science through this program.

Valeria also recognizes that this program helped her see that "you can study whatever you want and you can follow your dreams." This is something Valeria's learned from the different speakers and the different career professionals Valeria's met. If Valeria's exposed to science more, Valeria thinks she will be able to teach science better. Experiences are important for her to achieve this.

13. Summary. The girls’ interest in science was maintained or ignited through various experiences through the program. Three girls out of the eight interviewed felt that this program increased their interest in learning science. For Selena, meeting Dr. Keenan ignited an interest to learn more about malaria. Girls who visited the center multiple years started noticing variations in organisms which maintained or increased their interest in potential topics to be explored. Lilly was captivated by Laura’s bats and is looking forward to learning more about

these organisms in the future. Issa demonstrated a sustained interest in plants and shared, consistently, that she would like to pursue a career studying plants and medicine. Valeria's interest in becoming a teacher was maintained, but guided in a specific direction towards becoming a *science* teacher for English language learners.

Chapter Summary

This chapter presented the 13 themes that emerged from the data. Multiple themes helped inform each research question. Program attributes such as authentic experiences, opportunities to learn science practices, to learn science content, to be exposed to the outdoors created a venue for girls from underrepresented backgrounds to gain confidence and competence in science. Components that added to the creation of a science community helped the girls develop a science identity that helped maintain or ignite an interest in science. The girls' science competence was enhanced through the learning of ecology concepts, science protocols, and skills that they can use and apply in future opportunities.

CHAPTER V

CONCLUSIONS & IMPLICATIONS

This project explored the characteristics of an intervention that exposed middle schools girls to field research experience in a program called *El Espejo*, Spanish for “The Mirror.” The intervention affected the science competence and science confidence of middle school girls from marginalized backgrounds. There were two components to this dissertation: a pilot study and the main study guided by three research questions. The pilot study was motivated by the author’s intrinsic desire to find out why two Latina girls would want to pursue a career in biology. The main study consisted of three parts. The first was the exploration of the attributes that provided experiential learning opportunities to girls from marginalized backgrounds in a field research intervention called *El Espejo*. The second was a description of the girls’ ecological knowledge before and after their participation in the intervention. The final component of this dissertation explored the social system and the different science identities that the girls exhibited or emerged in the participants as a result of this experience.

Research Questions

Research questions centered on understanding the key components necessary to inspire and motive the girls to expand or become interested in

science. This interest was explored by examining their curiosity in asking questions or learning about the natural world, by looking at ecological knowledge as a component of scientific competence, and on understanding science identity formation as an integrated process:

Q1 Understanding a program that targets a special population. What characteristics of the intervention were necessary to engage girls from underrepresented background in the experience? What roles did facilitators undertake in this intervention that contributed or hindered the girls' experiences?

Q2 Ecological Knowledge as a Component of Scientific Literacy. What ecological knowledge did middle school girls have before and after the intervention?

Q3 Understanding Science Identity Formation as an Integrated Process. How did girls' science identities emerge or change over the course of the program? In what ways did being part of a "system" help or hinder the girls' science identity formation?

Summary of Findings

Before the creation of the intervention presented in this dissertation, the researcher studied the factors that afforded opportunities for Latina girls to pursue careers in biology. Three relevant themes emerged from the pilot study as being important factors in the journey of the girls that lead them to an interest in biology: 1) experiences that made a lasting positive or negative impact early in life; 2) an intrinsic desire to serve their community or people in need; and 3) sociocultural support networks.

The findings from the pilot study served as a starting point for the design of this dissertation project. The intervention had to be an experience that was longer than a day or a moment in time, meaning, it had to be more than the girls meeting a scientists for a career day or show and tell to make a lasting or positive impact. This critical component of the design allowed for relationship building and the opportunity for the girls to see scientists as real people. The second component touched on the important of relevance to the girls' everyday lives. The experience was place-based, and problem based, with problems possibly aimed at helping people in need or the local communities. Creating a connection to a local site enhanced the connection for girls like Selena who felt the PLC was the only place where she could be a scientist. Lastly, the experience included a supportive network where participants felt welcomed and willing to take risks. This characteristic of the program was very important for students who were still developing their ability to communicate in English, such as Valeria, and for students such as Maya where she felt "Free" to explore without being watched by judgmental eyes.

To create the program described in this dissertation, local community leaders, including teachers, professors, graduate students, and other stakeholders of the Poudre Learning Center joined forces to address the need of exposing girls to experiences that would enhance participants' sense of science identity and expose them to science experiences. Participants were active, engaged learners in this learning environment. The program was designed with these goals in mind: (1) to provide field experiences for a diverse group of girls

each summer by getting them outdoors and experiencing their place, (2) to advance science competence and skill development, (3) to offer opportunities for inquiry and critical thinking, (4) to expose the girls to career awareness through mentoring, and (5) to provide opportunities for social and cultural integration for girls who are in the process of forming their science identities.

The intervention took place at the Poudre Learning Center, an outdoor learning facility with 65 acres of natural space, where the girls were at the core of a social system in which science learning was welcomed and encouraged. This learning space was framed on a conceptual idea of systems theory which included these four systems components: 1) a systems view of education, 2) evolving mindsets about education, 3) understanding of the systemic change process, and 4) a systems design (Joseph, 1995).

This study provided a venue for the researcher to explore the girls' stories through case study methodologies and to learn more about the influence of science competence and science confidence in the development of science identities. Case study methods provide opportunities to hear thick, rich descriptions (Merriam, 2009; Stake, 1995) of the girls' stories as they navigate through a field research experience in the *El Espejo* program. Systemic creation of this type of intervention and the stories of the participants had not been documented until this dissertation study opportunity. There were 13 themes that emerged from the data.

The 13 themes were: Engaging the girls in science through unique experiences, creating science identities, program design features, entering a

community of science, learning ecology, joining a science community, connection to place, how others view me, learning science practices, my interest in science maintained or ignited, importance of experiences, applying reflective practices, and the role of facilitators in the girls' experiences.

For the past four summers, the program served 111 girls total, with 89 unique (non-repeat) participants. Participants represented a variety of cultural and ethnic groups in the community. The focus of this dissertation was on the most recent year, year 4, where 33 girls participated. Eight of the girls' stories were told and organized through 13 themes and grouped by their relevance to the research questions.

Engaging Girls Historically Underrepresented in Science Fields to Research Experiences

Q1 What characteristics of the intervention were necessary to engage girls from underrepresented background in the experience? What roles did facilitators undertake in this intervention that contributed or hindered the girls' experiences?

The characteristics necessary to engage the girls in a field science experience included a specific focus on learner centered opportunities to study science, the creation or enhancement of the girls' sense of place, the unique nature of the experience, the importance of such experiences, being part of a science community, and the facilitators. All of these attributes contributed to the engagement of the girls to experiential learning out in the field, in their local environmental learning center.

1. Program design features. The components of the program design that the girls found beneficial included having a science focus, learning protocols and

applying them to the design of their own studies, and having help from facilitators who were willing to provide support for the development of their scientific studies. By participating in this intervention, Angel saw more to education than math and reading. The opportunity to design her own project was important for Maya. She was empowered by the opportunity to take charge without feeling as if someone was judging her actions. For Winter, the ability to study her own choice of topic was also important, but what she found most beneficial was communicating her findings to an audience of community members. For Selena and Angel, having visiting scientists, such as the ornithologist, and the chiropterologist were important elements of the design. They had the opportunity to interact with mentors and as Angel puts it, “Learning about women who do science…and if you wanted to extend out a dream in science that you can do it.” The program helper her see that pursuing a career in science is something that is attainable if she so desires.

In this study, the focus of experiential learning took on a situated learning approach through place-based learning at a nature center. The authenticity in the research site was important. This intervention provided more opportunities for girls to develop relationships and learn about each other than what they typically had in their science classrooms. These relationships were important in creating a culture where: 1) it is *cool* to do science and 2) it is okay to ask for help from peers. The girls experienced a real-life opportunity for doing science, an opportunity to meet real scientists, and opportunities to collaborate to resemble the experiences of practicing scientists no matter if they work in the field or in a

lab. The girls practiced science at a site in close proximity to their homes and schools, in their local community, which was an experience that contributed to the girls' notion of place (Hart, 1979).

2. Connection to place. The Poudre Learning Center provided 65 acres for the girls to experience nature in a local context. For Maya having a place to conduct science where, "I can do the project. It's different because I can gather materials by myself and I can explore when nobody else is around me and I can use what I need, like materials and those things." This sense of empowerment to explore at her will helped create a bond not only with the birds she was studying but for future opportunities to visit the site and ask new questions.

For Lilly and Issa, the notion of place was enhanced. Lilly was already visiting the center regularly with her grandmother and her studies centered on exploring all the types of insects at the PLC. Lilly studied similar questions every year, but varied the sites she sampled or the types of insects, either terrestrial or aquatic. For Issa, being outside was very important to her experience. She enjoyed learning new things every time she wandered out, something she feels she doesn't do at home where she just sits and watches T.V., which is a sentiment also articulated by Selena2 when she said she would miss "meeting new friends and being able to go out in nature than just sitting at home." The opportunity to be outdoors and design scientific studies were attributes participants really enjoyed.

3. Unique experiences. Unique experiences were defined as experiences that were extra-ordinary, authentic, learning opportunities that the girls had not

yet been exposed because of access or lack of awareness, or both. Learning through experiential learning in this context was "the process whereby knowledge [was] created through the transformation of experience. Knowledge resulted from the combination of grasping and transforming experience (Kolb, 1984b, p. 41)." Authentic experiential learning opportunities included choice in project, choice in partners, choice in location within the site, and in the design of their individual or group study. Building capacity for them to conduct their own research project was very important. Even if it was a simple question, the girls had the opportunity to take ownership. For Issa, asking a simple question such as "What plant has pigments that stain cotton fabric best?" led to an interest in finding out what else is inside plants. Issa left the program with a new sense of possibility. Issa wants to be a scientist doctor and this program helped her see that this is one more possibility in her choices of careers for her future.

This program provided a transformative experience by exposing participants to a new definition of science. The eight girls interviewed defined school science as being something that was shown to them, something they read about or something defined as "an objective representation of how the world works (Zacharia & Barton, 2004, p. 203)." By participating in this program, science became something that was accessible to them. Science became an experience in which they could actively participate and contribute, and where their contributions mattered. The girls experienced scientific knowledge by finding explanations of how the world works through their own experiences. Zacharia &

Barton (2004) present this school science tradition as “critical school science” in a study they conducted on urban youth experiences with science.

4. Importance of experiences. Exposure to experiences in science that was different than previous science experiences, traditionally in a school setting, gave the girls a new definition of science. Exposure to mentors, scientists, science educators, and facilitators with a passion for science contributed to the girls’ experiences and engagement in science. Visitors from the community also played a vital role. This experience gave the girls an opportunity to communicate with people who were not familiar with their projects and who may not have had a science background. The girls took on the role of science translators during these visits, making science accessible to community members who may have had little background knowledge on the topics the girls selected. Community visitors came during the Women Leader’s Tea in the middle of the week, when the Rotary Club visited the girls over lunch, and when the girls presented their studies at the Community Symposium.

For Winter sharing her scientific study was a very important undertaking and the highlight of her week. The validation she received from the community counteracted the struggles with the facilitators during the week. Her identity as the communicator of science was evident and brought out strengths the facilitators may have perceived as irritating or off-task behavior—talking all the time and wanting people’s attention. Nonetheless, Winter still felt she belonged to a supportive community, especially by her group members.

5. Entering a community of science. As the girls arrived at the beginning of the week, a volunteer greeted them and they had their picture taken; the picture was placed on the community wall. This welcoming act showed the girls that they are a part of this community. We value that they were willing to take on this challenge. We will support them in any way we can. This was a place where the girls could take risks. The girls felt that if they failed, they would not be ashamed as Maya so willingly acknowledged. She could go out to the field on her own and people were not keeping a watchful eye. No one would be critical if she failed, whereas experiences in school learning tends to be that if she failed, she would be perceived as incompetent rather than making the failure a learning experience. Maya was willing to take risks and she was also someone who helped others take risks by helping them understand English, a language that the early language learners, Valeria and Carolina, had not yet mastered.

Interacting with each other enhanced the girls' sense of self. Working together gave them an increased confidence in their role as leaders and as learners. They were willing to help each other out. However, many of the girls struggled to work together in a project since for some of them, this was the first experience to collaborating in a team. The role of the facilitator was important in scaffolding opportunities to help girls build on a larger project instead of many isolated, projects seeking to answer very similar questions.

6. Role of facilitators in the girls' experiences. The program was designed to include facilitators to serve as mentors, models, and inquirers alongside the girls (Buxton, 2010). We did not use the term "teachers" because

we wanted the girls to separate this experience from school learning, where teachers are typically seen as dictators of learning (Rodgers, 2010). In this intervention the role of facilitators was primarily to expose participants to experiences.

From the participants' perspective, the facilitators did play an important role in the program. The facilitators were vital in Issa's experience getting started in her project since she acknowledged that question development was the hardest part. For Valeria, the facilitators helped her in her primary language when necessary. Valeria was always willing to practice her English, but she found it extremely helpful to codeswitch from English to Spanish, when she could not express her thoughts in English. Bilingual facilitators and facilitators with pedagogical skills working with English Language learners were important for her experience. A handful of facilitators had these areas of expertise throughout the four year. All Valeria needed was one facilitator who was patient enough to help her get going.

The facilitators played an important role even for Winter and Selena2, who rebelled against them. Both girls acknowledged that having someone they could go to for help was important, but not the main reason why they participated in the program. Winter and Selena 2 were there to be outdoors with each other and with the friends they had made over the years, to conduct their own studies, and to share their findings with community members. Learning about nature and science through ecology played an important role in all of the girls' experiences. As Angel puts it, "I didn't even know that was called ecology!"

Ecological Knowledge as a Component of Scientific Literacy – Building Science Competence

Q2 What ecological knowledge did middle school girls have before and after the intervention?

Competence in ecology was important to enhance the girls' knowledge of concepts in science and skills needed to conduct scientific research. Lack of mastery of ecology concepts did not hinder the girls' experience. Important themes that informed this research question were: 1) content knowledge in ecology, 2) science practices participants learned, and 3) reflective practices as they relate to learning content and practicing the nature of science.

7. Learning ecology. The girls learned foundational ecology concepts and basic field protocols as they relate to ecology field studies. The ecological principles explored using and adapted took from (Morrone et al., 2001) were: 1) the earth as a biosphere, 2) ecological energetics, 3) ecosystem succession, and 4) biotic interactions. The nature of the intervention design provided opportunities for girls to learn ecology concepts and research skills during first two days as they participated through the rotations where they learned field protocols. The girls were able to apply and transfer this knowledge when they pursued their own queries. During these rotations the girls had the opportunity to learn specific facts, ecology concepts, and foundational skills in science.

The ecology principles tool did not capture what the girls knew about the ecology principles of interest in a holistic manner. For example, Angel was able to explain verbally how concepts related and reached a level of concept connection not evident in her pre or post ecology knowledge test. Angel was able

to experience microclimate variations as she moved through different ecosystems at the Poudre Learning Center. She was able to expand on the interactions between different organisms and explained verbally energy flow in a level not adequately captured with the knowledge test.

Having a test at the beginning of year 4 and to conclude the week was counterproductive to the girls' experience. In the end, the experience was aimed at developing skills and knowledge that the girls could transfer to new situations. The test did not help advance our efforts because the tool itself did not capture the process of the girls learning, as an experiential learning opportunity, but rather, it captured what they knew at that moment in time. For some girls, the anxiety over having their presentations ready to go was a larger priority. One student randomly selected responses picking the first answer in all the questions. For Lilly, the confidence she gained when she was allowed to open her journal and reference her notes added to the detail of her responses. The girls were not asked to "study" for this post-test, which means some of the concepts were not visited and learned to reach mastery. Therefore, having their science journals as a source to refer to not only triggered memories, but also added to the description and explanation of the concepts they provided the researcher during the individual interviews. For Lilly, the ability to look something up that she knew she wrote down during the week showed initiative, self-discipline, and transfer of a skill that can potentially help her thrive in the 21st century (Trilling & Fadel, 2009).

8. Learning science practices. The science practices defined by the National Research Council (2012) include: asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, obtaining, evaluating, and communicating information. Angel learned the iterative process of question development and she learned that scientists who work in the field or in a lab may have specialized equipment depending on their area of expertise. Most of the girls maintained a journal. Lilly and Maya kept copious notes, while Winter and Selena2 barely wrote or drew any diagrams to document their thinking process.

The girls who kept detailed notebooks were able to use them as a point of reference when talking about their experience. For example, Angel and Lilly both pointed to the food web diagram in their notebooks and compared it to the post-test question and realized something was different and that their verbal explanations were not matching up to what the diagram in the post-test was indicating. Journaling not only enhanced and provided a venue to reference learning, but also provided a space to write thoughts and document ways to improve their study design if they were to continue studying the same topic or in designing another study; either experimental, correlative, or descriptive. Journaling also helped the girls inform their presentations. Girls who did not document their experience, such as Winter and Selena2, had posters that did not include in-depth conclusions and had lots of pictures and decorations. It was

important for them to share their experiences with the public, and they shared what it was like to be out in the field, but did not provide ample evidence for the conclusions.

The journals also helped several girls, such as Lilly, Selena, Angel, and Maya make ecology concept connections. During her interview, Selena explains the enduring understanding that *changing environmental conditions can alter the rate of decomposition*. She talks about changing temperature and how that will change the how fast decomposition occurs. Making conceptual connections leading to enduring understandings is necessary for the transfer and application of such concepts to other settings (Erickson, 2007).

Lilly made a concept connection across disciplines. Lilly highlights that *scientists apply the skills of reading, writing, and communicating, to document evidence to support claims*. This cross-disciplinary concept connection gives relevance to reading, writing, and communicating in the context of studying science. It's not something where she is told that scientists do that; rather, it was something that she was able to experience as a junior scientist.

8. Applying reflective practices. In order to fully engage in science practices mentioned above, participants connected prior knowledge to new understandings. The girls were designers of their own studies. Participants were able to think about their own process in designing the study and apply metacognitive thinking skills to improve their study design or their experience in the program (Wittrock, 1998). For Issa, question development was the hardest part. She took most of her time going to the field to see what was out there and

how she could formulate a question around something that interested her. Linear, logical experiences still play a role, but creative thinking needed to solve complex problems (Erickson, 2007).

Developing critical thinking skills is a step towards creative, critical, conceptual, and reflective thinking (Erickson, 2007). Angel notes the importance of what she learned in *El Espejo* as a component of her everyday life and she has gained tools necessary to find resources to help her learn more about things that interest her. The research and communication skills Angel learned is something she is planning on utilizing in the future. Angel began to integrate thinking and saw learning connections during *El Espejo* to her real lives. For Lilly Angel, and Maya, using corrective thinking when explaining their responses shows that they are thinking critically about what they learned. If something does not make sense when they were explaining it to the researcher, they corrected their diagrams to reflect their thinking processes. The way some girls actively used their science journals during the interviews also demonstrate the use of reflective thinking, searching for what they knew was in there and formulating answers based on prior learning and prior experiences.

Selena, who was a multiple year participant, realized that studying the natural world is an iterative process. Selena shared, “I think it would help to do it [scientific study] in that order and do it that way but I think there would be another way that you could do this just not in this order or this way that [I] have here.” Selena recognizes there are multiple ways of thinking about study design. She questions the “one” scientific method that includes, a question, a hypothesis,

experiment design, collecting data, and drawing conclusions. While these steps delineate how science is typically communicated, Selena learned that even developing her own question was something she had to go back and revisit multiple times. “How science works” has done a comparison of what they call the baking method versus the process of science (University of California Museum of Paleontology, 2012). Selena is reflective about the process of studying science and shares that she wants to come back to continue studying insects, but asking different questions. For Selena, coming to the Poudre Learning Center meant entering a place where she could be a scientist, but outside of this place, her connection to science diminished. The eight girls interviewed connected to being a scientist through one experience or another. The girls’ experiences are at the core of understanding the science identities they exhibited during the field experience. These experiences also had an effect on their science confidence.

Understanding Science Identity Formation as an Integrated Process – Building Science Confidence

Q3 How did girls' science identities emerge or change over the course of the program? In what ways did being part of a “system” help or hinder the girls’ science identity formation?

The girls’ science identities emerged through various experiences and roles as they created new understandings through the *El Espejo* program. For most of the girls, being part of a system helped their immersion into a community of science. For a couple of participants, Winter and Selena, being part of a system that included facilitators created tension that led to pushback form the girls, but still led to the increased interest in science that was reinforced by the

peer group experience rather than the experience created by the facilitators. Science identity formation was a result of an integrated system that included how others viewed the girl, how the girl perceived herself, and the risk she was willing to take in entering and being an active participant in this science community.

9 and 10. Entering and joining a community of science. For some participants, entering this community of science was an honor, and for others it was a risk—a risk worth taking. As they entered the community the girls experienced science practices that were in some cases, new, in other cases, a reinforcement of good teaching that is going on across the partner districts. The ability to use the equipment that the guest scientists brought showed the girls that science is something they can be a part of and something they can enjoy doing. For Lilly for example, using the equipment was one of the most memorable moments of the program, which also created a personal experience and relevance in studying science, something that was not evident in her traditional school experience. As the girls felt more comfortable working with one another, they not only joined a community of peers, but a community of science as well.

11. Creating science identities. The development of various science identities in the participants was evident as they moved from a peripheral role where they identified with science as something other people do to a central role where they are the ones that do science and are legitimized in this science community (Lave & Wenger, 1991; Peacock & Pratt, 2011). In some instances, the facilitators served as a bridge for the girls to identify with this science

community, to enter, and to become active participants in this community. In other instances, it was the girls themselves, the peer groups that the girls created that welcomed each other and created this space where doing science was cool and relevant to their lives.

All eight girls showed various science identities throughout the program. These identities emerged from experiences the girls brought with them, or from previous learning and they had the opportunity to apply what they already knew to completely new experiences that showed them that they come with stories that can help them make meaning as they study science and be contributors to the scientific dialogue.

Angel*—the science fan; the expert scientist.* When Angel first started the program, she acknowledged that science was not something that caught her attention. She was “not a big fan of science.” The experiences she was part of showed her that science can be fun and is not something that has to be boring. She identified with a science identity where science was fun and doable.

Another identity that emerged from Angel was that of “the expert scientists” who knew all about fish. Her peers acknowledged her as “the expert” which validated this science identity. Deep inside, Angel had a connection with multiple science identities but feared expressing her interest. Participating in this program built her confidence in sharing her thoughts about possible career options with more certainty than before coming to *El Espejo.* She is not ashamed or embarrassed that studying rocks is a possibility and something she would

really enjoy. This interest is something she hopes to develop in future programs or on her own.

Maya*—the empowered scientist.* Maya's confidence in changing the world was an empowering experience for me as a researcher. To hear her story, and to see how she was not afraid to do science, provided evidence that what we were doing for the girls' experiences was something worth doing. Her willingness to help her peers who were still emerging English-speakers was also empowering. She was not willing to let them stay behind. They were in this together.

Issa*— the scientist doctor; the doubtful scientist*. When the researcher asked Issa, "What are your career interest?" she replied, "I want to be a scientist doctor." During Issa's first year, she examined what could pigment dyer could stain a piece of cloth fabric most effectively. As an exiting forth grader Issa shared, "I really think there are things inside of plants that we can study." The researcher asked Issa, "What does a scientist doctor do?" She replied, "A scientist doctor makes medicines from plants. They make medicines from plants so I want to do that. I want to be able to study plants to see what kind of medicine I can make." Issa was a 3-year participant and since her first year, she has shared that she wants to be a scientist doctor. Issa was one of our youngest participants, starting when she exited 4th grade.

A secondary identity that Issa exhibited was "the doubtful scientist." All of the data that referenced her future aspirations said the same thing. She wants to be a scientist. In her mind, she is saying, "I can do it. I want to do it." But her environment is saying, "You're not going to make it. You are not one of them, one

of the people who make it." Her history and experiences being a part of the English language acquisition (ELA) program tells her that she cannot do science because she needs to learn English first. Issa was born and raised in the United States of America, but was placed in an ELA class because her mom indicated that Spanish was spoken at home. In her elementary years, she only had science 45 minutes per week. The rest of the days were dedicated for language support. Now that she's in middle school, she does not have a full year of science because she has to give up one extra period to accommodate her extra language class. One semester is dedicated to science, the second, to social studies. Issa's opportunity for science exposure is creating an equity gap and limiting her exposure to science content which she is expected to master in order to be eligible to take the advanced courses she needs. She doubts her potential and indicates her uncertainty by writing "I think" next to statements in the perceptions tool that looked at her perception towards becoming a scientist. Issa lacks self-confidence in her ability to be a scientist.

Winter and Selena2—*The rebellious scientists*. Winter and Selena2 were in constant feuds with the facilitators. Their engagement in the program came from having each other as a peer support group. Even though Winter and Selena2 did not show engagement in the traditional sense, the girls came back year after year and pursued their own studies. They were engaged in a different way. Their engagement came from knowing they would have the opportunity to share their experiences from the week with the community. These "rebellious scientists" pushed the facilitator's buttons because they both perceived the adults

as authority figures who were getting in the way of having fun outdoors. Winter and Selena2 were students who captured the facilitators' attention in a negative way, while Maya perceived the facilitators as non-threatening and actually felt quite at home in the outdoors where no one was watching her.

***Selena**- The place-based scientist*. Selena connected to a science identity only when she was at the Poudre Learning Center. Outside of this context, she did not see herself as a scientist. He needed to be there, in the moment. Selena was willing to take a risk by studying insects, something she initially did not think she would like. Being at this place triggers an affinity and a desire to study insects. She studied insects all four years she was part of the program. For Selena, studying insects was a driving force to continue being part of this experience for four consecutive years.

***Valeria**—the science teacher*. The first year Valeria participated in the program, she spoke very little English. Her love for frogs was amazing. She was one with nature. She lives in a mobile home trailer park and there are no natural areas within walking distance. Thus, she has little to no exposure to experiences such as *El Espejo.* Valeria wants to study science because she wants to be a teacher, a science teacher to English Language learners to be specific.

The stories the girls tell help define their identities. What we say as teachers, as community leaders, as professors impacts our students' identity formation. It either hinders science identity formation or develops it. The program helped the girls see that they have agency (Shanahan, 2009), to enhance their self-efficacy or confidence in science. Their perception and comfort in interacting

with science was evident even after a couple of days of being in the field. The girls have the potential to take action and to choose to study science now and in the future. They have gained confidence to potentially thrive in a science environment back at school knowing that they can share their knowledge with their own teachers and potentially transform their experiences back home. This newfound confidence can also translate to social behavior such as becoming a science major in the future (McLain, 2012). This system, called *El Espejo,* fostered the girls' individual needs to build science confidence and science competence.

Using a systems approach (Chen & Stroup, 1993) to design this intervention created a space that was conducive of the girls needs and increased their engagement because the topic they investigated was of their choice. Traditional school systems aim to provide individualized instruction, but they rarely accomplish this great endeavor. By providing individual and group based learning opportunities, the girls had the opportunity to go into topics and explore concepts in depth and had opportunities to practice 21st century skills, which is different from what is typical in their science classes. The 21st century skills that the girls learned and practiced were collaboration, information literacy, critical thinking and reasoning, self-direction and invention (Trilling & Fadel, 2009). These essential skills are used in science labs and in the field by practicing scientists.

13. My interest in science maintained or ignited. There was also an emotional response attached to the experience. Ritchart (2002) has documented

that emotional responses build a greater connection to experience. The results of this purposeful design effort were an enhanced sense of place, the creation of authentic learning experiences, inspiration in science careers, and preparation to build confidence in girls who are in the process of forming science identities. Interactions with science professionals, with careers and science and facilitators who had a strong science identity helped create an environment, a system, where the girls were encouraged to take risks, to ask questions, to seek answers, to learn about the scientific process and how it applies to field research experiences. This in turn helped enhance the girls' current interest in science or ignite a whole new interest in science.

Implications for Practice

President Barack Obama's call to action to improve STEM teaching and STEM experiences for students is evident in initiatives such as Race to the Top, 100,000 teachers in 10 years (100K-in-10), and Educate to Innovate. I have a unique opportunity now as I transition into the STEM education coordinator position for the Colorado Department of Education funded through Race to the Top funding. As the STEM education coordinator, I have the opportunity to inform policy, create STEM programs, and train teachers to integrate STEM skills to create experiential learning opportunities that are relevant, meaningful and engaging.

So, how do we provide opportunities for girls? The Colorado Coalition for Girls in STEM is saying is that it is important for us to target efforts across all STEM disciplines even in ecology, where women tend to be well-represented,

but not women from groups historically underrepresented in STEM careers, such as Latinos. Providing opportunities that are experiential, memorable, and extra-ordinary is important for students to associate science learning to positive recollections. Experiences, both good and bad, have a lasting impact. *El Espejo* was a positive experience, for the most of the participants, and students remembered the fun they had learning science years down the road. Alumni from the program have returned as juniors or seniors in high school to serve as volunteers. Encouraging high school girls to be mentors and volunteers for younger girls was a need identified as the program progressed. The involvement of local leaders, scientists, professors, and science educators was necessary, but this could only be accomplished by recruiting widely across multiple universities and community and governmental organizations.

The multi-faceted approach ignited the girls' willingness to learn. It provided context for girls to practice self-regulation as they pursued their study. Self-regulation added to girls intellectual disposition, a concept described by Ron Ritchard (2002) in his book *Intellectual Character*. This finding is relevant and important for the field. We need opportunities for girls to develop skills that are aligned with developing learners who can take initiative, and who can work in collaborative settings.

Participants shared that in-school experiences were not like the experiences they had during *El Espejo*. To enhance in-school experiences teachers can provide opportunities for students to present the projects they worked on during *El Espejo* to their school community or local community. For

Winter, sharing her work with an audience different than her peers was a critical component of the experience. This would create awareness for future participants and give the girls ownership and pride for their work. It could also validate her newly formed or emerging science identities. Ultimately, if the girls share their experiences their teachers may see that providing experiential learning opportunities in science may be a way to engage their students to ignite a passion that appears to be lacking based on the girls descriptions of traditional in-school science experiences.

All teachers in this region of Northern Colorado have access to the Poudre Learning Center. There have been large groups (50-100 students) who have come out to do mini-projects similar to *El Espejo*. In the context of the community of study, the Poudre Learning Center is *the* local natural area for exploration of ecological issues in this community. Knowing that it can be done, that girls can conduct meaningful studies outdoors provides insight for practicing teachers and for the staff at the PLC. Middle school girls from underrepresented backgrounds (both ethnic and socioeconomic) can learn about biology, the environment, river ecology, restoration efforts, and about anthropogenic disturbances in this multiple ecosystem space.

The findings can help educators and families find ways to keep their girls engaged in science. Thus, this field biology research opportunity serves as a venue to enhance participation in the sciences by girls typically underrepresented in this field. At the end of the day the key questions that remain are: Are these 89 girls potential scientist-in-training? Or is it equally important that the girls learned

skills that are transferable to other places and situations, skills that increased their science confidence and science competence?

Directions for Future Research

The program will be continuing even after the departure of the founder, who was also the program coordinator and the author of this dissertation. Continued involvement from the university, local community and potential involvement of industry will ensure the sustainability of the program. As the stakeholder involvement increases, there will be needs for more specific metrics to gage the level of success for the program. The potential replicability of the program across the state will allow for larger sample sizes.

For the purposes of replicability, creating a manual of core characteristics of the program will be a much-needed next step. Also, including a vision for research and evaluation as a core component of the program will help with sustainability efforts and provide information for funders willing to support exposing girls to experiential learning in science. Ultimately, this could provide a venue for long-term tracking of participants.

Long-term tracking of participants is also a potential research opportunity. As the girls exit the program, they are returning as volunteers. We wonder where they will end up. Will they pursue STEM career in 5-6 years? The state now has a way to share data between agencies to see where students end up. We can answer questions around job placement and enrollment and completion of post-secondary study.

We need scientists who come from all different backgrounds who bring different stories and different experiences to advance the field. The issue of engagement and interest in STEM careers is not isolated to 5-8th grade. We must develop ways to engage students early in their educational trajectories, in to middle school, and beyond. Experiences beyond middle school into high school could include opportunities for students continue to build skills and do a long-term research projects. The relationship with the university could facilitate access to graduate students or professors before they get to college. Perhaps high school girls could return as interns and conduct long-term studies under the guidance of an undergraduate or a graduate student. More in-depth field opportunities may keep girls from underrepresented backgrounds engaged in science throughout the year. The high school model could also be a 4-8 week program over the summer or throughout the year where participants would go out to the field 1 day per week.

To provide access to college experience, parents need to be aware of how the system works. Parents play a vital role in re-affirming and supporting their child's emerging science identities. Future research opportunities could include parents are at deeper level of engagement where they not only learn about what their daughters are doing during the program, but learn about how they can help their girls stay engaged throughout the year.

Concluding Remarks

There are many ways to structure experiences, but ultimately, what made the *El Espejo* experience memorable for the participants was that they had the

opportunity to ask questions about the natural world in a context that was relevant to them. This experience was life changing for participants such as Maya. Maya's affirmation, "I can do the project. It's different [the experience at *El Espejo*] because I can gather materials by myself and I can explore when nobody else is around me and I can use what I need, like materials and those things," shows that Maya's self-confidence in doing science changed. Maya was able to explore on her own and figure out what she needed to conduct her project. She was empowered to use the skills she learned to go out and do science *on her own*. Maya's resounding words capture the essence of the empowerment the girls gained from being part of this field research experience in science:

> I can do something,
> I can make something,
> I don't know how to explain it, but
> I can make the world,
> I can be part of the world,
> I can change the world.
>
> \- Maya

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APPENDIX A

IRB APPROVAL

UNIVERSITY of NORTHERN COLORADO
Institutional Review Board (IRB)

June 1, 2011

STUDENT'S COP

TO: Teresa McDevitt
School of Psychological Sciences

FROM: Maria Lahman, Co-Chair MJ
UNC Institutional Review Board

RE: Expedited Review of Proposal, *The Impact of Field Experiences on Youth and Facilitators in Supporting Ecological Content Knowledge and Perceptions,* submitted by Yeni Violeta Garcia (Research Advisor: Richard Jurin)

First Consultant: The above proposal is being submitted to you for an expedited review. Please review the proposal in light of the Committee's charge and direct requests for changes directly to the researcher or researcher's advisor. If you have any unresolved concerns, please contact Maria Lahman, Applied Statistics and Research Methods, Campus Box 124, (x1603). When you are ready to recommend approval, sign this form and return to me.

I recommend ~~approval~~ as is. revised Teresa McDevitt 6-10-2011
Signature of First Consultant Date

The above referenced prospectus has been reviewed for compliance with HHS guidelines for ethical principles in human subjects research. The decision of the Institutional Review Board is that the project is approved as proposed for a period of one year: 6-13-11 to 6-13-12.

Maria Lahman 6-13-11
Maria Lahman, Co-Chair Date

Comments: waiting for site permission 6-13-11

25 Kepner Hall ~ Campus Box #143
Greeley, Colorado 80639
Ph: 970.351.1907 ~ Fax: 970.351.1934

UNIVERSITY of NORTHERN COLORADO
Institutional Review Board (IRB)

June 1, 2011

Dear Researcher/Advisor,

I received your IRB application and am writing to give you an update of the status of your IRB review. Your protocol was assigned to **Teresa McDevitt** on **June 1, 2011** who will be conducting an **Expedited** review.

The summary information I have for your application is the following:

Principal Investigator(s):	Yeni Violeta Garcia
Department:	Biological Sciences
Student Email:	yeni.garcia@unco.edu
Research Advisor:	Richard Jurin
Title of Proposal:	*The Impact of Field Experiences on Youth and Facilitators in Supporting Ecological Content Knowledge and Perceptions*

Please let me know immediately if your contact information changes.

If the IRB reviewer has concerns or identifies required changes in the proposal, you will be asked to make the changes or see that the changes are made. When the IRB reviewer believes that you have made the appropriate changes, your proposal will then be forwarded to the IRB Co-Chair, Maria Lahman for final approval.

Your advisor will receive notice of final approval from the IRB Administrator, Office of Sponsored Programs. RESEARCH ADVISORS WILL INFORM STUDENT RESEARCHERS OF THIS APPROVAL.

Thank you!

Sherry May
IRB Administrator

25 Kepner Hall ~ Campus Box #143
Greeley, Colorado 80639
Ph: 970.351.1910 ~ Fax: 970.351.1934

APPENDIX B

IRB DOCUMENTATION

UNIVERSITY of NORTHERN COLORADO

Participant
Parent

CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH

Project Title: The Impact of Field Research Experiences on Middle School Girls and Facilitators in Supporting Ecological Content Knowledge and Science Perceptions

Researchers:	Yeni Violeta García Doctoral Student, School of Biological Sciences
Phone:	(562) 533-0976 (García-Spanish)
Email:	yeni.garcia@unco.edu
Research Advisor:	Richard Jurin, PhD
Phone:	(970) 351-2220

I am interested in assessing the ecological literacy and perceptions of middle school girls before and after *El Espejo* (Spanish for "mirror"). *El Espejo* is a summer field experience that aims to provide young women in 5th through 8th grade with opportunities to conduct research investigations pertaining to our local watershed and to enhance their decision-making abilities for environmental issues related to this region. You are receiving this letter because your child is participating in *El Espejo*. This study is designed to address the following research questions:

> What ecological content knowledge do middle school girls have before and after participating in *El Espejo*?
> What affect does *El Espejo* have on middle schools girls' perceptions of the natural world?

If you grant permission and if your child indicates a willingness to participate, we will give your child a questionnaire before and after the program. We will have an interview at the end of each day of the program where we will ask your child questions about their day. Your child will be observed while in the field and a copy your child's research journal will be collected. Any photograph taken may be used as data to understand your daughter's experience in the program. The purpose of this letter is to ask you for your permission to use the data (responses, questions, photographs etc.) from the summer program. All data will be kept confidential and in a secure location. The conversations will be recorded and the recorder will be locked in a secure location. The computer used in the study will be password protected. The recordings will be erased three years after the study.

Your child will be given a pseudonym (false name), which she may choose if she would like. Her real name, and location, will not appear in any report, presentation or summary of this research. We will also send you a written summary of our understandings of your child's ideas and ask you to read and comment on it (this is called member checking). You may edit or delete any information from the summary that you like.

Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact the Sponsored Programs and Academic Research Center, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1907.

Thank you for consenting for your child to participate in this study. Please feel free to contact either of us with any questions that you may have, and please retain one copy of this letter for your records.

Sincerely,

Yeni Violeta García

________________________________ ______________________________
Child's Name Date of Birth (month/day/year)

________________________________ ____________________ __________
Parent's Signature Date Researcher's Signature Date

UNIVERSITY of NORTHERN COLORADO

Participant
Parent- SP

FORMULARIO DE CONSENTIMIENTO DE LOS PARTICIPANTES HUMANOS EN LA INVESTIGACIÓN

Título del proyecto: El impacto de las experiencias de investigación del campo en niñas de escuelas intermedias y en los coordinadores de grupo en apoyar el conocimiento del contenido ecológico y de la percepción de la ciencia

Investigadoras:	Yeni Violeta García, Estudiante del doctorado, Escuela de Ciencias Biológicas
Teléfono:	(562) 533-0976 (García-español)
Correo electrónico:	yeni.garcia@unco.edu
Profesor:	Richard Jurin, PhD
Teléfono:	(970) 351-2220

Estoy interesada en la evaluación de los conocimientos ecológicos y las percepciones de las jóvenes de escuela intermedia antes y después del programa *El Espejo*. *El Espejo* es un programa de verano que tiene como objetivo proporcionar a jóvenes del 5º al 8º grado con oportunidades para llevar a cabo investigaciones sobre la cuenca local y aumentar su capacidad de tomar decisiones sobre cuestiones ambientales en esta región. Está recibiendo esta carta porque su hija esta participando en *El Espejo*. Este estudio está diseñado para investigar la siguiente pregunta:

¿Qué conocimientos ecológicos tienen las jóvenes antes y después de *El Espejo*? ¿Qué efecto tiene *El Espejo* en sus percepciones del mundo natural?

Si concede el permiso y si su hija indica una disposición a participar, vamos a darle un cuestionario antes y después del programa. Tendremos una entrevista al fin de cada día del programa en la cual le haremos preguntas a su hija sobre sus experiencias del día. Observaremos a su hija en el campo y nos quedaremos con copia de su diario de investigaciones. Cualquier fotografía tomada puede ser utilizada como datos para comprender la experiencia de su hija en el programa. El propósito de esta carta es para solicitar su permiso para usar los datos (respuestas, preguntas, fotografías etc.) del programa de verano. Todos los datos serán confidenciales y se guardarán en un lugar seguro. Las conversaciones serán grabadas y la grabadora guardará en un lugar con seguro. La computadora utilizada en el estudio estará protegida por contraseña. Las grabaciones se borrarán tres años después del estudio.

Su hija recibirá un seudónimo (nombre falso) que ella puede elegir si le gustaría. Su verdadero nombre y la ubicación, no aparecerá en ningún informe, presentación o resumen de esta investigación. También le enviaremos un resumen escrito de nuestra comprensión de las ideas de su hija y le pediremos que lea y comente en él (esto se llama "member check"). Puede editar o eliminar cualquier información en el resumen que usted reciba.

La participación es voluntaria. Usted puede decidir que su hija no participar en este estudio y si se empieza la participación que todavía puede decidir parar y retirarse en cualquier momento. Su decisión será respetada y no dará lugar a la pérdida de beneficios a los que tiene derecho. Después de haber leído lo anterior y haber tenido la oportunidad de hacer cualquier pregunta, por favor firme abajo si le gustaría que su hija participara en esta investigación. Una copia de esta forma se le dará para referencia futura. Si usted tiene alguna preocupación acerca de su selección o tratamiento como participante en esta investigación, contacte la oficina de Sponsored Programs y Academic Research Center, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1907.

Gracias por su consentimiento para que su hija participe en este estudio. No dude en contactarnos con cualquier pregunta que pueda tener, y por favor guarde una copia de esta carta para sus archivos.

Atentamente,

Yeni Violeta García

______________________________	______________________________
Nombre de su hija	Fecha de nacimiento (mes/día/año)
______________________________	____________________ __________
Firma del Padre Fecha	Investigadora Fecha

UNIVERSITY of NORTHERN COLORADO

Participant

ASSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH

Hi,

My name is Yeni Violeta and I am a researcher at the University of Northern Colorado. I do research on biology education. I am interested in student's knowledge and perceptions of ecology. You are getting this letter because you are participating in *El Espejo*. In this study I will examine the following research questions:

What ecological knowledge do middle school girls have before and after participating in *El Espejo*?
What effect does *El Espejo* have on your perceptions of the natural world?

If you are willing to participate, you will receive a survey before and after the program. You will be observed during the program and you will be interviewed. I will also keep copies of any photograph taken during the program to see what activities you were part of to learn more about your experience. A copy of your research journal will be collected. You will be given a pseudonym (false name), which you may choose if you would like. Your real name, and location, will not appear in any report, presentation or summary of this research. I will also send you a written summary of our understandings of your ideas and ask you to read and comment on it (this is called member checking). You may edit or delete any information from the summary that you like.

Thank you for your help in this study. You may decide not to participate in this study at any point. I will be glad to share any summaries or reports of this study. Please feel free to contact me with any questions that you may have, and please keep one copy of this letter for your records.

Thanks you!

Pseudonym: ______________________________

______________________________ ________________
Participant's Signature Date

______________________________ ________________
Researcher's Signature Date

APPENDIX C

PARTICIPANT INTERVIEW PROTOCOL

Student interview guide

Hi _______________,

- Today I will be asking you a series of questions to better understand *El Espejo* – girls summer science research program—a program you participated in last June. This information will be used to learn more about the program.
- Your responses are confidential, which means we will take the necessary steps to protect your identity; however, photos of you may be displayed in the final report. We will use the false name on your consent form on anything published.
- **The name we have for you is __________________ (Check IRB forms, make sure they are signed). Is this okay with you?**
- If at any point you feel uncomfortable answering a question or you don't know an answer, let me know. The interview will take less than 1 hour.
- When answering the questions, explain your answers as if you were talking to someone who doesn't know anything about the program.

Let's get started.

1. How did you find out about El Espejo? …What did he/she say about the program?

2. Before coming to El Espejo, had you ever been to the Poudre Learning Center?

3. What did you think El Espejo was before you were part of the program?

4. Tell me what happened during the week of El Espejo.

5. What did the facilitators do during the week?

6. Did the facilitators or volunteers help you? How so?

7. What did you enjoy the most from the week of El Espejo?

8. Follow up if not a learning experience for #7 ask: what did you enjoy learning the most during the week of El Espejo?

9. Tell me more about what you learned the week of El Espejo
Give me lots of detail. You can also draw diagrams to help you explain what you learned.

10. **Activity with cards** (only in-person interviews). Please organize and use the cards to tell me more about what you learned during the week of El Espejo. What connections can you see between the different words? (Take picture of cards and connections)

11. Specific questions to key terms:

    a. What did you learn about **ecology**? Pause.
    b. What does ecology mean to you? Tell me more.
    c. FYI:(The scientific study of the interactions that organisms have between each other and within the environment where they live).
    d. Did you know anything about ecology before participating in the program?

    a. Tell me about **ecosystems**. What are they?
    b. FYI: (The interactions of organisms and within the environment where they live)
    c. Did you know anything about ecosystems before participating in the program? Tell me more

    d. What did you learn about **interactions**?
    e. Pause. What does "interactions" mean to you? Tell me more
    f. FYI: (How plants, animals and other organism that make up an environment work with or against each other, or communicate with each other).
    g. Did you know anything about interactions before participating in the program?

    h. What did you learn about **food chains**?
    i. Pause. What are food chains? Tell me more
    j. FYI: (A diagram showing how living things get food; shows the flow of energy from one organism to another).
    k. Did you know anything about food chains before participating in the program?

    l. What did you learn about **food webs**?
    m. Pause. What are food webs? Tell me more
    n. FYI: (A complex diagram showing how different populations interact. Arrows pointing form the source of the energy to the organism consuming the source represent the flow of energy. Changes in population sizes will impact food web interrelationships).
    o. Did you know anything about food webs before participating in the program?

12. Do you have any questions you would like to investigate in the future?

13. How is learning science during *El Espejo* different than learning science at school?

14. Tell me about your project.
    a. What was your investigation about?
    b. What did you find out?
    c. What would you do differently if you were to repeat your investigation?

15. Tell me about the scientists you met during the week of *El Espejo*. (They met an ornithologist- Lauryn Benedict, a fire ecologist—Aramati Casper, a chiropterologist (study bats)—Laura Heikel, and a bioscientist – Susan Keenan.) Refresh the girl's mind if they said they did not meet any scientists.

16. What did you learn about science careers?

    a. If they say "nothing" then ask "what would you have liked to have learned about science careers?"

17. Did you see yourself as a "scientist" when you're out in the field?
    a. Did you feel like a scientist out there?
        i. What makes you feel like that?

18. Do you think other people see you or think of you as being a "science person"? Why do you think that?

19. How did you feel about science before participating in this program?

20. Do you enjoy doing science? Why/why not?

21. If you wanted to become a scientist what type of scientists would you be and why?

22. What does this program mean to you?

23. How many years have you participated in the program?
    a. If more than one: What excites you about coming back year after year?
    b. How has the program changed from the first time you did it?

24. What would you tell other girls who wanted to know more about *El Espejo*?

25. What are some ideas for activities that you would like to see next year during *El Espejo*?

26. How did you feel about working with girls from diverse backgrounds?

27. What leadership skills did you apply during *El Espejo*?

28. How will what you learned during *El Espejo* help you in the future?

29. Clarification questions from student application.

- GIVE copies of IRB, return journal, team photo.

- KEEP—pre/post test, original IRB,

-----------------Cut out----------------

Thank you! If you are going into 6th-8th grade we invite you to apply again. Applications will be available online, visit PLCoutdoors.org and look under the student tab starting January 2013, or call 970-352-1267. If you want to come back as a volunteer, please apply online when you are a junior or a senior in high school.
Stay in touch!

APPENDIX D

DATA CODING SCHEME

Color	Theme/ Code	Notes:
Yellow	Unique experiences (UE) Opportunity – (OPP) Not like school (NLS) Experiential Learning (EL)	These groups of codes reflect experiences that the girls would probably not have had if it were not for this program. Sometimes the girls say it straight out, but other times, we have to read in context and determine if this is something that is out of their every day experiences—making it an extraordinary experience. Science is about getting down and dirty—and that's awesome!
Bright Green	Creating Science Identities (SI)	This code refers to the girls saying that they are scientists in action. They are working on science practices, doing science and getting involved with the experience.
Aqua	Program Design features (PD)	This is to explain things to help people understand unique characteristics of the program. For example, rotations, the girls getting to design their own projects, and other activities that they did.
Pink	Entering a community fo science--Peripheral participation (PP)	Peripheral means "on the skirts" as opposed to being "central." This is when the girls see science practices but talk about it as "you" or someone else doing the science and not "I" in reference to herself as being the active learner. The one practicing science. For example "you would take the sample and you would measure it"
Blue	"Learning Ecology" Content Knowledge (CK) Ecology Concepts (flow of energy, cycles, interactions)	This is to explain any ecology learning that took place. What I want here is to see if there are any real moments of the girls getting in-depth with the learning that they were experiencing.
Red	Joining a science community--Community of Practice (CoP)	A community of practice is when a group of people feel part of a group because they share a common vision, or a common goal for leaning. The use of "us" girls in El Espejo, or we did this and that.. hints that the girls acknowledged that they were part of a team of science learners.

Color	Theme/ Code	Notes:
Green	Connection to Place-- Sense of Place (SoP)	Sense of Place refers to a connection to the land, to the place (the Poudre Learning Center) to the river, to anything nature related that the girls felt they connected to in a deeper way.
Teal	How others view me (Others)	This relates to how other people see the girl. If they say my friends say I'm a science person because I like to ask questions. Things like that. Or my parents think I can be a scientist.
Dark Red	Learning Science Practice (SP)	Using evidence, exploring literature. What are they doing that a scientists would normally do if they were doing research out in the field.
Dark Yellow	Maintain interest in science (MiS) Increased interest in Science (IiS)	This refers to the girls saying things such as "I liked science before, but this program just made me love it even more" or I didn't really like science, but now I do.
Gray 50%	Importance of Experiences (iEX)	This is when the girls acknowledge that were it not for this program, they probably would not have the opportunity to experience nature this way.
Gray 25%	Applying science Practices Reflective Thinking (RT)	This includes the girls making suggestions for program improvement. It also included when they are thinking something and they correct themselves because what they were saying was inaccurate and realized it and corrected their train of thought.
Black	Role of Facilitator in the girls experiences (RoF)	This category is to explain the different roles that facilitators took on throughout the project. Sometimes they were teachers, other times they were helpers, etc.

APPENDIX E

SAMPLE CURRICULUM

1.1 A Research Request

Action Synopsis

Students receive a request to survey animals and their food resources on a local site, then talk about what they already know and how they could find out more.

One Session	40 minutes
1. Present the challenge of becoming ecologists to study a nearby site.	*posing a challenge*
2. Talk about why knowing what animals eat is important.	*linking to real world*
3. Create a visual image of the study site.	*familiarizing*
4. Share thoughts about what animals live on the study site, and what they eat.	*examining prior ideas*
5. Brainstorm ideas of evidence that will give clues about animals that live on the site.	*generating ideas & questions*

Desired Outcomes

Throughout the lesson, check that students:

✓ Realize that people can harm or protect the food resources animals need to survive.

✓ Have a mental image of the study site, and some ideas about what animals live there.

✓ Are curious and have questions about animals and their food.

✓ Have ideas of how to look for animals and animal signs.

What You'll Need

For the class:

- ❑ items to help students preview their study site (see "Getting Ready")

Vocabulary

ECOLOGIST- A scientist who studies how living things interact with each other and their physical environment.

ORGANISM - A living thing (plant, animal, or microbe).

PHYSICAL ENVIRONMENT - The non-living surroundings (air, water, rocks, soil) and conditions (light, heat, wind) that something lives in.

Getting Ready

◆ Choose a project focus (see page 48). Invite a project sponsor — a local landowner, a member of an environmental group, or a school representative — to present the research request to the class. Explain that you want students to develop an understanding of food webs, and discuss how the sponsor can infuse a need for knowing what animals eat into the study request. See page xx for a sample letter from a project sponsor.

◆ Gather materials that will give students a preview of their study site. If they'll be studying a park or nature preserve you might be able to get brochures that describe the area. Otherwise, take some photographs, or collect some natural artifacts, such as a pine cone, a leaf, a soil sample, dead leaves and twigs from the ground, or a piece of trash. If you've taught this module in past years, gather lists, reports, and maps previous classes have left in the school "archives."

◆ Plan pairs of students.

Action Narrative

Over the next few weeks, each person in this class will be a type of scientist called an ECOLOGIST. What does an ecologist study?

Students are likely to mention plants, animals, and the environment. Confirm that ecologists study all of these parts of nature, but most importantly they try to figure out how these things — both living and non-living — interact.

Sometimes people ask ecologists to study a place they want to learn more about or protect. Our guest is here to tell us about a study s/he would like us to do.

Introduce your project sponsor, who might present an invitation letter to students (optional) and talk about the goals of the requested study. Continue with the following discussion after this presentation, involving your guest in familiarizing students with their study site.

So your job as ecologists will be to figure out what animals live in an outdoor area, and then figure out what those animals eat to survive. Why is it important to know what animals in a certain location use as food?

One reason students might suggest is that if an animal's food disappears or becomes toxic, the animal might die or have to find someplace else to live.

Endangered Food, Endangered Species

There is a direct link between wild animals, their food, and human activities. Species can become endangered when their food source changes, often as the result of people's actions. The giant panda, who eats only bamboo, has come close to extinction because people developed and disturbed the land where the bamboo once grew.

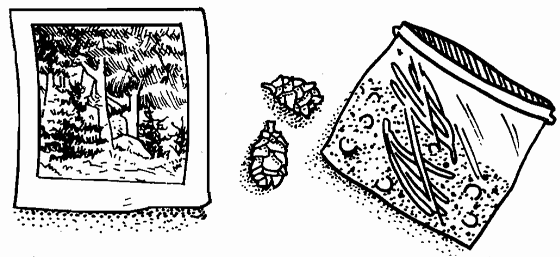
The whooping crane is also endangered because people harmed its food source, but in quite a different way. Hunters in marshes used lead bullets. Lead from their discarded bullets leaked into the soil, where it was taken up by plants. When the whooping crane ate these plants, the lead got into their bodies, reducing their ability to reproduce.

In both of these cases, people did not understand the link between their actions and the livelihood of animals. Research that uncovers ecological linkages can help people evaluate the consequences of their actions, and when necessary modify their plans.

Scientists always begin an investigation by thinking about what they and other people already know about the subject they're going to study. What do we already know about (name of the study site)**? Has anyone ever been there? What is it like?**

If students are familiar with the site (e.g., the schoolyard) make a list of the characteristics they mention.

If the site is not familiar, describe what you saw when you visited it, or have your guest describe it. Show them brochures, photographs, natural artifacts, or information that previous classes have gathered about the site. If you have enough items, divide the class into small groups and give each an object. Then have groups report to the class what they learned about the site.



Scientists use the word ORGANISM for all living things — plants, animals, and other life forms such as bacteria and fungi. They use the term PHYSICAL ENVIRONMENT for non-living things such as rocks, soil, water, pavement, hills, and holes.

Reinforce the new vocabulary words by having students label the site characteristics they've mentioned as organisms or physical environment.

Now that we know a little bit about the site, what animals that we haven't mentioned do you think might live there?

Students will most likely think only of mammals and other vertebrates at first, so remind them that the term *animal* is used for all creatures, large and small, with and without backbones. This will help them consider common insects such as mosquitoes, flies, termites, and ants, as well as other familiar creatures such as snails, spiders, and earthworms.

What do you think those animals might eat?

Make a list of students' suggestions. Encourage them to talk about where their ideas came from — direct observations, books, television, other people. Ask them which sources of information they most trust to be accurate, and why.

Invite students to record questions on a class chart. You might want to add some questions such as:

Do most animals eat just one thing or many different things?

Does more than one kind of animal eat the same thing?

Will we find more animals that eat plants, or more that eat other animals?

How are we going to figure out what animals live on our site? Then how will we figure out what they eat? Work with a partner for a few minutes to come up with some ideas of what we should look for outside to tell us what animals live there and what they eat. Remember that it's not always easy to see animals directly, so we'll also have to find evidence that they live there. Think about using all of your senses, not just sight.

Have pairs share some of their ideas with the whole class. Some animal evidence they might mention: seeing feathers, fur, bones, droppings, snakeskins, insect eggs, galls, nests, holes, tracks, trails, dens, burrows, woodpecker holes, chewed plants, scratchings, piles of pine cones; hearing bird calls, insects buzzing, dogs barking, squirrels and chipmunks scolding, scurrying sounds in bushes; smelling skunks and fox dens.

The idea of looking for animal signs outdoors might be foreign to some students, particularly if they live in a city. Using a human analogy might help. Ask students to imagine that they are visiting another country, and they want to figure out what the people there eat. Since they cannot speak or understand the language, they have to look for *evidence* of what the people eat. List students' ideas of where they would look to gather evidence. They might suggest cupboards, refrigerators, garbage cans, restaurants, grocery stores, and markets. They could go to dinner at someone's house, or watch people to see what food they buy or gather, observe if they have gardens or major crops, and if they raise and slaughter animals.

Once you have a list of suggestions, draw analogies:

Humans	Wildlife
Cupboards or refrigerator	Stashes of acorns, nuts, berries, etc.
Leftovers	Partially chewed or bored nuts, berries, leaves, etc.
Garbage	Piles of pine cone scales left by squirrels, chewed corncobs left by raccoons, etc.
Grocery shopping	Animals gathering food
Visit for dinner	Watch animals eat
Eating utensils	Animal mouthparts, claws, etc.

Ongoing Assessment

Student Reflections

Have students send a C-Mail message or record thoughts in their journals. Optional writing prompts include:

What would it be like to have to find my own food in nature instead of going to a grocery store? What would I eat?

What animal signs have I seen before? What could have made them?

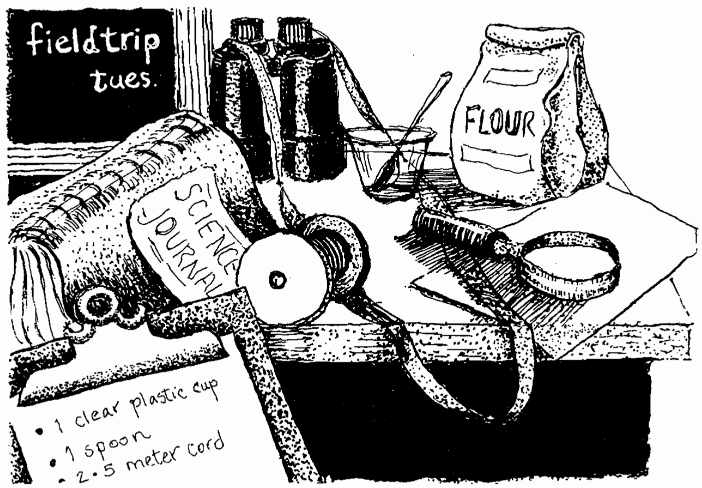
Teacher Reflections

- ❑ How rich is students' knowledge about what animals live in the local area?
- ❑ How familiar are they with different kinds of animal signs?
- ❑ Do they have realistic or imaginative notions about what wild animals eat?

Extension

Endangered Species. Challenge students to find out about an animal that is endangered and what circumstances led to its current situation. Encourage them to contact Congressional representatives for their perspectives on the federal Endangered Species Act.

1.2 Preparing for Field Work



Action Synopsis

Students become familiar with what animals and animal signs to look for outdoors, then practice field research skills and methods.

Session 1	40 minutes
1. Show and discuss pictures of animals and animal signs.	*familiarizing*
2. Plan and practice field techniques (setting up a study plot, finding animals and animal signs, capturing and observing small animals).	*demonstrating methods*

Session 2	40 minutes
1. Practice observation and notetaking skills.	*observing & recording*
2. Prepare a journal page for recording observations and ideas.	*documenting*
3. Discuss how to behave like scientists while doing field work.	*setting standards*

Desired Outcomes

Throughout the lesson, check that students:

✓ Are familiar with some of the animals and animal signs they might see outdoors.

✓ Know how to gather evidence of what animals eat.

✓ Know how to set up a study plot and where to look for animals within the plot.

✓ Are able to use humane techniques for capturing and observing small animals.

✓ Have sharper observation skills, and understand the difference between an observation and an idea.

✓ Are ready to behave like scientists outdoors.

What You'll Need

Session 1

For the class:

- ❑ overhead transparencies of animals and animal signs (see "Getting Ready")
- ❑ set of field equipment:
  - pointed metal or wooden stake, about 60 cm long
  - 2.5 meter cord tied to a metal ring that fits over the stake
  - clear plastic cup
  - plastic spoon
  - cotton swab
  - index card
  - small eraser or piece of chalk

Session 2

For each student:

- ❑ hand lens
- ❑ item to observe (see "Getting Ready")

Vocabulary

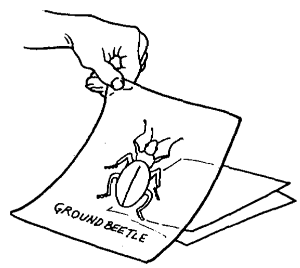
FIELD - Scientists' name for the outdoors.

STUDY PLOT - A small piece of land used for observations.

Getting Ready

Session 1

- Make overhead transparencies using pictures from the *Who Eats What* guide (pages 355–382). First find the habitat description that most closely resembles your study site. Then choose pictures of a few signs of animals from pages 360–364, and several animal pictures from pages 367–381. Animals students are most likely to see include squirrels, sow bugs, millipedes, beetles, and spiders. You might want to enlarge the pictures on a copier so that you have just one image per overhead.



Session 2

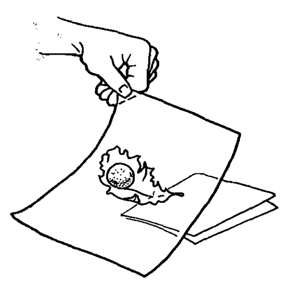
- Gather enough objects so that each student (or every two students) has something to use to practice observation skills. Small stones, dead leaves, pine cones, twigs, or pieces of fruit are appropriate materials. Using items that are similar to one another will allow you to extend the activity by mixing them and challenging students to find the object they observed.

Action Narrative

Session 1

Let's look at some pictures of animal signs we might see on our study site.

Show and discuss the animal signs overheads you've made, pointing out that looking on or among plants provides many clues about animals. Also emphasize that finding animals and animal signs takes careful observation and patience.



One way to find animal signs is to think like Sherlock Holmes. When he walked onto the scene of a crime he looked for things that were out of place or different from usual. On the study site, green leaves and fresh twigs on the ground could mean that squirrels or insects are feeding overhead. Dirt and leaves scraped aside might indicate that an animal is burying or looking for food there. Leaves with holes or edges eaten away could mean that a caterpillar or other insects are eating the leaf. A white coating of droppings on leaves might be the result of a bird that flew over or perched above them. Keeping your eyes open for things that don't appear quite right is a good way to tune into animal activity outdoors.

Now let's look at some pictures of animals we might see at our study site. By thinking about the answers to three questions, we can figure out some information about what an animal eats:

1) Where is the animal located?

2) What sort of body (mouth, eyes, legs, and shape) does the animal have?

3) How does the animal behave?

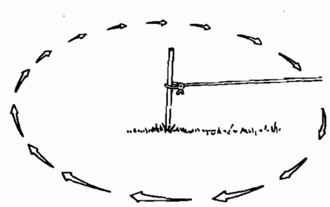
If you show a picture of an earthworm, students might suggest that it is found in the soil near the surface, so there is a good chance it eats something that is in or on top of the soil. It doesn't seem to have eyes or legs. It does have a mouth opening, but no teeth or pincers, so it probably doesn't eat other animals. It stretches and contracts. This helps it get food in the soil, and to avoid becoming food for another animal by retreating quickly from the surface. Have students take this kind of reasoning as far as they can for each animal picture you show.

Scientists always make a plan of action before they start an investigation. What are some things we should plan before we go outside?

Students might mention that they need to decide what they should do, what equipment they'll need, what notes they should take, and how to split up the space and tasks. Give them as much responsibility for deciding how to run the study as possible, trying to strike a balance between encouraging them to develop their own plans and teaching them the field methods described below.

We're going to use some of the same methods ecologists use when they do studies like ours in the FIELD, their name for the outdoors. We'll work in small groups. Each group will have a set of field equipment to make a STUDY PLOT, a small piece of land used for observations.

Show students the field equipment. Ask a volunteer to hold the stake upright on the floor. Slip the ring and cord over the stake and have another student hold the end of the cord so that it is fully stretched.



When you're outside, another team member will walk behind the person holding the cord to sprinkle a flour border in his or her footsteps.

Have the cord holder walk the circumference of the circle, acting like a human drawing compass, while a student follows pretending to sprinkle flour.

The area within your flour circle will be your study plot. Where will you look for animals and animal signs within your plot?

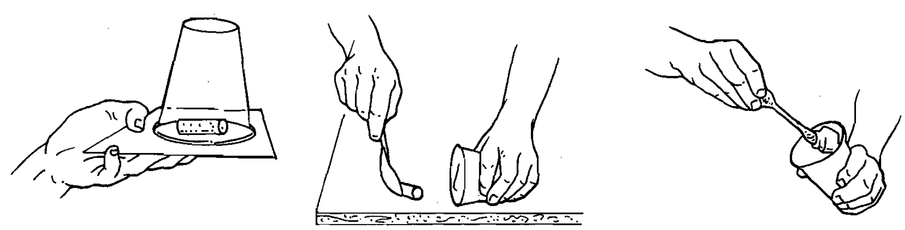
Students might suggest looking under leaves, sticks, rocks, and logs; on leaves, twigs, and trunks; in moist spots, crevices, and topsoil.

In order not to trample any plants, animals, or animal homes, remember to step lightly, touch gently, and move gracefully within your plot. Imagine yourselves "stalking" nature, acting like Native Americans did while hunting, being both aware and respectful.

Have a few students demonstrate stalking around the classroom.

Ecologists often capture small animals for closer observation. How would it feel to be an ant captured by a giant? How would you want to be treated?

Demonstrate three ways that a small animal can be gently captured, using a pencil eraser or a small piece of chalk to represent the animal:



1 2 3

1) Put the open end of the cup over the object, then slide an index card beneath it. Once sealed, turn the cup right side up and keep the card on top.

2) Coax the animal into the cup using the spoon.

3) Put the cotton swab in the path of the animal so it will crawl up it, then put the swab and animal in the cup.

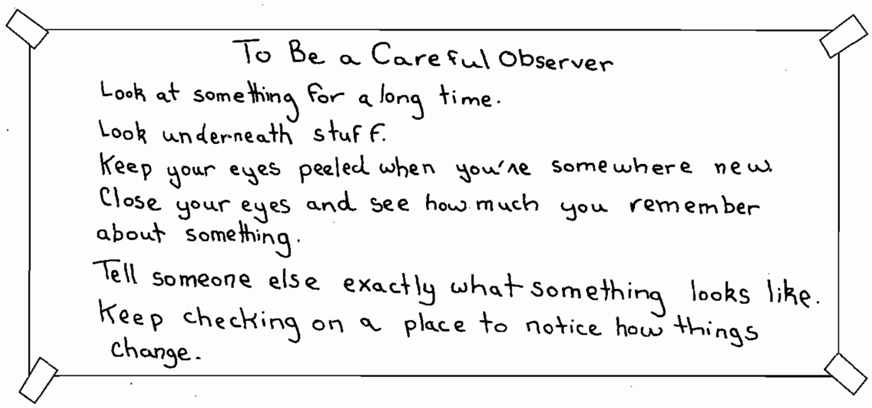
Demonstrate how to use the hand lens through the top, side, or bottom of the cup for closer viewing.

After you observe a small animal, it is important to return it back where you found it. Be sure not to touch animals with your bare hands — for your own safety and for the creature's protection.

Session 2

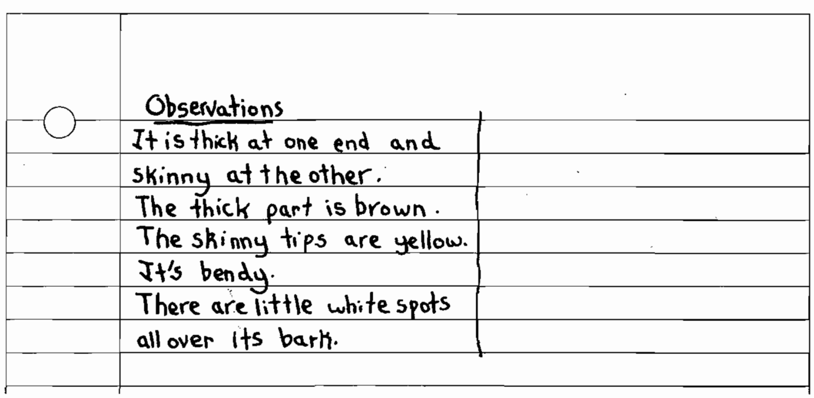
Scientists have to be careful observers. What does a good observer do?

As students list characteristics of good observers, encourage them to talk about times when they have watched something carefully or noticed something that nobody else did. Key qualities of observers include: looking closely and carefully, listening intently, noticing key features, watching something over time, being patient and aware, and practicing these skills often. You might want to record students' ideas on a poster to hang in the classroom, and encourage them to continue to add to or revise the list.



Let's practice observation and recording skills using your science journal. On the left side of a page write "Observations." When I give you something to observe, look closely at it. Then, when you're ready, jot down some words that describe it.

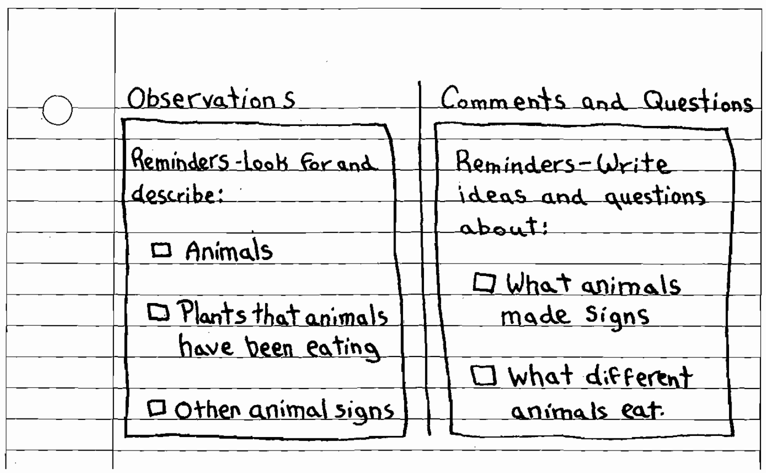
Give each student or pair of students an object to observe (e.g., a twig, leaf, rock). Make your own observations of an object along with the students.



After five or ten minutes, show students a hand lens and demonstrate how to use it. The best approach is to hold the hand lens up to your eye, resting your thumb on your cheek, then bring the object up to the lens, or move your head to the object, rather than moving the lens away from your eye toward the object. Give each student a lens so that they can practice this technique.

You'll need a place to record notes while we're outside. Scientists always prepare a data sheet to remind them what information to record. Prepare a page in your journals for your notes by drawing a line down the center of an empty page. Write "Observations" on the left half, and "Comments and Questions" on the right side. What kinds of notes will you put in each of these sections?

Students are likely to respond that in the "Observations" section they'll record whatever they see that gives them clues about what animals live on the site and what they eat: animals, plants that animals have been eating, and other signs of animals. In the "Comments and Questions" section they'll write ideas about what they think an animal they saw might eat, what animal might have made a sign they see, as well as questions relating to animals and their food. They might want to note some of these points in their journals to remind them what to record in each section when they're outside.



What other information would be useful to record?

Encourage students to make additional sections for notes they think are important to take, such as: the date, notes about weather conditions, a list of non-living things, an overall description of the site, etc.

One last thing we need to talk about is how scientists behave while doing outdoor research. What are your ideas?

After students have shared their thoughts, add anything they haven't mentioned, such as:

- Outdoors is a place for work, like the classroom, so use time wisely.
- Handle living things and equipment with care.
- Don't damage plants by ripping leaves or bark off trees, etc.
- Stay inside the boundaries of the study area.
- Never put any leaves, berries, mushrooms, etc. in your mouth.

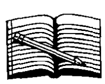
- Don't run, throw things, or chase animals.
- Work quietly so as not to scare away wildlife.
- Don't touch or collect any sort of dead animal, whether it's a bird, mammal, insect, worm, or whatever.
- Don't touch or pick mushrooms.
- Don't touch or collect animal droppings.
- Don't touch human artifacts that are a health hazard (e.g., needles, vials, band-aids, broken glass).
- Don't put anything, including your hands, in your mouth.
- Wash your hands as soon as you come indoors.

If exploring the outdoors is new to your students, talk through any anxieties or fears they have. Help them think of ways to get comfortable with being outdoors, so their emotions don't lead to behaviors that will distract them and others from their tasks.

Ongoing Assessment

Student Reflections

Have students send a C-Mail message or record thoughts in their journals. Optional journal writing prompts include:



Animals I'd like to see and learn more about are...

Times when I've been a good observer are...

Teacher Reflections

- ❑ Do students have ideas of where and how to look for animals and clues about what they eat?
- ❑ Are they prepared to set up study plots, use observation equipment, and take notes while outdoors?

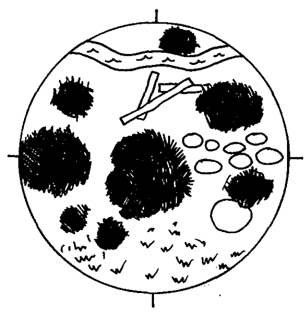
Extensions

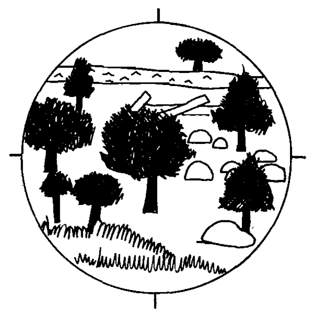
Mapmaking Preparation. Making a map of the study site is an optional part of the next lesson. A map of the site's natural features provides a compelling visual nucleus for students' reports, and is a common component of professional field ecologists' reports. Students will need some practice in map making techniques, however, before going outdoors.

Bring to class, and ask students to collect, examples of site maps, such as from nature center, zoo, and museum brochures. Also try to borrow a survey map of some local land from a realtor or the town or county planning department. Talk about how the scale and purpose of these maps differ from road and continent maps.

Place the map samples at stations that students can visit to observe the different techniques the map makers used. Discuss what they notice about the maps, such as how plants, paths, roads, and other features are represented, and whether or not symbols and a key are used.

You might want to enlist the help of the art teacher in providing instruction and practice drawing maps, perhaps by mapping the classroom. Precise scale is not so important for the study site map as is simply getting the prominent features of the plots drawn in a way that is easy for the viewer to interpret. The maps shown below use combinations of symbols and pictures from two viewpoints: a bird's eye view in which the artist imagines s/he is hovering over the plot looking down on what is there, and a ground level view in which the artist stands at one edge of the plot.


Bird's Eye View


Ground Level View

Before going outside, students might want to make a key of symbols for common objects such as dead logs, pine trees, other trees, shrubs, small plants, and rocks. They can refine and add to these symbols once they are outside.

Finally, help students make a map template by drawing a circle on a piece of unlined paper to represent their study plot This is best done with a compass (or a string tied to a pencil), or by tracing a circular object. Ask them to imagine the circle as a clock face and make short lines at 12, 3, 6, and 9 o'clock. At the top of the circle (12 o'clock), have them write a large N for north. When they are outside students can use flour to mark these same lines on their plot circle, to use as guides for placing features on their map.

More Observation Practice. Take the class outdoors. Set boundaries. Then give students about ten minutes to find a plant or non-living object and write a description of it. Have them exchange their descriptions with a partner, and try to find the object their partner has described. When they have found it (either on their own or with their partner's help), have them add as many new written details as they can to the original description. Once back indoors, discuss why it was easy or difficult to find the objects and how the activity helped them sharpen their observation and recording skills.

APPENDIX F

KNOWLEDGE PROGRESSION

Knowledge — Food Webs

Food for Plants

N • Soil, water, and air are food for plants.
• Plants take in food and make their own food.

N+ • Shows some ideas from Novice level and some from Proficient level.

P • Plants need soil, nutrients, water, and air to live, but these are not food.
• Plants meet their food needs differently than animals do because they cannot eat or take in food.
• Plants use soil, water, carbon dioxide, and energy from sunlight to make their own food (sugars), using the process of photosynthesis.
• Plants use the food they produce to grow and stay healthy.

P+ • Shows some ideas from Proficient level, and some from Advanced level.

A • Some food energy is stored inside plants, and some is released as heat when plants use the food to grow and function.

Food for Animals

N • Anything an animal takes in is food.

N+ • Shows some ideas from Novice level and some from Proficient level.

P • Animals need food, water, and air to live.
• Animals get food from eating plants or other animals.
• Animals get both nutrients and energy from food.

P+ • Shows some ideas from Proficient level, and some from Advanced level.

A • Unlike plants, animals take in food and break it into small particles in their guts.
• Some food energy is stored inside animals, and some is released as heat when animals use the food to grow and function.

Feeding Interactions in Ecosystems

N • Big things eat smaller things.
• An ecosystem is where plants and animals live.

N+ • Shows some ideas from Novice level and some from Proficient level.

P • An ecosystem is an area where living things interact with each other and their physical environment.
• Plants are called producers in an ecosystem because they produce food.
• Animals and microbes are called consumers in an ecosystem because they consume plants and/or animals for food.
• Consumers include: herbivores that eat plants; carnivores that eat animals; omnivores that eat plants and animals; and decomposers that eat dead plants, dead animals, and animal wastes.
• The flow of food from producers to all types of consumers is called a food chain.
• No matter what an animal eats, it depends on the green plants that are at the base of its food chain.

P+ • Shows some ideas from Proficient level, and some from Advanced level.

A • Most organisms and microbes eat and are eaten by more than one thing.
• A food web is the connections among everything animals and microbes in a location eat and are eaten by.
• If a population of plants, animals, or microbes in a food web increases or decreases significantly, the sizes of the populations of other organisms in the web may also change.

Knowledge — Decomposition

Cause of Decomposition

N
- Dead things disappear on their own as time passes.
- Physical conditions, such as wind, rain, battering, and trampling, cause dead things to break down and disappear.

N+
- Shows some ideas from Novice level and some from Proficient level.

P
- Some dead things get eaten by bugs, but dead things also decompose because of physical conditions.

P+
- Shows some ideas from Proficient level, and some from Advanced level.

A
- Dead things decompose because decomposer organisms use them for food.
- Dead things do not decompose without the action of decomposers.

Decomposer Organisms

N
- The only organisms that eat dead plants and animals are things like insects, earthworms, and vultures.
- All microbes are germs that cause diseases.
- Microbes are not living things.

N+
- Shows some ideas from Novice level and some from Proficient level.

P
- Decomposers are animals and microbes that use dead plants and animals and their wastes as food.
- Microbes are everywhere, but are usually invisible to the naked eye.
- Microbes are living things.
- Decomposer microbes get nutrients and energy by consuming food.
- Some bacteria and fungi are decomposer microbes that use dead plants and animals as food.

P+
- Shows some ideas from Proficient level, and some from Advanced level.

A
- Bacteria and fungi consume dead material by being inside or beside it, releasing chemicals to break the material down, then absorbing the tiny particles of nutrients and food energy.

Conditions for Decomposition

N
- Things decompose better in certain conditions, like where it is wet, because the condition itself (e.g., the water) makes them decompose.

N+
- Shows some ideas from Novice level and some from Proficient level.

P
- Most microbes grow best in warm, moist conditions.
- Microbes grow best on dead material that is high in nutrients and energy, and is easy to digest.

P+
- Shows some ideas from Proficient level, and some from Advanced level.

A
- When more decomposers grow on dead material, it decomposes more quickly.
- When people change environmental conditions, decomposition may speed up or slow down.

Knowledge — Nutrient Cycling

Nutrients	Fate of Decomposed Matter	Flow of Nutrients in an Ecosystem
N • Nutrients are like good food. • Nutrients provide energy.	**N** • When things decompose, the matter they were made of disappears. • When things decompose, some of the matter they were made of goes into the ground, but much of it vanishes from existence.	**N** • Nutrients float in the air, not necessarily driven by any particular biological or physical processes. • Nutrients go from one thing to another like a disease travels from person to person.
N+ • Shows some ideas from Novice level and some from Proficient level.	**N+** • Shows some ideas from Novice level and some from Proficient level.	**N+** • Shows some ideas from Novice level and some from Proficient level.
P • Nutrients are tiny particles of matter, not energy. • Nutrients are the building blocks of all living things. • Nutrients are in food, living things, and the physical environment. • Living things grow and stay healthy by taking nutrients into their bodies.	**P** • Decomposed matter goes into the ground as tiny particles. • Decomposed matter might disappear from sight, but the material it was made of does not disappear from existence.	**P** • Nutrients are passed along food chains from plants to animals, from animals to animals, and from dead plants and animals to decomposers. • Decomposers release nutrients from dead material into the physical environment.
P+ • Shows some ideas from Proficient level, and some from Advanced level.	**P+** • Shows some ideas from Proficient level, and some from Advanced level.	**P+** • Shows some ideas from Proficient level, and some from Advanced level.
A • Living things that aren't getting the right kinds or amounts of nutrients often show physical symptoms of stress, such as discolored leaves on plants.	**A** • Decomposed matter becomes part of the organisms that consume it, or it is released into the soil, water, or air. • Matter is not created or destroyed, but is recycled into new forms.	**A** • A nutrient cycle is the flow of nutrients back and forth between living things and the physical environment. • Nutrient cycles are driven partly by biological processes such as the uptake of materials from the physical environment by plants, and the consumption of food and the release of wastes by animals.

APPENDIX G

SAMPLE SCHEDULE

El Espejo 2012

		Team A - Lily
	Time	Team 1
F	8:30-9:00	Photos/Paperwork (Jen)
	9:00-10:30	Pretest/ Intro Dress a Scientists Activity/ Researcher's request
	10:30-12:00 Rotation 1	Rotation I: Team A- Station 1- Biological Surveys/Plants animals (1.1- 1.2)- Facilitator: Jen/Violeta
	12:00-12:30	Lunch
	12:30-2:00 Rotation II	Rotation II: Team B- Station 2- Study Plot Techniques (1.3)- Facilitator: Laura
	2:00-3:30 Rotation III	Rotation III: Team C- Station 3- Feeding Habits (1.4)- Facilitator: Melissa
	3:30-4:00	Facilitator debrief, preparation for next day
		Team A - Lily
	Time	Team 1
S	8:30-9:00	Photos/Paperwork (Jen)
	9:00-10:30	Group photo/ whole group activity- writing letter about camping, then scientist profile: Dr. Mary Price. Facilitators: Jen/Violeta
	10:30-12:00 Rotation IV	Rotation IV: Team A- Station 4- From observation to researchable question (2.3 & 2.5)- Facilitator: Laura
	12:00-12:30	Lunch
	12:30-2:00 Rotation V	Rotation V: Team B- Station 6- Making food chains and food webs- aquatic station (1.6/ 1.8/2.2)- Facilitator: Stephanie
	2:00-3:30 Rotation VI	Rotation VI: Team C- Station 5- Interactions and Human impact (Riparian Trailer)- Facilitator: Melissa
	3:30-4:00	Facilitator- groups for next week, debrief (Jen)
S	Day Off!!!	Sunday
	Time	Team 1
M	8:30-9:00	
	9:00-10:30	Ornithologist- Dr. Benedict
	10:30-12:00	Project Development

	12:00-12:30	**Lunch**
	12:30-2:00	Project Development
	2:00-3:30	Project Development/ Claims/ Full Research Proposal/ Reflection
	3:30-4:00	**Facilitator debrief, preparation for next day (Violeta/Jen)**
T	8:30-9:00	
	9:00-10:30	Rotation VII: Art & Science (paper making)
	10:30-12:00	Bats! - Laura
	12:00-12:30	**Lunch**
	12:30-2:00	3 Talking points/Data Collection
	2:00-3:30	**Women Leaders Tea**
	3:30-4:00	**Facilitator debrief, preparation for next day (Violeta/Jen)**
W	8:30-9:00	
	9:00-10:30	Data Collection/ Question modification/ preparation of presentation
	10:30-12:00	Data Collection/ Question modification/ preparation of presentation
	12:00-12:30	**Lunch**
	12:30-2:00	**Rotary**
	2:00-3:30	Data Analyis/ evidence to support or refute claims/preparation of presentations
	3:30-4:00	**Facilitator debrief, preparation for next day (Violeta/Jen)**
R	8:30-9:00	
	9:00-10:30	Rotation VIII: Fishing
	10:30-12:00	Data Analyis/ evidence to support or refute claims/preparation of presentations
	12:00-12:30	**Lunch**
	12:30-2:00	Data Analyis/ evidence to support or refute claims/preparation of presentations
	2:00-3:30	Data Analyis/ evidence to support or refute claims/preparation of presentations
	3:30-4:00	**Facilitator debrief, preparation for next day (Violeta)**
F	8:30-9:00	**parent signatures (research)**

	9:00-10:30	Finish, set up, and practice presentations
	10:30-12:00	Post knowledge test/ Retroactive Pre-test
	12:00-12:30	Lunch
	12:30-2:00	Group activity
	2:00-3:30	Summer Symposia
	3:30-4:00	Facilitator Focus Group (Violeta/Jen)

APPENDIX H

ECOLOGICAL PRINCIPLES TOOL

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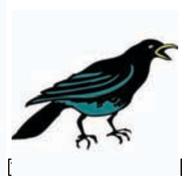
APPENDIX I

CONOCIMIENTOS ECOLÓGICOS (SPANISH)



APPENDIX J

ATTITUDES AND PERCEPTIONS TOWARDS SCIENCE INSTRUMENT

El Espejo: Attitudes and Perceptions

Please circle the number that best indicates how much you agree with each statement BEFORE participating in *El Espejo* and AFTER participating in *El Espejo*.

Circle the word you agree with the most.
1. NO! - Strongly disagree with this statement. This is not who I am or what I think at any time.
2. no - Somewhat disagree. Sometimes this is me.
3. yes - Somewhat Agree. This is who I am or what I think more often than not.
4. YES! - Strongly Agree. This is who I am or what I think most or all of the time.

Example:

	BEFORE participating in this program		AFTER participating in this program
I like pizza.	NO! no yes YES!		NO! no yes YES!

Please circle your answer for each statement →	**BEFORE participating in this program**		**AFTER participating in this program**
I know a lot about science careers.	NO! no yes YES!		NO! no yes YES!
I see myself as a scientist.	NO! no yes YES!		NO! no yes YES!
I study about nature on my own.	NO! no yes YES!		NO! no yes YES!
I see myself as a leader.	NO! no yes YES!		NO! no yes YES!
Humans can have an impact on nature.	NO! no yes YES!		NO! no yes YES!
I do not know how to design an experimental study.	NO! no yes YES!		NO! no yes YES!
Other people do not see me as a science person.	NO! no yes YES!		NO! no yes YES!
My parents (guardians) do not like science.	NO! no yes YES!		NO! no yes YES!
I am able to design my own experimental study.	NO! no yes YES!		NO! no yes YES!
Other people think of me as a science person.	NO! no yes YES!		NO! no yes YES!
I have confidence in my ability to learn to design an experiment.	NO! no yes YES!		NO! no yes YES!
I am not good at science.	NO! no yes YES!		NO! no yes YES!
I do not like asking science-related questions.	NO! no yes YES!		NO! no yes YES!
I do not like to work with others.	NO! no yes YES!		NO! no yes YES!
I like to ask a lot of questions.	NO! no yes YES!		NO! no yes YES!
I like to find answers to questions.	NO! no yes YES!		NO! no yes YES!
I use evidence to back up my claims in an investigation.	NO! no yes YES!		NO! no yes YES!
Girls can do science.	NO! no yes YES!		NO! no yes YES!
Science is only about experimenting with things.	NO! no yes YES!		NO! no yes YES!
My parents (guardians) like science.	NO! no yes YES!		NO! no yes YES!
Human actions do not impact nature.	NO! no yes YES!		NO! no yes YES!

Please circle your answer for each statement →	**BEFORE participating in this program**				**AFTER participating in this program**			
I like to learn about new things.	NO!	no	yes	YES!	NO!	no	yes	YES!
My parents (guardians) see me as a leader.	NO!	no	yes	YES!	NO!	no	yes	YES!
Other people like to work with me.	NO!	no	yes	YES!	NO!	no	yes	YES!
I have had at least one good science teacher.	NO!	no	yes	YES!	NO!	no	yes	YES!
I have not had good science teachers.	NO!	no	yes	YES!	NO!	no	yes	YES!
I prefer not to read about science.	NO!	no	yes	YES!	NO!	no	yes	YES!
Science is not always about experimenting with things.	NO!	no	yes	YES!	NO!	no	yes	YES!
I prefer to work alone.	NO!	no	yes	YES!	NO!	no	yes	YES!
I work well with others.	NO!	no	yes	YES!	NO!	no	yes	YES!
I enjoy reading about science.	NO!	no	yes	YES!	NO!	no	yes	YES!
To write a conclusion, I never look for evidence. I just write what I think should be right.	NO!	no	yes	YES!	NO!	no	yes	YES!
If I have a question, I search for solutions or answers.	NO!	no	yes	YES!	NO!	no	yes	YES!
I do not like spending time outdoors	NO!	no	yes	YES!	NO!	no	yes	YES!
My parents (guardians) think that I am not good at science.	NO!	no	yes	YES!	NO!	no	yes	YES!
I do not like being wrong.	NO!	no	yes	YES!	NO!	no	yes	YES!
When I can't figure something out, I give up.	NO!	no	yes	YES!	NO!	no	yes	YES!
I believe everything my teacher says.	NO!	no	yes	YES!	NO!	no	yes	YES!
Girls are not good at science.	NO!	no	yes	YES!	NO!	no	yes	YES!

Please answer the following questions:

Do you participate in science related things at school? Give examples.
Do you participate in science related things outside of school? Give examples.
Do you have any hobbies (activities you enjoy)? What are they?

APPENDIX K

ATTITUDES AND PERCEPTIONS TOWARDS SCIENCE INSTRUMENT

(SPANISH)

El Espejo: Actitudes y Percepciones

Por favor circula la palabra que indica que tan de acuerdo estás con cada declaración ANTES de participar en *El Espejo*, y DESPUES de participar en *El Espejo.*

1. NO! - Totalmente en desacuerdo. No me describe a mí o lo que pienso en cualquier momento.
2. no - En desacuerdo, a veces me describe.
3. si - De acuerdo. Esto me describe a mí o lo que pienso más seguido.
4. SI! - Totalmente de acuerdo. Me describe a mi o lo que pienso la mayoría el tiempo o todo el tiempo.

Ejemplo:	ANTES **de participar en este programa**		DESPUES **de participar en este programa**
Me gusta la pizza.	NO! no si SI!		NO! no si SI!
No me gusta la pizza	NO! no si SI!		NO! no si SI!

Por favor marque su respuesta para cada afirmación.→	**ANTES de participar en este programa**		**DESPUES de participar en este programa**
Yo sé mucho acerca de las carreras científicas.	NO! no si SI!		NO! no si SI!
Yo me veo como un científico.	NO! no si SI!		NO! no si SI!
Yo estudio acerca de la naturaleza por mi propia cuenta.	NO! no si SI!		NO! no si SI!
Yo me veo como una líder.	NO! no si SI!		NO! no si SI!
Los seres humanos pueden tener un impacto en la naturaleza.	NO! no si SI!		NO! no si SI!
Yo no sé cómo diseñar un estudio experimental.	NO! no si SI!		NO! no si SI!
Otras personas no me ven como una persona que le gusta la ciencia.	NO! no si SI!		NO! no si SI!
A mis padres/tutores no les gusta la ciencia	NO! no si SI!		NO! no si SI!
Yo soy capaz de diseñar mi propio estudio experimental	NO! no si SI!		NO! no si SI!
Otras personas me ven como una persona que le gusta la ciencia.	NO! no si SI!		NO! no si SI!
Yo tengo confianza en mi habilidad de aprender a diseñar un experimento.	NO! no si SI!		NO! no si SI!
Yo no soy buena con la ciencia	NO! no si SI!		NO! no si SI!
No me gusta hacer preguntas relacionadas con la ciencia.	NO! no si SI!		NO! no si SI!
No me gusta trabajar con los demás.	NO! no si SI!		NO! no si SI!
Me gusta hacer muchas preguntas.	NO! no si SI!		NO! no si SI!
Me gusta encontrar respuestas a mis preguntas.	NO! no si SI!		NO! no si SI!
Puedo usar la evidencia para respaldar mis afirmaciones en una investigación.	NO! no si SI!		NO! no si SI!
Las niñas son buenas en la ciencia.	NO! no si SI!		NO! no si SI!

Por favor marque su respuesta para cada afirmación→	**ANTES de participar en este programa**		**DESPUES de participar en este programa**
La ciencia consiste solamente de experimentar con las cosas.	NO! no si SI!		NO! no si SI!
A mis padres/tutores les gusta la ciencia.	NO! no si SI!		NO! no si SI!
Las acciones humanas no afectan a la naturaleza.	NO! no si SI!		NO! no si SI!
Me gusta aprender cosas nuevas.	NO! no si SI!		NO! no si SI!
Mis padres/tutores me ven como una líder	NO! no si SI!		NO! no si SI!
A las otras personas les gusta trabajar conmigo.	NO! no si SI!		NO! no si SI!
He tenido por lo menos un buen maestro de ciencia.	NO! no si SI!		NO! no si SI!
No he tenido buenos maestros de ciencia.	NO! no si SI!		NO! no si SI!
Prefiero no leer sobre la ciencia.	NO! no si SI!		NO! no si SI!
La ciencia no siempre se trata de experimentar con las cosas.	NO! no si SI!		NO! no si SI!
Prefiero trabajar sola.	NO! no si SI!		NO! no si SI!
Trabajo bien con los demás.	NO! no si SI!		NO! no si SI!
Me gusta leer acerca de la ciencia.	NO! no si SI!		NO! no si SI!
Para escribir una conclusión, nunca busco la evidencia. Yo sólo escribo lo que pienso que debe estar correcto.	NO! no si SI!		NO! no si SI!
Si tengo una pregunta, yo busco la solución o la respuesta.	NO! no si SI!		NO! no si SI!
No me gusta pasar tiempo al aire libre.	NO! no si SI!		NO! no si SI!
Mis padres/tutores creen que no soy buena en la ciencia	NO! no si SI!		NO! no si SI!
No me gusta estar equivocada.	NO! no si SI!		NO! no si SI!
Cuando no puedo encontrar alguna respuesta mejor me doy por vencida.	NO! no si SI!		NO! no si SI!
Creo que todo lo que mi maestro dice.	NO! no si SI!		NO! no si SI!
Las niñas no son buenas en la ciencia.	NO! no si SI!		NO! no si SI!

Por favor contesta las siguientes preguntas:

¿Qué aprendiste sobre las careras en la ciencia? Nombra algunas de las mujeres profesionales que conociste y que aprendiste de ellas.
Si quisieras ser una científica, cual tipo de científica fueras y explica por que.
¿Cuáles experiencias que tuviste durante la semana del Espejo te ayudaran en el futuro?
Describe tu experiencia de esta semana en 3 palabras.

APPENDIX L

SAMPLE RECRUITMENT FLYER

GIRLS SUMMER RESEARCH INSTITUTE

June 22 - 29, 2011
Poudre Learning Center

SCHOLARSHIPS AVAILABLE

TRANSPORTATION AVAILABLE

- ✔ Develop an outdoor science project to explore your world
- ✔ Make new friends
- ✔ Stretch your imagination in new creative ways
- ✔ Learn new skills

$150
for the week!

El Espejo

GIRLS 5TH - 8TH GRADE

For more information contact
Poudre Learning Center
8313 West F Street
Greeley, Colorado 90631
(970)352-1267

Poudre Learning Center

Your Partner in Inquiry & Application for 21st Century Skills

APPENDIX M

FACILITATOR, MENTOR, VOLUNTEER FLYER

Mentors, Researchers, and Volunteers Needed

El Espejo, Spanish for mirror, is an ongoing summer research program for youth at the Poudre Learning Center (PLC) promoting inquiry based learning for 5th-8th grade girls. All activities are designed to promote career awareness, cultural awareness, mentorship, and the development and application of 21st Century skills. This program provides opportunities for youth to envision what it would be like to be a researcher (whether a scientist, a mathematician, or an engineer) as a future profession. Students will be exposed to one week of research-oriented inquiry activities. In order to make this happen, we need your help! We are seeking talented individuals interested in working with 3-4 middle school youth on individual or team projects.

Mentors can be any community leaders, teachers, or college students who are interested in building personal relationships with young adults throughout the week. You will be involved in teambuilding, leadership activities, and may even learn some science yourself!

Researchers can be practicing scientists, or engineers as well as graduate students interested in guiding the team through an inquiry based project. Your can decide if you want students to carry out an individual project or a team project. Each team will decide how they want to document the experience and showcase the development of the research question(s), the data you team gathered, and discussion/conclusions of the project.

Volunteers can be high school or college students with strong leadership potential. As a volunteer, you will be in charge of documenting the team's experience through video and photography. You will also serve as the team liaison with the program coordinator and gather any materials needed based on your team's project.

Dates: June 22- June 29 **Hours:** 8:30am-4:00pm

(only two team leaders need to be present at any given time,
e.g. mentor-volunteer, volunteer-researcher, or mentor-researcher).
We ask for **at least 10 hours** of your time during the week.

For more information contact **Tammy Rusch** at trusch@plcoutdoors or
Yeni Violeta García at yeni.garcia@unco.edu
Phone: 970.352.1267 Website: PLCoutdoors.org/El_Espejo

APPENDIX N

BILINGUAL PROGRAM APPLICATION

Student Application

Poudre Learning Center
8313 West F Street
Greeley, Colorado 80631
970.352.1267

I. STUDENT INFORMATION

Name:

Date of birth:

Age:

Current school:

Current Grade: ☐ 5th ☐ 6th ☐ 7th ☐ 8th

School **NEXT** year:

Ethnicity (check all that apply):

☐ Native American or Native Alaskan ☐ Asian or Pacific Islander ☐ Black or African American

☐ Latino/Hispanic ☐ White/Caucasian ☐ Other:

Are you a part of the Free or Reduced Lunch Program at school?
¿Calificas para el programa de almuerzo gratis o de costo reducido en la escuela? ☐ Yes ☐ No

II. PARENT/GUARDIAN INFORMATION

Parents/Guardians:

Address:

City: Phone:

State: Zip Cell Phone:

Email:

III. EMERGENCY CONTACT

Name of person not living with you:
Nombre de un familiar que no vive en su hogar

Address:

City: State: Zip Code:

Phone: Cell phone:

Relationship to student: *(Aparentasgo al estudiante)*

Do you need a ride to the Poudre Learning Center? *¿Necesitas transportación al Poudre Learning Center?* ☐ Yes ☐ No

Would you like our help in arranging transportation to the Poudre Learning Center?
¿Quisieras nuestra ayuda para buscar transportación al Poudre Learning Center ☐ Yes ☐ No

IV. PROGRAM APPLICATION SHORT ESSAYS

Answer each question. *Contesta cada pregunta. Puedes contestarlas en español.*

1. What leadership skills do you have to offer? *¿Cuáles cualidades de liderazgo puedes ofrecer?*

2. What interests you about science or engineering? *¿Qué es lo que te intersa de la ciencia o la ingeniería?*

3. What class or classes interest you most and why? *¿Cuál materia o materias te intersán más y por qué?*

4. Why do you want to participate in *El Espejo*? *¿Por qué quieres participar en* El Espejo*?*

V. PHOTO RELEASE

By signing below, I hereby assign and grant to the Poudre Learning Center (PLC) the right and permission to use and publish the photographs/ film/videotapes/electronic representations and/or sound recordings made of my daughter during the *El Espejo:* Girls Summer Science Research Program or other activities related to this PLC program.
I hereby release the PLC from any and all liability from such use and publication.
I hereby authorize the reproduction, sale, copyright, exhibit, broadcast, electronic storage and/or distribution of said photographs/film/ videotapes/electronic representations and/or sound recordings without limitation at the discretion of the PLC and I specifically waive any right to any compensation I may have for any of the foregoing.

Parent/Guardian signature:

Yo, al firmar este documento otorgo al Poudre Learning Center (PLC) el derecho y el permiso para utilizar y publicar las fotografías/películas/ videos/representaciones electrónicas o grabaciones realizadas de mi hija durante *El Espejo*: programa de ciencias en el verano para chicas o otras actividades relacionadas con este programa del PLC.
Yo, por medio de este documento, libero al PLC de cualquier y toda responsabilidad de su uso y publicación de tales materiales.
Por la presente autorizo la reproducción, venta, derechos de autor, exhibición, difusión, almacenamiento electrónico y distribución de dichas fotografías/películas/videos/representaciones electrónicas, o grabaciones, sin limitaciones, a la discreción del PLC y específicamente renuncio a cualquier derecho a cualquier compensación que pueda tener cualquiera de los anteriores.

Firma del padre/guardián:

V. PAYMENT

Select one:

- ◯ Full payment of $150.00 is enclosed. Checks payable to the "Poudre Learning Center".
  El pago completo de $150 esta incluido. Cheques a nombre del "Poudre Learning Center"
- ◯ I would love to participate but need financial assistance to do so. (Please fill out the **scholarship application**.)
  Me encantaría participar pero necesito ayuda financiera para hacerlo. (Favor de completar la solicitud de becas "**scholarship application**")

What is your family income? (Optional) ¿Cuál es el ingreso de tu familia?

◯ Below $10,000 ◯ $10,001 to $20,000 ◯ $20,001 to $30,000 ◯ $30,001 to $40,000
◯ $40,001 to $50,000 ◯ $50,001 to $75,000 ◯ $75,000 and above

VI. SIGNATURE

I certify that all information supplied in this application is accurate and complete. *Aseguro que la información en este formulario esta exacta y completa.*

Signature of student: Date:

Signature of parent/guardian: Date:

Mail completed form to **Tammy Rusch** at:

Poudre Learning Center
8313 West F Street
Greeley, Colorado 80631

Or have a parent or guardian drop off the application at the PLC
Or ask your teacher or counselor to send it via school mail if you are in the Greeley-Evans school district.
Or scan and email application to trusch@plcoutdoors.org

Mark your calendar for June 22 through June 29th
Program time 9:00am to 3:30pm

APPENDIX O

SCHOLARSHIP APPLICATION

8313 West F Street
Greeley, Colorado 80631
970.352.1267

Scholarship Application

I. STUDENT INFORMATION

Student name: ____________________

Parents/Guardians: ____________________

Phone number: ____________________

II. NEEDS ASSESSMENT

Will you need a full scholarship, or a partial scholarship?

☐ Full scholarship ☐ Partial scholarship, we can pay $____________ towards program registration fees.

III. SHORT ESSAYS

Please explain any circumstance that is keeping you from being able to pay for this program.

How would this experience benefit you in achieving your personal goals?

IV. SIGNATURES

I certify that all information supplied in this application is accurate and complete. *Aseguro que la información en este formulario esta exacta y completa.*

Signature of student: ____________________ Date: __________

Signature of parent/guardian: ____________________ Date: __________

Mail completed form to **Tammy Rusch** at:

Poudre Learning Center
8313 West F Street
Greeley, Colorado 80631

Or have a parent or guardian drop off the application at the PLC
Or ask your teacher or counselor to send it via school mail if you are in the Greeley-Evans school district.
Or scan and email application to trusch@plcoutdoors.org

APPENDIX P

DATA MATRIX

Data Planning Matrix. Goals: To explore the unique aspects of the design of *El Espejo* that lends itself to exposing girls to field ecology; to determine what this program provides for the enhancement of ecological literacy of participants and the formation of a science identity for girls from underrepresented backgrounds and the roles facilitators embrace in this process.

Focus	What information do I need to know?	Why do I need to know this?	What kind of data do I need to answer this?	Where can I find the data?	Why is this method appropriate?	Timeline for acquisition
1- Understanding a Program that Targets a Special Population	**RQ 1: What characteristics of the intervention were necessary to engage girls from underrepresented background in the experience?** What attributes of a defined intervention contributed to the effectiveness of the intervention as measured by the goals fulfilled? What roles did facilitators undertake in this intervention that contributed or hindered the girls' experiences?	To identify and explain the attribues of the intervention that the girls participate in and the field protocols they learned; to explore the design/characteristics of the program. To understand the role facilitators had in the program and program design.	Focus groups Individual semi-structured interviews Participant-observer field notes Year 1 team quilt Photo documentation Participant journals Artifacts	Planning/curriculum binder Past schedules Facilitator journals Girls' journals Researcher journal Researcher's computer PLC shared drive for photos, other documents	Observation rendered first-hand account of phenomenon; second-hand account will come from the other sources of data. Exploring what role facilitators played during the program helped me understand if they had an impact on the girl's development of a science identity or not. I could potentially learn if the facilitators, influenced the girls interest in science or not.	2009 - June 29, 2012 May 2012- Curriculum-May 2012 Photographs- after June 29th June 22-29
2 -Ecological Knowledge as a Component of Scientific Literacy	**RQ 2: What ecological knowledge did middle school girls have before and after the intervention?** How did ecological knowledge contribute to girls' scientific literacy?	To understand the role of of informal science education on the learning of ecological concepts	Content knowledge pre-post test Retroactive pre-test Semi-structured interviews Participant-observer field notes 5 min. observation protocol Symposium presentations	Instruments were adapted form existing instrument Week of *El Espejo* Facilitator journals Girls' journals Researcher journal Researcher's computer	Having baseline data helped understand what key concepts the girls learned during the week. The semi-structured interviews helped clarify concerns that arise as a result of the pre/post test.	2009 - June 29, 2012 June 22- give pre-test June 29- give post test June 29th- copies of all journals July- schedule and interview selected participants July- transcribe all interviews
3- Understanding Science Identity Formation as an Integrated Process	**RQ 3: In what ways did middle school girls' science identities develop through participation in *El Espejo*?** Did being part of a "system" help or hinder the girls' science identity formation? How did girls' science identities change over the course of the program?	To assess the girls' awareness of their science identity and how the program builds or hinders this development	Semi-structured interviews Participant Observer field notes Attitudes and perceptions pre/post tool	Facilitator journals Girls' journals Researcher journal Researcher's computer for transcripts Instrument adapted form existing instrument to gage pre/post attitudes and perceptions about science and science practices	Understanding if the girls perceived themselves as "science people" or as interested in science may be important if they did not see themselves as science people before participating in the program	2009 - June 29, 2012 June 22- give pre-test June 29- give post test Student interviews-July 2012 Facilitator focus groups- June 21, June 29th

APPENDIX Q

ECOLOGICAL KNOWLEDGE PARTICIPANT RESPONSES PRE/POST

	Participant 1		Participant 2		Participant 3		Participant 4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. A major forest fire in Colorado creates dust and reduces sunlight only near the area where the fire is occurring.	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE
2. The primary source of energy on earth is the sun.	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3. Flooding on a river renews and replenishes the environment.	TRUE	TRUE	I DO NOT KNOW	FALSE	TRUE	TRUE	FALSE	FALSE
4. When colonizing a new area, plants, animals, and even people compete for resources to live, grow, and reproduce	I don't understand the question	I don't understand the question	I don't understand the question	I do not know	TRUE	TRUE	I do not know	I do not know
5. The warming of the Pacific Ocean influences the weather	I don't understand the question	throughout North and South America	I do not know	I do not know	Throughout north and south america	throughout North and South America	I do not know	I do not know
6. For a person to get the most food energy out of 100 lbs of vegetables and grain the person should…	I don't understand the question	eat the vegetables and grain	I do not know	feed the fegetables and grain to an animal and eat the meat	eat the vegetables and grain	eat the vegetables and grain	eat the vegetables and grain	I do not know
7. To protect an area from flooding, walls are constructed along the riverbanks. As a result, downstream flooding will…	decrease	increase	decrease	decrease	I do not know	increase	I do not know	I do not know
8. Landowners sometimes build dams on streams to create ponds. What is the impact of a dam on a stream? The dam causes	changes in the entire stream	I don't understand the question	I do not know	changes the stream in the pond area	changes in the entire stream	changes in the entire stream	I do not know	I do not know
9. Each summer your neighborhood is sprayed with the same bug killer to control mosquitoes. After a few years of spraying the same product, what do you think will happen? The mosquitoes will likely	become resistant to the spray	become resistant to the spray	I do not know	I do not know	become resistant to the spray	become resistant to the spray	I do not know	disappear
10. What usually happens to organisms when an area gets crowded?	I don't understand the questions	I don't understand the question	I don't know	They compete against each other	They compete against each other	They compete against each other	They compete against each other	I do not know

	Participant 5		Participant 6		Participant 7		Participant 8	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. A major forest fire in Colorado creates dust and reduces sunlight only near the area where the fire is occurring.	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
2. The primary source of energy on earth is the sun.	I DO NOT KNOW	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3. Flooding on a river renews and replenishes the environment.	TRUE	TRUE	I DO NOT KNOW	FALSE	TRUE	FALSE	I DO NOT KNOW	FALSE
4. When colonizing a new area, plants, animals, and even people compete for resources to live, grow, and reproduce	TRUE	TRUE	I do not know	TRUE	I don't understand the question	TRUE	I don't understand the question	I do not know
5. The warming of the Pacific Ocean influences the weather	Throughout north and south america	throughout North and South America	NO RESPONSE	I do not know	I do not know	I do not know	I do not know	I do not know
6. For a person to get the most food energy out of 100 lbs of vegetables and grain the person should…	Feed the vegetables and grain to a cow to produce the milk, feed the milk to an animal, eat the meat.	feed the vegetables and gran to a cow to produce milk, feed the milk to an animal and eat the meat.	I don't understand the question	eat the vegetables and grain	I do not know	I do not know	I do not know	feed the vegetables and gran to a cow to produce milk, feed the milk to an animal and eat the meat.
7. To protect an area from flooding, walls are constructed along the riverbanks. As a result, downstream flooding will…	decrease	increase	increase	increase	increase	increase	decrease	decrease
8. Landowners sometimes build dams on streams to create ponds. What is the impact of a dam on a stream? The dam causes	Changes the stream in the pond area	changes the stream in the pond area	I do not know	changes in the entire stream	I don't understand the question	changes in the entire stream	I do not know	changes in the entire stream
9. Each summer your neighborhood is sprayed with the same bug killer to control mosquitoes. After a few years of spraying the same product, what do you think will happen? The mosquitoes will likely	become resistant to the spray	become resistant to the spray	disappear	disappear	become resistant to the spray	I do not know	disappear	I do not know
10. What usually happens to organisms when an area gets crowded?	I don't know	They compete against each other	They compete against each other	They compete against each other	They compete against each other	They compete against each other	I don't know	They compete against each other

	Participant 9		Participant 10		Participant 11		Participant 12	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. A major forest fire in Colorado creates dust and reduces sunlight only near the area where the fire is occurring.	TRUE	FALSE	FALSE	FALSE	TRUE			
2. The primary source of energy on earth is the sun.	TRUE	TRUE	TRUE	TRUE	TRUE			
3. Flooding on a river renews and replenishes the environment.	FALSE	FALSE	I DO NOT KNOW	I do not know	FALSE			
4. When colonizing a new area, plants, animals, and even people compete for resources to live, grow, and reproduce	TRUE	TRUE	TRUE	TRUE	FALSE			
5. The warming of the Pacific Ocean influences the weather	I do not know	I do not know	Throughout north and south america	I do not know	I do not know			
6. For a person to get the most food energy out of 100 lbs of vegetables and grain the person should…	I do not know	eat the vegetables and grain	eat the vegetables and grain	feed the vegetables and grain to an animal and eat the meat	I do not know			
7. To protect an area from flooding, walls are constructed along the riverbanks. As a result, downstream flooding will…	decrease	decrease	decrease	decrease	increase			
8. Landowners sometimes build dams on streams to create ponds. What is the impact of a dam on a stream? The dam causes	changes the stream in the pond area	changes in the entire stream	Changes the stream in the pond area	changes in the entire stream	Changes the stream In the pond area			
9. Each summer your neighborhood is sprayed with the same bug killer to control mosquitoes. After a few years of spraying the same product, what do you think will happen? The mosquitoes will likely	become resistant to the spray	become resistant to the spray	disappear	remain the same year after year	remain the same year after year			
10. What usually happens to organisms when an area gets crowded?	The compete against each other	They compete against each other	They compete against each other	They compete against each other	I don't know			

	Participant 13		Participant 14		Participant 15		Participant 16	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. A major forest fire in Colorado creates dust and reduces sunlight only near the area where the fire is occurring.	FALSE	FALSE	I DO NOT KNOW	FALSE	I DO NOT KNOW	FALSE	FALSE	FALSE
2. The primary source of energy on earth is the sun.	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	I do not know
3. Flooding on a river renews and replenishes the environment.	TRUE	TRUE	FALSE	TRUE	I DO NOT KNOW	FALSE	I DO NOT KNOW	FALSE
4. When colonizing a new area, plants, animals, and even people compete for resources to live, grow, and reproduce	TRUE	TRUE	TRUE	TRUE	I don't know	TRUE	TRUE	TRUE
5. The warming of the Pacific Ocean influences the weather	Throughout north and south america	throughout North and South America	Throughout North and South America	I do not know	I do not know	I do not know	I do not know	throughout North and South America
6. For a person to get the most food energy out of 100 lbs of vegetables and grain the person should…	eat the vegetables and grain	eat the vegetables and the grain	feed the vegetables and grain to an animal and eat the meat	eat the vegetables and grain	I do not know	I don't understand the question	eat the vegetables and grain	eat the vegetables and grain
7. To protect an area from flooding, walls are constructed along the riverbanks. As a result, downstream flooding will…	increase	decrease	increase	increase	I do not know	increase	increase	increase
8. Landowners sometimes build dams on streams to create ponds. What is the impact of a dam on a stream? The dam causes	changes in the entire stream	changes in the entire stream	changes in the entire stream	changes in the entire stream	I do not know	changes the stream in the pond area	changes in the entire stream	changes the stream in the pond area
9. Each summer your neighborhood is sprayed with the same bug killer to control mosquitoes. After a few years of spraying the same product, what do you think will happen? The mosquitoes will likely	become resistant to the spray	become resistant to the spray	disappear	disappear	I do not know	become resistant to the spray	become resistant to the spray	become resistant to the spray
10. What usually happens to organisms when an area gets crowded?	They compete against each other	They compete against each other	I don't understand the questions	They compete against each other	I don't know		They usually die out	They compete against each other

	Participant 17		Participant 18		Participant 19		Participant 20	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. A major forest fire in Colorado creates dust and reduces sunlight only near the area where the fire is occurring.	FALSE	FALSE	I DO NOT KNOW	FALSE	FALSE	FALSE	FALSE	FALSE
2. The primary source of energy on earth is the sun.	I DO NOT KNOW	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	FALSE
3. Flooding on a river renews and replenishes the environment.	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
4. When colonizing a new area, plants, animals, and even people compete for resources to live, grow, and reproduce	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
5. The warming of the Pacific Ocean influences the weather	Throughout North and South America	throughout North and South America	I do not know	Throughout North and South America	Throughout North and South America	Throughout North and South America	Throughout North and South America	just in the United States
6. For a person to get the most food energy out of 100 lbs of vegetables and grain the person should…	eat the vegetables and grain	eat the vegetables and grain	I do not know	feed the vegetables and gran to an animal and eat the meat	eat the vegetables and grain	feed the vegetables and grain to an animal and eat the meat	eat the vegetables and grain	eat the vegetables and grain
7. To protect an area from flooding, walls are constructed along the riverbanks. As a result, downstream flooding will…	decrease	increase	increase	I do not know	decrease	I do not know	decrease	increase
8. Landowners sometimes build dams on streams to create ponds. What is the impact of a dam on a stream? The dam causes	changes in the entire stream	changes in the entire stream	I do not know	changes in the entire stream	changes in the entire stream	changes in the entire stream	changes the stream in the pond area	changes in the entire stream
9. Each summer your neighborhood is sprayed with the same bug killer to control mosquitoes. After a few years of spraying the same product, what do you think will happen? The mosquitoes will likely	become resistant to the spray	remain the same year after year	disappear	become resistant to the spray	become resistant to the spray	become resistant to the spray	become resistant to the spray	become resistant to the spray
10. What usually happens to organisms when an area gets crowded?	I don't know	They compete against each other	I don't know	they usually die out	They compete against each other	They compete against each other	They compete against each other	They compete against each other

	Participant 21		Participant 22		Participant 23		Participant 24	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. A major forest fire in Colorado creates dust and reduces sunlight only near the area where the fire is occurring.	TRUE	TRUE	I DO NOT KNOW	I do not know	FALSE	FALSE	FALSE	FALSE
2. The primary source of energy on earth is the sun.	TRUE	I do not know	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3. Flooding on a river renews and replenishes the environment.	I DON'T UNDERSTAND THE QUESTION	FALSE	I DON'T UNDERSTAN D THE QUESTION	FALSE	TRUE	TRUE	FALSE	TRUE
4. When colonizing a new area, plants, animals, and even people compete for resources to live, grow, and reproduce	I DON'T KNOW	FALSE	TRUE	TRUE	I don't understand the question	I do not know	TRUE	TRUE
5. The warming of the Pacific Ocean influences the weather	I don't understand the question	just in the United States	I do not know	I don't undestand the question	Throughout North and South America	just in California	I do not know	throughout North and South America
6. For a person to get the most food energy out of 100 lbs of vegetables and grain the person should…	eat the vegetables and grain	feed the vegetables and grain to an animal and eat the meat	I do not know	I do not know	Feed the vegetables and grain to a cow to produce the milk, feed the milk to an animal, eat the meat.	feed the vegetables and gran to a cow to produce milk, feed the milk to an animal and eat the meat.	Feed the vegetables and grain to a cow to produce the milk, feed the milk to an animal, eat the meat.	eat the vegetables and grain
7. To protect an area from flooding, walls are constructed along the riverbanks. As a result, downstream flooding will…	decrease	increase	increase	I do not know	increase	increase	decrease	increase
8. Landowners sometimes build dams on streams to create ponds. What is the impact of a dam on a stream? The dam causes	Changes the stream in the pond area	changes in the entire stream	Changes the stream in the pond area	I do not know	changes in the entire stream	changes in the entire stream	changes in the entire stream	changes in the entire stream
9. Each summer your neighborhood is sprayed with the same bug killer to control mosquitoes. After a few years of spraying the same product, what do you think will happen? The mosquitoes will likely	disappear	I don't understand the question	disappear	I do not know	remain the same year after year	remain the same year after year	become resistant to the spray	become resistant to the spray
10. What usually happens to organisms when an area gets crowded?	They usually die out	they usually die out	I don't know	I do not know	they cooperate with each other	They compete against each other	They compete against each other	They compete against each other

	Participant 25		Participant 26		Participant 2		Participant 2	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. A major forest fire in Colorado creates dust and reduces sunlight only near the area where the fire is occurring.	TRUE	FALSE	TRUE	TRUE				
2. The primary source of energy on earth is the sun.	TRUE	TRUE	TRUE	TRUE				
3. Flooding on a river renews and replenishes the environment.	I DO NOT KNOW	I do not know	FALSE	FALSE				
4. When colonizing a new area, plants, animals, and even people compete for resources to live, grow, and reproduce	TRUE	TRUE	TRUE	TRUE				
5. The warming of the Pacific Ocean influences the weather	I do not know	I do not know	just in California	I do not know				
6. For a person to get the most food energy out of 100 lbs of vegetables and grain the person should…	Feed the vegetables and grain to a cow to produce the milk, feed the milk to an animal, eat the meat.	feed the vegetables and grain to an animal and eat the meat	I don't understand the question	eat the vegetables and grain				
7. To protect an area from flooding, walls are constructed along the riverbanks. As a result, downstream flooding will…	increase	stay the same	decrease	increase				
8. Landowners sometimes build dams on streams to create ponds. What is the impact of a dam on a stream? The dam causes	changes in the entire stream	changes in the entire stream	changes the stream in the pond area	I do not know				
9. Each summer your neighborhood is sprayed with the same bug killer to control mosquitoes. After a few years of spraying the same product, what do you think will happen? The mosquitoes will likely	remain the same year after year	remain the same year after year	become resistant to the spray	disappear				
10. What usually happens to organisms when an area gets crowded?	I don't know	they usually die out	They compete against each other	they work together with each other				

	Participant 29		Participant 30		Participant 31		Participant 32 (SP)		Participant 33	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. A major forest fire in Colorado creates dust and reduces sunlight only near the area where the fire is occurring.	FALSE		TRUE	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE	FALSE
2. The primary source of energy on earth is the sun.	FALSE		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3. Flooding on a river renews and replenishes the environment.	TRUE		FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	I DO NOT KNOW	FALSE
4. When colonizing a new area, plants, animals, and even people compete for resources to live, grow, and reproduce	TRUE		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE
5. The warming of the Pacific Ocean influences the weather	Throughout North and South America		I don't understand the question	I do not know	Throughout North and South America	I do not know	I DO NOT KNOW	I do not know	just in California	throughout North and South America
6. For a person to get the most food energy out of 100 lbs of vegetables and grain the person should…	feed the vegetables and grain to an animal and eat the meat		I don't understand the question	eat the vegetables and grain	eat the vegetables and grain	eat the vegetables and grain	eat the vegetables and grain	eat the vegetables and grain	I do not know	eat the vegetables and grain
7. To protect an area from flooding, walls are constructed along the riverbanks. As a result, downstream flooding will…	increase		increase	increase	decrease	increase	stay the same	I do not know	decrease	decrease
8. Landowners sometimes build dams on streams to create ponds. What is the impact of a dam on a stream? The dam causes	causes no major impact		changes in the entire stream	changes the stream in the pond area	I do not know	changes the stream in the pond area	Changes the stream in the pond area	I do not know	changes the stream in the pond area	changes in the entire stream
9. Each summer your neighborhood is sprayed with the same bug killer to control mosquitoes. After a few years of spraying the same product, what do you think will happen? The mosquitoes will likely	become resistant to the spray		no answer	disappear	I do not know	remain the same year after year	remain the same year after year	remain the same year after year	become resistant to the spray	become resistant to the spray
10. What usually happens to organisms when an area gets crowded?	I don't know		They usually die out	They compete against each other	remain the same year after year	they work together with each other	They usually die out	They compete against each other	They compete against each other	They compete against each other

	Participant 1		Participant 2		Participant 3		Participant 4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
11. Fertilizers are applied to lawns, gardens, and crop fields to encourage plant growth. Phosphorus is one type of fertilizer. What happens when phosphorus washes into a lake?	the phosphorus kills the fish	I don't understand the question	I do not know	the phosphorus kills the fish	Phosphorus will increase the gowth of algae	Phosphorus will increase the growth of algae	I do not know	I do not know
12. How do plants make food? (drawing)	no response	no response	no response	no response	no response	no response	no response	no response
12b. How to plants make food (written response)	plants make food because they are eaten by something in the wild that needs it.	Plants make food by give other animals that eat it energy	plants make food with water sunlight and air. The leaves have holes and air comes in.Then the sunlight air and water mixes and makes this white sweet stuff which is called food for the plants	Plants use three things, water, air, and the sun. The water helps make the food and the air too threw the sun makes a sweet food.	plants make food through photosynthesis. Chlorophil in the plant catches sunlight changing it into chemical engery, and that is changed into food in a way I don't understand.	plants make food through photosynthesis	The sun produces the food.	the sun
12c. How do plants make food (confidence)	very confident	I am a little confident	I am a little confident	I am a little confident	I am a little confident	I am very confident	I am very confident	no response
13a. How do animals get food/nourishment? (Drawing)	No response	no response	No response	no response	No response	no response	No response	no response
13b. How do animals get food/nourishment?(written response)	animals get food by finding eatible for their stomach to handle	Animals get nourishment by eat thing and that makes them not hungery	Well animals might have to hunt their food, or they might have to wait for their food to die	well they have to find their food	Animals get food/nurishment by eating plants or eating other animals	animals get food/nourishment by eathing either plants or other animals	no response	the sun
13c. How do animals get food/nourishment? (confidence)	I am a little confident	I am a little confident	I am unsure	I am unsure	I am very confident	I am very confident	I don't understand the question	no response

	Participant 5		Participant 6		Participant 7		Participant 8	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
11. Fertilizers are applied to lawns, gardens, and crop fields to encourage plant growth. Phosphorus is one type of fertilizer. What happens when phosphorus washes into a lake?	Phosphorus will increase the gowth of algae	Phosphorus will increase the growth of algae	I do not know	no response	I do not know	the phosphorus kills the fish	the phosphorus kills the fish	the phosphorus kills the fish
12. How do plants make food? (drawing)	no response	no response	no response	seed --> tiny plant-->small plant-->small tree-->big tree with fruit	no response	no response	no response	no response
12b. How to plants make food (written response)	The sun shines on the plant, the leaves of the plant work to make food. It goes through photosynthesis	They go through photosynthesis. The leaves make food.	Plants make food by a seed that grown into a plant and makes a type of fruit or vegetable	The plant my food by a seed that grows up to be a vegi or a fruit	Plants make food using photosythesis. They take the energy of the sun and CO2 and water to make food	plant smake food with photosynthesis, sunlight, water and carbon dioxide	Plants make food by growing. I am not positive on how exactly. I am nsure that you need a lot of water to grow food.	I think plants get the food from the fetilizers. Then they get energy from the sun. The plant uses energy to grow
12c. How do plants make food (confidence)	I am very confident	I am very confident	I am unsure	I am a little confident	I am a little confident	I am very confident	I am unsure	I am a litle confident
13a. How do animals get food/nourishment? (Drawing)	No response	no response	no response	no response	No response	no response	no response	dead bear
13b. How do animals get food/nourishment?(written response)	The animals eat plants and meat to get nourishment	They eat plants or animals that eat plants	some animals get there food by proaying or just of the growd (ground)	the get food by praying there food or by jut getting them from plants	Animals get food by either eating plants or animals depending on if they are a omnivore, hebivore, or carnivore	animals get food by eating other organisms (plants/animals)	Animals just look for food. All animals fertilize plants. Then the plants grow. The animals will eat the food.	1. FBI eats beat. 2. FBI gets eaten 3. The animlas that ate the FBI got food
13c. How do animals get food/nourishment? (confidence)	I am unsure	I am very confident	I am a little confident	I am unsure	I am a little confident	I am a little confident	I am unsure	I am a little confident (erased "very confident)

	Participant 9		Participant 10		Participant 11		Participant 12	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
11. Fertilizers are applied to lawns, gardens, and crop fields to encourage plant growth. Phosphorus is one type of fertilizer. What happens when phosphorus washes into a lake?	the phosphorous kills the fish	the phosphorus kills the fish	Phosphorus will increase the gowth of algae	the phosphorus kills the fish	I do not know			
12. How do plants make food? (drawing)	no response	drawing of a leaf with carbon dioxide, oxygen and sun pointing towards leaf	no response	no response	no response			
12b. How to plants make food (written response)	plants make food by gathering sun energy, oxygen, and water	plants make their food from carbon dioxide, oxygen and sunlight	they get energy from the sun and will make food	they take energy from the sun	The plants produs food when they have inave (enough) water and sunlight			
12c. How do plants make food (confidence)	I am unsure	I am a little confident	I am unsure	I am a little confident	I am a little confident			
13a. How do animals get food/nourishment? (Drawing)	no response	no response	no response	no response	no response			
13b. How do animals get food/nourishment?(written response)	animals get food by eathing their proey that eat the producers, which collect nutrients.	animals get their food from killing their prey, or getting nutrients from plants	animals eat plants or other animals who eat plants	they eat plant or eat the anial that ate the plant	The animals get energy from the three and that gives to the anamals.			
13c. How do animals get food/nourishment? (confidence)	I am a little confident	I am very confident	I am very confident	I am very confident	I don't understand the question			

	Participant 13		Participant 14		Participant 15		Participant 16	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
11. Fertilizers are applied to lawns, gardens, and crop fields to encourage plant growth. Phosphorus is one type of fertilizer. What happens when phosphorus washes into a lake?	the phosphorous kills the fish	the phosphorus kills the fish	Phosphorus will increase the gowth of algae	the phosphorus kills the fish	I do not know		the phosphorous kills the fish	Phosphorus will increase the growth of algae
12. How do plants make food? (drawing)	no response	no response	no response	no response	no response		no response	no response
12b. How to plants make food (written response)	through photosynthesis. The plant takes energy from the sun and carbon dioxide and converts it to food.	through photosynthesis	plants make food by finding water to store them in the stem so it can stay alive	plants make food by get water to story it in the stem	they need the sun and the ruts (roots) get water and food, like nutrients.		I don't know	they get nutrients from the soil
12c. How do plants make food (confidence)	I am very confident	I am very confident	I am unsure	I am a little confident	I am unsure		I am unsure	I am a litle confident
13a. How do animals get food/nourishment? (Drawing)	no response	no response	no response	no response	no response		no response	no response
13b. How do animals get food/nourishment?(written response)	they drink water and hunt for food, like plants and other animals.	from photosynthesis, carbon dioxide, and soil	animals get food by eating plant and water and lines (?) kill other animals.	animals get their food by eating other animals and eating plants	no response		animals get food by smelling and finding there (their) food.	they hunt, scavenge, and polinate
13c. How do animals get food/nourishment? (confidence)	I am very confident	I am very confident	I am a little confident	I am very confident	I don't understand the question		I am a little confident	I am a little confident

	Participant 17		Participant 18		Participant 19		Participant 20	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
11. Fertilizers are applied to lawns, gardens, and crop fields to encourage plant growth. Phosphorus is one type of fertilizer. What happens when phosphorus washes into a lake?	Phosphorus will increase the gowth of algae	the phosphorus kills the fish	I do not know	not much will happen	the phosphorous kills the fish	the phosphorus kills the fish	the phosphorous kills the fish	the phosphorus kills the fish
12. How do plants make food? (drawing)	no response	no response	no response	no response	no response	no response	no response	no response
12b. How to plants make food (written response)	plants make food by using photosinthesis to use sunlight to grow the plant by making into food.	plants make food by using photosinthesis to use the sun to grow	they tak the sun light and the water so the soil and mixes it all together and makes food.	they take the sunlight and water with the soil and makes food	plants make food by obsorbing (absorbing) the sun and changing it into energy and nutrience (nutrients). This is called photosynthesis.	Plants make food by soaking up the sun. This is called photosinthisis. They also soak up water	the use sunlight to make energy and also to make food	plant use sunlight and photosynthesis to make food
12c. How do plants make food (confidence)	I am unsure	I am a little confident	I am a little confident	I am a little confident	I am very confident	I am very confident	I am unsure	I am very confident
13a. How do animals get food/nourishment? (Drawing)	no response	no response	no response	no response	no response	no response	no response	no response
13b. How do animals get food/nourishment?(written response)	animals get food by eating plants or another animals.	animals get food by eating plants	they either hunt or find food	they hunter or look like for berrys	animals get food and nourishment by eating other plants and animals. They also have to drink water and get sleep.	animals get food and nourishment by eating and drinking	they find plants or smaller animals and eat them	they eats plants or other animals
13c. How do animals get food/nourishment? (confidence)	I am very confident	I am a little confident	I am a little confident	I am a little confident	I am a little confident	I am a little confident	I am a little confident	I am very confident

	Participant 21		Participant 22		Participant 23		Participant 24	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
11. Fertilizers are applied to lawns, gardens, and crop fields to encourage plant growth. Phosphorus is one type of fertilizer. What happens when phosphorus washes into a lake?	I don't understand the question	not much will happen	I do not know	I don't understand the question	the phosphorous kills the fish	the phosphorus kills the fish	I do not know	the phosphorus kills the fish
12. How do plants make food? (drawing)	no response	no response	no response	no response	no response	no response	no response	no response
12b. How to plants make food (written response)	I have no idea	no response	the plant's seed sprouts out and inside it's very busy	I don't understand	plants make food by photosyntesis. They get energy from the sun, then they do the photosynthesis cycle, then the eat the food and give off oxygen	plants make food by tetting energy from the sun and perform photosynthesis and makes food	they use energy from the sun and water	they use energy from soil, sun, and water
12c. How do plants make food (confidence)	I don't understand the question	I don't understand the question	I am unsure	I am unsure	I am a little confident	I am a little confident	I am very confident	I am very confident
13a. How do animals get food/nourishment? (Drawing)	no response	no response	no response	no response	no response	no response	no response	no response
13b. How do animals get food/nourishment?(written response)	animals eat plants and other animals	animals eat plants, other animals, and fish	from plant's and dead animals	I don't know	Animals find their food. Carnivours hunt there food and eat it raw. Herbavours eat grass and search for berry's and such. Aminvores do both those tequnikes.	they hunt for food and eat it raw- carnivores. They find eatable berrys and plant- herbavorous. They find both meat and plants- omnivours	they hunt and find food and eat	they eat food
13c. How do animals get food/nourishment? (confidence)	I am a little confident	I am very confident	I am a little confident	I am unsure	I am very confident	I am a little confident	I am a little confident	I am very confident

	Participant 25		Participant 26		Participant 2		Participant 2	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
11. Fertilizers are applied to lawns, gardens, and crop fields to encourage plant growth. Phosphorus is one type of fertilizer. What happens when phosphorus washes into a lake?	the phosphorous kills the fish	the phosphorus kills the fish	the phosphorous kills the fish	the phosphorus kills the fish				
12. How do plants make food? (drawing)	no response	no response	no response	no response				
12b. How to plants make food (written response)	plants make food by the nutrition the sun gives them	Well plants make food by tetting nutreance from the sun	plants take food by growing they take sun energy, food, nutrients. By making food they take soil and make it.	plants make fod by getting soil with their roots. Also cleaning it to be good food. Plants also get water with their roots and drink or eat it.				
12c. How do plants make food (confidence)	I am a little confident	I am very confident	I am very confident	I am very confident				
13a. How do animals get food/nourishment? (Drawing)	no response	no response	no response	no response				
13b. How do animals get food/nourishment?(written response)	well some animals get food off of bacteria and other animals get food off of plants, but the most common one is other animals eat other animals.	well some animals eat meat. Some animals eat plants. They get energy from that	animals get food by hunting other animals. They get food by eating plants.	animals get food by hunting				
13c. How do animals get food/nourishment? (confidence)	I am very confident	I am very confident	I am very confident	I am very confident				

	Participant 29		Participant 30		Participant 31		Participant 32 (SP)		Participant 33	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
11. Fertilizers are applied to lawns, gardens, and crop fields to encourage plant growth. Phosphorus is one type of fertilizer. What happens when phosphorus washes into a lake?	Phosphorus will increase the gowth of algae		the phosphorous kills the fish	the phosphorus kills the fish	Phosphorus will increase the gowth of algae	Phosphorus will increase the growth of algae	the phosphorous kills the fish	the phosphorus kills the fish	the phosphorous kills the fish	the phosphorus kills the fish
12. How do plants make food? (drawing)	no response		no presonse	no response	no response	no response	no response		no response	no response
12b. How to plants make food (written response)	they can create vegtales and they become edible. Sometimes its in other places on the plant like the root		phosphorous	compost…sun …photosinthesis	Plants go through photosynthusous and create plant food	plants make food by photosynthesis	with the roots and sun	por las rallises	plants make food by collecting sun rays, oxygen and water	plants make there food by using the sun, oxygen, and carbon
12c. How do plants make food (confidence)	I am a little confident		I am unsure	I am unsure	I am a little confident	I am very confident	I am a little confident	tengo poca confianza	I am a little confident	I am very confident
13a. How do animals get food/nourishment? (Drawing)	no response		no response	no response	no response	no response	no response	no response	no response	no response
13b. How do animals get food/nourishment?(written response)	they eat plants and sometimes other animals		photosynthesis	plants	animals eat the plant in which give the animal nourishment	animals feed on plants and other animals	with plants and water	salen abuscar al bosque en la noche	animals get food by eating the animals that ate the producers	animals ge there food by eating a consumer that ate a producer
13c. How do animals get food/nourishment? (confidence)	I am a little confident		I am unsure	I am unsure	I am very confident	I am very confident	I am unsure	tengo poca confianza	I am very confident	I am a little confident

	Participant 1		Participant 2		Participant 3		Participant 4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (drawing)	Arrow pointing from bunny to grasshopper, bunny to plant, from grasshopper to plant, and bird to grasshopper	Arrows pointing away from bunny towards grasshopper, and plant. Arrow pointing away from grasshopper to plant. Arrow pointing from crow to grasshopper.	line connecting rabbit to plant, plant to grasshopper, and grasshopper to bird	Arrow pointing from bunny to plant, from grasshopper to plant, from crow to grasshopper.	Drew the sun,with an arrow pointing toward the plant. Arrow points from plant to bunny, and from plant to grasshopper. From grasshopper to bird.	Drew in coyote and sun. Arrow from sun to plant. From plant to bunny, from bunny to coyote. Arrow from plant to grasshopper. From grasshopper to crow.	no response	added an owl to the picture. arrow pointing from the rabbit to the plant, from the owl to the rabbit, from the grasshopper to the plant and from the crow to the grasshopper.
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (written response)	The bunny and grasshopper eat the plants. The bird and bunny both eat the grasshopper. Well you could put the turkey on the (picture)	The bunny and grasshopper eat grass, bunny, and bird eat grasshopper.	Well the bird eats grasshoppers, and grasshoppers eat the plants, The bunny also eats the plants,that's how they are related	Well the rabbit and grasshoppers eat plants so then the enegy is from the plant. The bird gets it's enegy by the grasshopper.	The plant gets energy from the sun. The rabbit and cricket both eat the plant, The bird eats the cricket.	The plant gets energy from the sun, and then is eaten by grasshoppes, and rabbits. Grass hoppperss are eatern by birds, and rabbits are eaten by coyotes.	The bug eat the plant and so does the bunny. But the bird eats the bug	no response
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (confidence)	I am very confident.	I am very confident	I am a little confident	I am a little confident	I am a little confident	I am very confident	I am a little confident	no response
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Drawing)	No response	no response	No response	no response	No response	no response	No response	no response

	Participant 5		Participant 6		Participant 7		Participant 8	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (drawing)	Arrow pointing from sun to the plant with the word "nutritious" as a linking word. Arrow pointing from the rabbit to the plant, from grasshopper to the plant and from bird to grasshopper.The connecting word "eat" on the last three animals	arrow pointing wary from bunny to plant. Away from sun to plant. Away from grasshopper to plant. From crow to plant. From bunny to crow.	no response	arrow from bunny to plant, from grasshopper to plant, from crow to grasshopper, from crow to bunny	Drew arrow pointing from plant to rabbit, from plant to grashopper, from grasshopper to bird. Added decomposers (worm) and arrows pointing from all organisms to decomposers.	arrow from plant to bunny, from plant to grasshopper. From grasshopper to crow. Arrow from bunny all around to FBI	Curved line from rabbit to plant. Arrow pointing from bird to grasshopper to plant.	arrow from bunny to plant. From bunny to FBI, from grasshopper to plant. From grasshopper to crow
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (written response)	The crow eats the crickets/grasshoppers, the grasshopper eats the plants, and the rabbit eats the plants	The bunny eats the plant, the sun gives energy to the plant. The grasshopper eats the plant. The crow eats the grasshopper an dthe bunny eats the crow.	no response	grasshopper eats plants and abbit and bird eats rabbut and grasshopper	The grasshopper eats the plant, the bird eats the grasshopper, and the worm/decomposers. The rabbit eats the producer.	grasshopper eats grass, bird eats grasshopper, bunny eats grass. Decomposers decompose everything	The prosses (process) is simple. The plant gets fertilized. Then animals eat the plant. That animal gets eatern. It just keeps repeating.	no response
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (confidence)	I am unsure	I am very confident	I don't understand the question	I am unsure	I am a little confident	I am a little confident	I am unsure	I am a little confident
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Drawing)	No response	no response	no response	no response	No response	no response	no response	no response

	Participant 9		Participant 10		Participant 11		Participant 12	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (drawing)	arrow pointing FROM plant to bunny, FROM plant to grasshopper. Arrow FROM grasshopper to bunny and from grasshopper to bird.	arrow from sun to plant. From plant to bunny, from plant to grasshopper. From grasshopper to bunny. From grasshopper to crow	no response	no response	arrow from rabbit to plant. From crow to grasshopper to plant			
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (written response)	This cycle says the plant goes into the rabbit andgrasshopper's tummy. Then the grasshopper goes into the rabbit and crow's tummy.	First, the plant soaks in the sunlight. Then, the plant gets eaten by the cricket and rabbit. Then the cricket gets eaten by the bird and the rabbit.	no response	no response	I think the bird eats the gras happer and the rabit eats the plants. And the grashapper eats the plants too			
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (confidence)	I am very confident	I am a little confident	I don't understand the question	I do not understand the question	I am a little confident			
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Drawing)	no response	dead duck: too little nutrients, too much nutrients	no response	no response	no response			

	Participant 13		Participant 14		Participant 15		Participant 16	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (drawing)	arrow pointing from an owl (added) to the crow, grasshopper, and rabbit. Arrow pointing from rabbit to plant, from plant to grasshopper, from crow to grasshopper.	arrow from plant to bunny, from bunny to owl. Arrow from plant ot grasshopper. From grasshopper to owl, from grasshoper to crow, then to owl.	no response	arrow from bunny to plant, from crow to grasshopper	no response		no response	arrow from plant to bunny. From bunny to coyote. From plant to grasshopper from grasshoper to crow
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (written response)	An own eats rabbits, grasshoppers, and small birds	I added an owl because it ate many of the organisms shown	no response	I think the bird eat the cricket and the rabbit eat the plants	no response		I don't know	the energy from the plant goes to the bunny when it eats the plant
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (confidence)	I am very confident.	I am very confident	I don't understand the question	I am a little confident	I don't understand the question		I don't understand the question	I am very confident
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Drawing)	no response	no response	no response	no response	no response		no response	no response

	Participant 17		Participant 18		Participant 19		Participant 20	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (drawing)	Arrows pointing from rabbit to plant, from bird to rabbit, from bird to grasshopper and from grasshopper to plant	arrow from bunny to plant. From grasshopper to plant. From crow to rasshopper. Form dots on plant to crwo and bunny	no response	no response	arrow pointing from bird to grasshopper to plant. Arrow from rabbit to plant.	sun drawn, arrow pointing towards plant. Arrow pointing from plant to bunny, from plant to grasshopper, from grasshopper to crow	arrow pointing from bird to bunny to grasshopper to plant.	arrow from bunny to plant. From grasshopper to plant. From crow to grasshopper from crow to bunny.
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (written response)	a rabbit or grashopper may eat a plant and then a raven might eath the rabbit or grassphopper	say a bug eats a plants and a bird eats the bug and then the bird dies the nutrients in the bird get in the plant	the grasshopper eats the plants the bird eats the bug and the bunny eats the plant	the bird eats the grasshopper and the grasshopper eats the plant	These organisms interact by: the bird eats the grasshopper and other bugs, the bugs and rabits eat plants.	The plants get energy from the sun. The bunny and grasshopper eat the plant and the bird eats the grasshopers.	The grasshopper eats poisonous plants and the bunne eats the poison and grasshopper. The bunny dies and the crow eats the bunny	no response
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (confidence)	I am a little confident	I am a little confident	I am a little confident	I am a little confident	I am unsure	I am a little confident	I am very confident	I am very confident
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Drawing)	no response	no response	no response	no response	no response	no response	no response	no response

	Participant 21		Participant 22		Participant 23		Participant 24	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (drawing)	no response	no response	arrow pointing from bunny to plant. From crow to grasshopper (unclear)	no response	arrow pointing from bird to grasshopper to plant	arrow from crow to bunny, from bunny to grasshopper, from grasshopper to plant.	added water to diagram	arrow form plant to rain; from bunny to plant; from grasshopper to plant; from crow to grasshopper; from crow to bunny
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (written response)	no response	no response	grasshopper eats plant bunny eats grasshopper	no response	the bunny eats seed from plants and poops it our and it starts gwoting a plant which the grasshopper eats in order to live, and the crow eats the grasshopper and feeds it for her young.	The grasshopper eats the plant then the bunny eats the grasshopper, then the crow eats the bunnny after it dies.	The plant like eats the water the grasshopper and rabbits eat plants and the bird eats the grasshopper	the plant get eaten by grasshopper and rabbit bird eats bunnie and grasshoppers
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (confidence)	I don't understand the question	I don't understand the question	I am unsure	I am unsure	I am very confident	I am a little confident	I am a little confident	I am very confident
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Drawing)	no response	no response	No response	no response	no response	no response	no response	no response

	Participant 25		Participant 26		Participant 2		Participant 2	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (drawing)	arrow from rabbit to grasshopper. From rabbit to plant. Arrow from grasshopper to plant, from crow to grasshopper.	arrow from bunny to plant; from bunny to grasshopper; from grasshopper to plant; from crow to grasshopper	arrow pointing from bunny to plant. Another arrow pointing from bunny to grasshopper and from the crow to the grasshopper	no response				
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (written response)	Well the bug eats the plant. The bird eats the nug. And the bunny eats both the plant and the bug.	well they inteact with each other look above	A grasshopper eats the plant. The rabbit eats the plant and the grasshopper While the crow eats the grasshopper and the plant	a rabbit and a crow eat a grasshopper and the grasshopper eats a plant				
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (confidence)	I am very confident	I am a little confident	I am very confident	I am very confident				
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Drawing)	no response	no response	no response	no response				

	Participant 29		Participant 30		Participant 31		Participant 32 (SP)		Participant 33	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (drawing)	no response		arrow from rabbit to plant. Arrow from crow to grasshopper to plant.	arrow from plant to bunny; from plant to grasshopper; from grasshopper to crow	drew the sun (1) and a line between the sun and the plant (2). Rabbit (5) eat plant (2). Crow (4) eat grasshopper (3) arrow pointing to plant(2) indicating grasshopper lives on plant	arrow from plant to bunny; from plant to grasshopper; from grasshopper to crow	arrow pointing fom rabbit to grasshopper and plant. From crow to grasshopper , from crow to rabbit, from crow to plant, from grasshopper to plant	arrow from bunny to plant; from grasshopper to plant; from crow to plant and to bunny	Arrows from plant to rabbit. From plant to grasshopper. From grasshopper to rabbit. From grasshoper to crow	drew in sun; arrow from sun to plant; from plant to bunny; from plant to grasshopper; from grasshopper to bunny; from grasshopper to crow
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (written response)	the grasshoppet jumps on the plant. The crow eats the grasshoppet. The bunny eats the plant.		the arrows show what eats what	The arrows show what eats what	The cricket lives in or on the plant. Then the bird eats the cricket so it ca suvive. The plant thrives on making food from the sun, and the bunny eats the plant.	the bunny eats the plant and get energy	no response	porque yo creo que asi es como funciona	The grasshopper and the rabbit eats the plant. And the crow eats the grasshopper and does the rabbit	the plan is eaten by the grasshopper an dthe rabbit. The grasshopper is eaten by the bird and rabbit
14. The following organisms are found in an ecosystem at the Poudre Learning Center. Explain how the following organisms interact? You can use arrows to explain the relationship and write your explanation in the lines provided. If you think something is missing, you can draw it in. (confidence)	I am very confident		I am a little confident	I am very confident	I am a little condident	I am a little confident	I am a little confident	tengo poca confianza	I am very confident	I am a little confident
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Drawing)	no response		no response	no response	no response	no response	no response	no response	no response	no response

	Participant 1		Participant 2		Participant 3		Participant 4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Written Response)	Without the right amount of nutrios, they cannot live or do things it could with nutrions	without it it could die and then other thing would die off too	They need to get the right amount of nutrients because if (they) don't, something can go wrong in your body.	it's important because when it dies other bug get its nutrients	If a living thing doesn't get the right amount of nutrients, it starves and dies.	If a living thing doesn't get the right amount of nutrients, it starves.	no response	because it will dye
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Confidence)	I am very confident	I am very confident	I am unsure	I am unsure	I am very confident	I am a little confident	I don't understand the question	no response
16. What happens when an organism dies? (Drawing)	No response	no response	No response	drawing of dead bunny with invertebrates, bacteria, and fungus around it	Dead rat on its back.	Drawing of a dead from. Mold, maggots on the dead frog.	Bunny on its back with tounge sticking out and bones exposed	dead bear, bones showing, worm-like organism next to bear.
16. What happens when an organism dies? (Written Response)	If an organism dies, the animal that ate it would either have to find a new food. It would die. The rest of the food chain would go away because of that one organism	when organisms die other die to lik if no more grass is here bunnies die then snakes then so on.	I do not know this question	when an organism dies stuf called the FBI eat it until it goes away. They eat it to get nutrients.	Dead rat, maggots and rot.	no response	Bugs eat the bunny	no response
16. What happens when an organism dies? (Confidence)	I am very confident	I am very confident.	I do not understand the question	I am very confident.	I am very confident	I am very confident.	no response	no response

	Participant 5		Participant 6		Participant 7		Participant 8	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Written Response)	If a living thing doesn't get enough nutrients it will die. If it gets too much, then it can get sick and/or die.	If it gets too much, it dies. If it doesn't get enough, it dies.	no response	So then it can become a vegi or plant or fruit or animals to live	It is important for the organisms to get the righat amoung of nutrients so it can live.	it's important because If they get too little or too much, they might not survive	people need vitamins to stay healthy. Without them, people could die.	if they don't get nutriention, they wont be healthy. Afte a while they will die.
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Confidence)	I am a little confident	I am very confident	I am unsure	I am unsure	I am unsure	I am unsure	I am unsure	I am very confident
16. What happens when an organism dies? (Drawing)	No response	dead organisms with bones showing on bottom half	Drawing inclues animal skull and bones surrounded by grass.	bones, grass	Drew a dog with worm-like things and an arrow pointing to the base of a tree.	dead organisms. Arrow towards FBI. Arrow towards plants.	no response	dead organism <--FBI<--animal <--plant<--animals
16. What happens when an organism dies? (Written Response)	I don't really understand what happends.	the carcuss decomposes	It is an animal sthat has died maybe because it didn't have enough food or water.	dead animal	When an organism dies decomposers such as flies and worms decomes it than it becomes nutrients to the plant in that area.	After an organism dies decomposers decompose it and the nutrients get back into the plants with gets eaten by animals which die.	I do not know about organisms dying.	no response
16. What happens when an organism dies? (Confidence)	I don't understand the question.	I am very confident	I am very confident	I am a little confident	I am a little confident	I am very confident	no response	I am very confident

	Participant 9		Participant 10		Participant 11		Participant 12	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Written Response)	It is important for any organism to get the right amount of nutients because if they had too much or too little the animal could die.	This is because if an animal gets too much, or too little nutrients, the animal could die.	so it can liver?	so it can live?	the living theing needs enave (enough) water, bechtavol (vegetables), and frouts (fruits).			
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Confidence)	I am very confident	I am very confident	I am unsure	I am a little confident	I am a little confident			
16. What happens when an organism dies? (Drawing)	diagram depicting a dead organism with an arrow pointing to layers of rock and another arrow pointing to nutrients on the ground and the last arrow represents the organims becoming a fossil	dead fish --> dead fish- nutrients get suck in the ground -->layers of rocks over the dead animal-->fossil	no response	no response	stick figure, mammal, tree, sun			
16. What happens when an organism dies? (Written Response)	when an animal dies it starts off on the ground dead. Then it gets covered with layers or rocks/soil. Next, the nutrients get soaked into the ground. Lastly, it's bones and remains get turned into the rock/soil as a fossil.	I think once a fish dies their nutrients get suched into the ground. Then, layer sof rocks cover the dead animals, and it becomes a fossil	the hole (whole) animal dies until nothing is left	no response	If one of the things dies it avects (affects) everythign. For example if all the trees where dies then the animals would die and so would we.			
16. What happens when an organism dies? (Confidence)	I am unsure	I am a little confident	I am unsure	I do not understand the question	I am a little confident			

	Participant 13		Participant 14		Participant 15		Participant 16	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Written Response)	too little nutrients would kill the animal. Too much may harm the aimal	too much will make the animal fat, or give it a heart attach. Too little will make it starve to death	it is important because you need nutrients to live for your blood the (to) keep on going.	it important so it can live and eath the plants if we didn't have animals plant would be energy were.	so that it can survive		It is important for living things to get the right amount of nutrients because then they'll die.	to live and be healthy
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Confidence)	I am very confident	no response	I am a little confident	I am a little confident	I am unsure		I am a little confident	I am a little confident
16. What happens when an organism dies? (Drawing)	dead wolf arros showing interactions, clouds etc.	dead bear.	no response	drawing of several dead organisms	no response		no response	dead mouse--> fly -> decomposer
16. What happens when an organism dies? (Written Response)	the organism decomposes. It supplies nutrients for scavengers, plants, and fungi. It also gives shelter to animals.	the FBI eats it and other animals eat the FBI	no response	bugs would be everywhere and plants too	no response		when the organism dies, another one comes	when a mouse dies the fly's and bateria eat the nutrients then the minitals and nutrients go in the ground.
16. What happens when an organism dies? (Confidence)	I am very confident	I am very confident	I don't understand the question	I am unsure	I don't understand the question		I am unsure	I am very confident

	Participant 17		Participant 18		Participant 19		Participant 20	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Written Response)	It is important to get the right amount of nutrients becaue the wrong amoungt could affect your health	It is important for a living thing to get the right amount of nutrients because if they get the wrong amounts the living thing will die.	so it will be healthy	its important cause if it doesn't it will die	It's important to have nutriance so we can live.	so it can live	so they are healthy	so it doesn't die
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Confidence)	I am a little confident	I am a little confident	I am a little confident	I am a little confident	I am a little confident	I am a little confident	I am unsure	I don't understand the question
16. What happens when an organism dies? (Drawing)	Tree crossed out, dead animal crossed out, bird crossed out	three dead organisms	wilted plant	no response	no response	dead bunny, plant, FBI. Arrow pointing from plant to bunny, from bunny to FBI. From FBI to plants	picture of crow eating the bunny	dead organism getting eaten by crow
16. What happens when an organism dies? (Written Response)	when an organism dies, say a plant the other organisms are affected because then athat dies out and the bird has nothing to eat so it dies out.	what happens when an organism des is that it effects every other organism	bugs eat it or it welts(wilts)	then the FBI will get ride of it	when something dies, it effects the whole ecosystem because somethings food just went away.	FBI eats the dead bunny, plants eat FBI, and the alive bunny eats the plants.	crows eat dead animals	it is eaten by a crow (decomposition)
16. What happens when an organism dies? (Confidence)	I am a little confident	I am a little confident	I am a little confident	I am a little confident	I am a little confident	I am very confident	I am very confident	I am very confident

	Participant 21		Participant 22		Participant 23		Participant 24	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Written Response)	It's important because if they get too much or too little, they will die.	If a living thing get too much or too little nutrients it will die because their body is made for only a certain amount of nutrients	no response	no response	it is important for a living thing to get the right amout of nutrients because it is healthy and a healthy thing keeps our environment healthy too.	It is important because the poo grows plants and the ecosystem is good and the environment is healthy	its important or else they get unhealthy	it's important or else you will become unhealthy
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Confidence)	I am unsure	I am very confident	I don't understand the question	I don't understand the question	I am unsure	I am a little confident	I am a little confident	no response
16. What happens when an organism dies? (Drawing)	no response	no response	no response	picture of a crow	drawing of a dead bird, a rat, a bear and a bird.	dead organism, plant, FBI	no response	dead person --> dirt
16. What happens when an organism dies? (Written Response)	Then what it had eaten has a larger population or it beomes more common	no response	no response	crow eats it	when a bird dies, a cat eats it's carcass, and then a bird eats the rat and a bear eats the bird and it goes on.	when an organism dies, FBI(fungus, bacteria, then insectabors) eat it and it decomposes.	they decompose	it decomposes
16. What happens when an organism dies? (Confidence)	I am very confident	I am unsure	I don't understand the question	I am unsure	I am unsure	I am very confident	I am very confident	I am very confident

	Participant 25		Participant 26		Participant 2		Participant 2	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Written Response)	well it's important for any animal to get it's nutrients by there daily food sources. It's imporatn for a plant to get nutrients by the sun.	well they get the right amount because of their daily diet	it is important because without nutrients the living thing can't live healthy.	It is important because it not it will die				
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Confidence)	I am a little confident	I am a little confident	I am very confident	I am very confident				
16. What happens when an organism dies? (Drawing)	no response	no response	no response	no response				
16. What happens when an organism dies? (Written Response)	well if one organisms dies then I think that the whole food chain dies because there primary food source is gone. How are they going to survive.	well when 1 dies they all die up because the whole thing is messed up	When an organism dies it diesn into the soil then animals eat the remains.	when an organisms dies a scavenger eats the leftovers				
16. What happens when an organism dies? (Confidence)	I am very confident	I am very confident	I am very confident	I am very confident				

	Participant 29		Participant 30		Participant 31		Participant 32 (SP)		Participant 33	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Written Response)	if an animal doesn't get nutrieants, it will slow down and can't hunt		I don't know how to explain it	so it can have energy	It is important because you get your energy from the nutrients and they can thrive	it is important because that animal could die but that would also help other oganisms	It's important because animals need to have a place to live	no response	it is important for animals to get the right nutrients because it helps their body and helps not make them die	the insect need an important amount of nutrient because they would overflow and will have to much
15. Nutrients include the vitamins and minerals an organism needs to live. Why is it important for a living thing to get the right amount of nutrients? (Confidence)	I am very cofident		I don't understand the question	I am unsure; I don't understand the question	I am unsure	I am unsure	I am unsure	no estoy segura	I am unsure	I am unsure
16. What happens when an organism dies? (Drawing)	diagram of one organism with arrow showing how it got broken up		no response	dead bear	no response	two dead organisms	no response	no response	no response	drawing of a bird and a fish
16. What happens when an organism dies? (Written Response)	The organism becomes food for other organisms		don't know	fungus and magets eat it…	if an organism dies decomposers decompose the organism and feed on it	another animal feed on that dead animal	no response	se desaparese y se ase huesos	The organism dies and then it could sesolve into the grown and the remaining are eaten by scavengers	the bird eats the fish. The fish desolves into the ground --> dirt
16. What happens when an organism dies? (Confidence)	no response		no response	I am very confident	I am a little confident	I am very confident	no response	tengo poca confianza	no response	I am unsure

APPENDIX R

ATTITUDES AND PERCEPTIONS PARTICIPANT RESPONSES PRE/POST

	Participant 1		Participant 2		Participant 3		Participant 4		Participant 5		Participant 6		Participant 7		Participant 8	
Statement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
I know a lot about science careers.	3	2	2	2	2	3	1	3	3	4	3	4	2	3	2	3
I see myself as a scientist.	3	2	3	4	3	3	1	2	2	3	4	4	2	2	3	4
I study about nature on my own.	3	2	3	3	3	4	1	2	3	3	-	3	3	3	2	3
I see myself as a leader.	4	3	4	4	2	3	4	4	3	4	3	4	3	3	4	4
Humans can have an impact on nature.	4		4	4	4	4	2	4	4	4	3	4	4	4	4	4
I do not know how to design an experimental study.	3	2	3	1	2	2	1	4	1	1	3	3	2	1	1	2
Other people do not see me as a science person.	4	3	3	1	2	2	4	4	1	2	3	1	3	2	2	1
My parents (guardians) do not like science.	1	2	1	1	2	1	1	1	2	1	1	1	2	2	2	1
I am able to design my own experimental study.	1	3	2	4	4	3	3	4	4	4	4	2	3	3	2	4
Other people think of me as a science person.	3	2	1	4	3	3	1	3	4	4	3	4	2	3	3	4
I have confidence in my ability to learn to design an experiment.	4	3	4	4	4	4	4	4	3	4	3	3	2	3	4	4
I am not good at science.	4	2	1	3	1	2	3	2	4	1	-	3	2	2	2	1
I do not like asking science-related questions.	3	3	1	1	1	1	4	3	1	1	-	3	2	2	2	3
I do not like to work with others.	1	2	1	1	3	2.5	1	1	1	1	3	3	2	2	1	1
I like to ask a lot of questions.	3	3	3	4	3	3	1	2	3	4	3	2	2	2	2	3
I like to find answers to questions.	4	2	3	4	4	4	3	2	3	4	3	3	4	3	4	3
I use evidence to back up my claims in an investigation.	3	3	3	2	3	3	4	4	3	4	2		4	3	4	4
Girls can do science.	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4

	Participant 1		Participant 2		Participant 3		Participant 4		Participant 5		Participant 6		Participant 7		Participant 8	
Statement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Science is only about experimenting with things.	1	2	2	1	2	1	1	1	2	1	2	2	2	2	2	1
My parents (guardians) like science.	3	3	4	4	3	4	4	4	3	4	4	4	3	3	3	4
Human actions do not impact nature.	2	2	1	1	1	1	3	2	1	1	-	1	1	1	1	1
I like to learn about new things.	4	3	4	3	4	4	3	2	4	4	4	4	4	4	4	4
My parents (guardians) see me as a leader.	4	3	4	4	2	3	4	4	4	4	3	4	3	4	4	4
Other people like to work with me.	4	3	4	4		3	4	4	4	4	3		3	3	4	4
I have had at least one good science teacher.	3	3	4	4	4	3	3	4	4	4	4	4	4	4	3	4
I have not had good science teachers.	2	2	1	1	1	2	1	1	1	1	1	1	1	1	2	1
I prefer not to read about science.	4	4	1	3	1	1	4	2	2	3	3	2	1	2	-	1
Science is not always about experimenting with things.	4	3	4	4	3	4	4	3	3	1	-	1	3	4	3	1
I prefer to work alone.	1	2	1	1	3	3	1	1	2	3	2	2.5	3	3	2	2
I work well with others.	4	3	4	4	2	2.5	4	4	3	4	4	-	3	3	4	4
I enjoy reading about science.	1	2	2	3	4	4	1	1	2	2	2	2	3	3	3	4
To write a conclusion, I never look for evidence. I just write what I think should be right.	4	3	1	1	1	2	4	2	1	1	1	1	1	1	2	1
If I have a question, I search for solutions or answers.	3	3	4	4	4	4	2	2	4	4	3	2.5	3	3	3	3
I do not like spending time outdoors	1	2	1	1	1	2	3	3	1	1	1	1	2	2	2	1
My parents (guardians) think that I am not good at science.	1	2	1	1	2	1	1	1	1	1	1	4	2	2	2	1
I do not like being wrong.	3	3	1	1	3	3	4	4	3	4	2	-	2	2	2	2

	Participant 1		Participant 2		Participant 3		Participant 4		Participant 5		Participant 6		Participant 7		Participant 8	
Statement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
When I can't figure something out, I give up.	2	2	1	1	2	2	4	4	2	1	1	1	2	1	2	1
I believe everything my teacher says.	2	2	3	3	2	1	4	3	2	2	3	3.5	2	2	2	2
Girls are not good at science.	1	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1

Statement	Participant 9 Pre	Participant 9 Post	Participant 10 Pre	Participant 10 Post	Participant 11 Pre	Participant 11 Post	Participant 12 Pre	Participant 12 Post	Participant 13 Pre	Participant 13 Post	Participant 14 Pre	Participant 14 Post	Participant 15 Pre	Participant 15 Post	Participant 16 Pre	Participant 16 Post
I know a lot about science careers.	3	4	1	3	3		3		1	3	1	3	2	3	3	
I see myself as a scientist.	2	2	1	3	3		3		1	4	2	3	2	2	2	
I study about nature on my own.	2	2	3	4	2		3		1	4	1	1	2	2	3	
I see myself as a leader.	4	4	3	4	2		3		1	4	1	3	4	3	3	
Humans can have an impact on nature.	4	4	4	4	3		4		3	4	3	3	4	4	3	
I do not know how to design an experimental study.	2	4	4	4	2		1		1	1	1	4	3	1	3	
Other people do not see me as a science person.	3	4	2	3	3		2		1	2	2	1	3	4	2	
My parents (guardians) do not like science.	1	1	3	3	2		1		1	1	3	1	2	2.5	2	
I am able to design my own experimental study.	2	4	1	4	3		4		1	4	2	1	2	3	3	
Other people think of me as a science person.	1	4	1	3	2		3		3	4	1	3	2	3	1	
I have confidence in my ability to learn to design an experiment.	4	4	3	4	3		4		2	4	3	4	3	3	3	
I am not good at science.	3	1	4	1	2		1		1	1	2	1	2	3	3	
I do not like asking science-related questions.	3	2	3	2	2		1		1	1	2	1	4	3	3	
I do not like to work with others.	1	1	4	1	2				4	2	4	1	2	1	4	
I like to ask a lot of questions.	3	4	2	3			2		2	4	2	3	3	2	3	
I like to find answers to questions.	3	4	1	4	3		3		3	3	4	4		3	2	
I use evidence to back up my claims in an investigation.	3	4	1	3	2		4		2	3	3	4	2	4	4	
Girls can do science.	4	4	4	4	4		4		4	4	4	4	4	4	4	

	Participant 9		Participant 10		Participant 11		Participant 12		Participant 13		Participant 14		Participant 15		Participant 16	
Statement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Science is only about experimenting with things.	2	2	3	1	2		1		1	1	1	3	1	1	4	
My parents (guardians) like science.	3	4	2	2	3		3		1	4	3	3	2	2.5	4	
Human actions do not impact nature.	1	1	1	4	2		1		3	1	2	1	1	1	3	
I like to learn about new things.	4	4	3	-	3		4		2	4	4	4	1	3	4	
My parents (guardians) see me as a leader.	4	4	4	3	2		3		2	4	1	3	4	2.5	4	
Other people like to work with me.	4	3	4	2	2		4		3	3	3	3	2	4	4	
I have had at least one good science teacher.	4	3	3	3	4		4		3	-	4	3	3	4	4	
I have not had good science teachers.	2	2	3	2	2		1		1	1	1	1	1	1	1	
I prefer not to read about science.	3	3	4	4	2		3		1	3	3	1	3	2	1	
Science is not always about experimenting with things.	2	3	4	3	3		4		1	4	2	1	1	4	3	
I prefer to work alone.	1	1	4	4	2		2		1	3	1	1	1	1	1	
I work well with others.	4	4	1	1	3		3		3	4	4	4	3	4	4	
I enjoy reading about science.	2	2	1	1	3		2		1	3	3	3	2	2	3	
To write a conclusion, I never look for evidence. I just write what I think should be right.	2	1	4	3	2		1		1	1	4	1	4	1	2	
If I have a question, I search for solutions or answers.	4	4	2	3	3		4		1	4	4	4	1	4	3	
I do not like spending time outdoors	3	2	1	1	2		1		3	2	4	1	1	3	3	
My parents (guardians) think that I am not good at science.	1	1	3	2	2		1		3	1	3	1	1	2.5	3	
I do not like being wrong.	3	4	4	4	2		3		2	3	4	3	4	1	4	

	Participant 9		Participant 10		Participant 11		Participant 12		Participant 13		Participant 14		Participant 15		Participant 16	
Statement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
When I can't figure something out, I give up.	1	1	1	1	2		1		4	2	1	1	2	1.5	2	
I believe everything my teacher says.	1	2	2	3	2		3		2	3	3	2	1	1	3	
Girls are not good at science.	1	1	1	1	1		1		4	1	4	1	1	1	3	

	Participant 17		Participant 18		Participant 19		Participant 20		Participant 21		Participant 22		Participant 23		Participant 24	
Statement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
I know a lot about science careers.	3	3	3	3	1	4	4	3	2	1	1		4	3	2	3
I see myself as a scientist.	4	3	2	4	3	4	2	2	2	3	3		4	3	3	3
I study about nature on my own.	1	1	4	2	4	3	4	2	2	2	2		4	3	2	3
I see myself as a leader.	3	4	4	4	4	3	4	4	3	1	4		3	3	2	4
Humans can have an impact on nature.	4	4	4	4	4	4	2	4	3	4	4		4	3	3	4
I do not know how to design an experimental study.	1	3	2	3	1	1	4	2	3	4	4		3	1	3	1
Other people do not see me as a science person.	1	3	2	3	4	1	4	2	3		2		4	1	2	1
My parents (guardians) do not like science.	2	2	1	4	2	2	4	1	2	3	1		2	1	1	1
I am able to design my own experimental study.	4	3	3	4	1	4	1	3	3	2	1		4	4	2	4
Other people think of me as a science person.	4	2	-	3	1	4	1	2	2	3	3		1	3	2	4
I have confidence in my ability to learn to design an experiment.	4	3	3	3	4	4	4	3	3	1	3		4	4	4	4
I am not good at science.	1	2	2	3	4	1	4	2	2	4	2		1	1	3	2
I do not like asking science-related questions.	2	2	1	3	3	2	4	4	2	4	2		1	1	4	2
I do not like to work with others.	4	2	1	4	4	3	4	1	1	1	1		3	1	3	1
I like to ask a lot of questions.	3	3	4	4	4	4	1	4	2	4	4		4	2	-	4
I like to find answers to questions.	3	3	4	3	3	4	1	1	3	4	4		4	3	2	4
I use evidence to back up my claims in an investigation.	3	3	4	4	4	4	-	3	2	2	3		4	4	4	3
Girls can do science.	4	4	4	3	4	4	4	4	4	4	4		4	4	4	4

	Participant 17		Participant 18		Participant 19		Participant 20		Participant 21		Participant 22		Participant 23		Participant 24	
Statement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Science is only about experimenting with things.	1	2	2	4	3		1	1	2	2	2		2	2	1	1
My parents (guardians) like science.	3	2	4	1	4	3	4	4	3	3	4		4	3	3	4
Human actions do not impact nature.	1	1	1	4	1	1	4	1	2	4	1		1	2	3	1
I like to learn about new things.	4	3	4	4	4	4	4	4	3	4	4		4	3	4	3
My parents (guardians) see me as a leader.	3	3	4	4	2	4	4	4	3	1	4		4	4	4	4
Other people like to work with me.	3	4	4	4	4	3	1	4	4	3	4		4	4	4	4
I have had at least one good science teacher.	-	3	4	4	4	4	1	4	4	1	3		3	4	4	3
I have not had good science teachers.	2	1	1	2	1	2	1	1	1	2	2		1	1	1	2
I prefer not to read about science.	2	4	2	2	2	4	1	3	3	4	1		1	3	1	2
Science is not always about experimenting with things.	4	4	4	2	4	4	1	4	3	4	1		2	3	4	3
I prefer to work alone.	4	3	1	4	4	4	4	1	2	1	2		3	-	1	1
I work well with others.	2	4	4	3.5	1	3	1	4	3	-	4		2	2	4	4
I enjoy reading about science.	3	1	4	3	3	2	1	2	2	-	3		3	2	4	2
To write a conclusion, I never look for evidence. I just write what I think should be right.	2	1	1	2	3	1	1	1	2	-	1		1	1	1	2
If I have a question, I search for solutions or answers.	4	2	4	2	4	4	4	4	2	-	3		4	2	1	2
I do not like spending time outdoors	3	2	1	-	1	2	3	1	2	4	1		1	2	1	2
My parents (guardians) think that I am not good at science.	1	2	1	4	4	1	4	2	1	4	1		1	1	1	4
I do not like being wrong.	4	4	3	4	3	4	1	3	4		2		1	3	4	2

	Participant 17		Participant 18		Participant 19		Participant 20		Participant 21		Participant 22		Participant 23		Participant 24	
Statement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
When I can't figure something out, I give up.	2	2	1	1	1	2	1	1	2	1	1		1	1	1	1
I believe everything my teacher says.	2	2	1	4	4	2	1	1	2	3	3		2	2	4	2
Girls are not good at science.	1	1	1	1	1	1	4	1	1	1	1		1	1	1	1

	Participant 25		Participant 26		Participant 27		Participant 28		Participant 29		Participant 30		Participant 31		Participant 32		Participant 33	
Statement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
I know a lot about science careers.	2	3	3	4	1		3		2	4	3	3		3	1	3	3	3
I see myself as a scientist.	2	3	3	3	3		2		2	4	3	3		3	3	3	2	1
I study about nature on my own.	3	3	1	4	2		2		3	3	1	2		3	2	1	2	2
I see myself as a leader.	2	3	3	4	1		3		2	2	3	4		4	1	1	3	3
Humans can have an impact on nature.	4	4	4	4	3		4		4	4	4	4		4	3	3	4	3
I do not know how to design an experimental study.	1	3	3	1	1		1		1	4	3	2		4	1	3	1	4
Other people do not see me as a science person.	2	1	4	2	2		2		2	2	4	3		4	2	2	2	2
My parents (guardians) do not like science.	1	1	2	2	3		1		1	1	2	2		1	3	3	1	4
I am able to design my own experimental study.	4	3	2	4	2		2		4	4	2	4		4	2	3	2	4
Other people think of me as a science person.	3	2	1	4	2		3		3	2	1	2		4	2	3	3	3
I have confidence in my ability to learn to design an experiment.	3	3	4	4	3		4		3	4	4	3		4	3	2	4	4
I am not good at science.	3	-	2	4	1		2		3	1	2	1		1	1	2	2	2
I do not like asking science-related questions.	1	1	3	2	2		3		1	1	3	2		2	2	3	3	3
I do not like to work with others.	3	3	1	4	4		2		3	3	1	1		1	4	4	2	1
I like to ask a lot of questions.	3	4	2	3	1		2		3	3	2	3		4	1	3	2	2
I like to find answers to questions.	3	4	2	4	3		3		3	-	2	4		4	3	3	3	3
I use evidence to back up my claims in an investigation.	3	4	3	4	1		2		3	4	3	3		4	1	3	2	3
Girls can do science.	4	4	4	4	3		4		4	4	4	4		4	3	3	4	4

Statement	Participant 25 Pre	Participant 25 Post	Participant 26 Pre	Participant 26 Post	Participant 27 Pre	Participant 27 Post	Participant 28 Pre	Participant 28 Post	Participant 29 Pre	Participant 29 Post	Participant 30 Pre	Participant 30 Post	Participant 31 Pre	Participant 31 Post	Participant 32 Pre	Participant 32 Post	Participant 33 Pre	Participant 33 Post
Science is only about experimenting with things.	2	2	2	1	3		1		2	1	2	1		1	3	3	1	1
My parents (guardians) like science.	4	4	3	4	3		4		4	4	3	3		4	3	3	4	4
Human actions do not impact nature.	1	1	2	1	4		1		1	1	2	1		1	4	3	1	1
I like to learn about new things.	3	4	3	4	4		4		3	4	3	4		4	4	4	4	4
My parents (guardians) see me as a leader.	3	3	3	4	2		4		3	3	3	4		4	2	3	4	4
Other people like to work with me.	3	3	4	4	2		3		3	-	4	4		4	2	3	3	3
I have had at least one good science teacher.	3	3	4	4	4		2		3	4	4	4		3	4	4	2	3
I have not had good science teachers.	2	2	1	1	1		2		2	1	1	1		2	1	4	2	1
I prefer not to read about science.	1	1	4	1	1		4		1	3	4	4		3	1	2	4	-
Science is not always about experimenting with things.	4	3	3	1	1		2		4	3	3	2		1	1	2	2	4
I prefer to work alone.	3	4	4	2	1		1		3	3	4	1		1	1	2	1	1
I work well with others.	3	3	4	4	3		3		3	3	4	4		4	3	3	3	4
I enjoy reading about science.	4	4	1	3	4		1		4	4	1	1		-	4	3	1	2
To write a conclusion, I never look for evidence. I just write what I think should be right.	2	1	3	1	2		1		2	1	3	1		1	2	3	1	1
If I have a question, I search for solutions or answers.	3	4	3	4	4		4		3	3	3	4		4	4	3	4	4
I do not like spending time outdoors	1	1	1	4	2		1		1	2	1	1		1	2	-	1	1
My parents (guardians) think that I am not good at science.	1	1	3	1	1		1		1	1	3	2		1	1	3	1	1
I do not like being wrong.	3	1	4	4	2		4		3	2	4	4		3	2	1	4	1

	Participant 25		Participant 26		Participant 27		Participant 28		Participant 29		Participant 30		Participant 31		Participant 32		Participant 33	
Statement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
When I can't figure something out, I give up.	2	1	3	1	3		1		2	1	3	2		1	3	2	1	1
I believe everything my teacher says.	2	1	3	4	4		2		2	2	3	2		4	4	2	2	2
Girls are not good at science.	1	1	1	1	2		1		1	1	1	1		1	2	3	1	1