Citizen science as a framework for secondary science teacher preparation: A hermeneutic ethnography

by

Stacey A. Britton

(Under the Direction of Deborah J. Tippins and Melissa Freeman)

ABSTRACT

Science teacher preparation courses provide a foundation for many future science educators in educational theory and practice. This dissertation focuses on one pre-service science teacher education course which used citizen science as the pedagogical framework for instruction. Citizen science promotes the intersection between science, society, ecology, and students by allowing for knowledge acquisition to occur while participating in environmental and social action. Emphasizing citizen science as a pedagogical framework allowed the instructor to address ecojustice philosophy, reasoning that promotes the inherent connection between social and environmental justice, by encouraging knowledge and awareness of physical, spiritual, and emotional connections between humans and their environment. This research presents a detailed account of how the course was designed, why the focus was on citizen science pedagogy, and what issues unfolded over the semester. Hermeneutic ethnography was utilized as the methodological framework that allowed for action to be processed and meaning ascribed, with the awareness that the researcher played a large role in making sense of what was important. Extensive time spent as a participant observer, multiple interviews, self-reflection, and artifact analysis supported the use of thick descriptions and promoted hermeneutics as a theory of understanding. Findings from this research concentrate on three primary tensions. The first tension furthers the discussion of embodied learning, including the value participants placed on being in and a part of the process behind learning to teach science. A second tension addresses the structure of science teacher education as a theory to practice or practice to theory approach; participants faced challenges when both approaches were presented with equal emphasis, but a seemingly greater value ascribed to one. The final tension suggests developing intellectual communities of dialogue as especially valuable in helping participants understand how the course unfolded, the significance of its structure, and how their personal teaching philosophy developed.

INDEX WORDS: Preservice science teacher education; secondary science teacher preparation; methods; instructional practice; course structure; citizen science; ecojustice; embodied learning; theory and practice; hermeneutic ethnography

CITIZEN SCIENCE AS A FRAMEWORK FOR SECONDARY SCIENCE TEACHER PREPARATION: A HERMENEUTIC ETHNOGRAPHY

by

STACEY A. BRITTON

MS, University of Southern Mississippi, 2001

BS, University of Southern Mississippi, 1998

Citizen science as a framework for secondary science teacher preparation: A hermeneutic ethnography

Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2011

CITIZEN SCIENCE AS A FRAMEWORK FOR SECONDARY SCIENCE TEACHER PREPARATION: A HERMENEUTIC ETHNOGRAPHY

by

STACEY A. BRITTON

Major Professors: Deborah J. Tippins
Melissa Freeman

Committee: Ajay Sharma
Steve Oliver

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
August 2011

DEDICATION

For those who came before me and those who remain. Because of you, I know that I can do anything. Thank you for never letting me forget what is important and showing me how to be just what I am. Because of you, I know how to accept that person and live a full life. You allowed me to develop the philosophy that anything could happen and taught me that faith will get me through when I lose purpose. Being everything that you believe I can be is my purpose. I may be the first, but we know those letters are just details in a life worth of lessons in things that don’t always count.

For wisdom *is* a defense, and money *is* a defense: but the excellency of knowledge *is, that* wisdom giveth life to them that have it. *Ecclesiastes 7:12*

ACKNOWLEDGEMENTS

There are so many people who helped me get through the process of graduate school (it's always about more than the dissertation). Mother and Daddy, thanks for letting me work through the distractions, and for giving me the space to just create and be me. You let me know I could do it all and continue to bring me back down when I get too far above my raising. I promise to always know where I came from. My babies, thank you for being patient and loving me unconditionally (even when it seemed that Aunt Stacey always had to work). You made me stop and play, cook, and hug – you demand my time and constantly remind me of the most important things in life. You will always be my babies and I will always love you unconditionally. I appreciate the sanctuary you give and the constant projects, in the world of jobs that never end.

- Doc. Were it not for you, I would never have figured out what I wanted to be in life. At least, I never would have been a real teacher. Above all, you showed me that it could be fun and to have high expectations. You have influenced my life so very much and still represent someone I would like to emulate.
- Deborah. Thank you for pushing me to make sense of the world in a way I had never considered. Thinking inside the box has always been a challenge, and through many tearful sessions of dissertation work you got me to think more like a researcher. Hopefully, I helped you see that even though some of us fall apart at times – we don't all require kid gloves. I like to think I helped you remember to slow down sometimes. You are an amazing major professor and I am thankful we ended up assigned to each other!
- Melissa. I feel privileged that I was the first committee you co-chaired. Thank you for sitting with me over coffee, helping me make sense of what I was doing, who I was, and why it all mattered. You may not realize, but those sessions helped me through more than

just research. You kept me sane when I just couldn't make sense of things, explained the same idea over and over, yet let me think I made sense of it on my own. I appreciate having the opportunity to work with you more than you know, and I also look forward to future endeavors.

- Dr.'s Oliver and Sharma. Thank you for making up the rest of my committee. I valued your input and hope to continue learning from the things you have done and will do in the future.
- Etta and Laura. Ladies, you made things bearable at times and took darn good care of me. We have a standing lunch date if I ever get to Athens. You are both fantastic people. You may never know how much I appreciate the genuine friends you became, but thank you.
- Morgan. Thank you for letting me invade your class. Thanks for patiently sitting down after every one of them to talk about what happened. I learned a lot about myself through our discussions.
- My study participants. I can't spell you out, but I can say you taught me so very much. Some of it was through the gist of research, some of it was just being able to listen and see the world through your eyes. Your words make me rich. Thank you.
- Countless others who taught me about life, people, and the ways of the world. I appreciate the experiences that helped shape me into what resulted.
- God. You are responsible for it all. Even when I am stubborn I hear the voice that lets me know what is next. I hope to one day deserve being called your child.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

Introduction to the study

In the context of our rapidly globalizing world, the preparation of science teachers is undergoing continuous change. Reform documents of the last two decades have stimulated thinking, debate, and changes in the way we conceptualize the preparation of science teachers, reflecting a shift in emphasis from teaching skills and strategies to providing conditions associated with the prospective teachers' increased responsibility for their own learning. Yet, as Northfield (1998) points out, for the most part, pre-service teacher preparation programs are designed to present what "science educators believe new teachers need to know and understand to begin to work in the profession" (pp. 695). For example, many science educators agree on the importance of inquiry-based teaching (Abrams, Southerland & Silva, 2008; Chiappetta & Adams, 2004; Schwab, 1962), instruction which addresses the needs of diverse populations (Aikenhead, 2006; Bryan, Atwater & Trumbull, 2002; Sleeter, 2001), and scientific literacy for success in everyday living, or for gaining admission into the scientific community (Holbrook & Rannikmae, 2007; Hurd, 1998; Lang, Drake & Olson, 2006; Roth & Barton, 2004) as essential components of science teacher preparation. However, science education researchers such as Aikenhead (2006), Elmesky (2006), Lynch (2001), Maulucci (2008), and Tobin (2006) suggest the need for changes in the way science teachers are prepared, changes that more effectively meet the demands of diverse communities who are often at risk socially and environmentally. It is not surprising that nearly a half-century after Sputnik these science educators, and others like them, point to the failure of science teacher preparation to align with criteria such as relevance, interest and justice underlying many of the pervasive questions of equity in science education. Thus, it is imperative that schools and universities come together to understand what schools are for in the 21st century and create a new vision of science teacher preparation—one in which prospective teachers examine the way their assumptions come to be formed, and not only solve problems but discover how they originate.

One possible direction for a new vision in science teacher preparation is the inclusion of a social justice curriculum. Cochran-Smith, Shakman, Jong, Terrell, Barnatt, and McQuillan (2009) noted that an emphasis on social justice curriculum tends to create negative waves in the education community, especially when individuals believe that teaching must be *either content /or social justice*. The argument made by Cochran-Smith et al. is that that content and social justice philosophy can exist within discipline specific teacher preparation courses. Cochran-Smith et al. (2009) point out that many opponents contend that educators who utilize a social justice framework cannot adequately address content (such as science) in teacher preparation if the focus is on larger issues rather than experiences which foster the development of subject matter and pedagogical content knowledge. Teaching for social justice is described as equipping future teachers to become advocates for their community, to encourage deliberate awareness and education surrounding social inequities, all while "enhancing students' learning and their life chances" (Cochran-Smith et al., 2009, p. 350). Social justice education concerns itself with learning for all students – addressing areas of equity which often translate into the societal roles in which learners reside. Social justice is linked with environmental justice within the scope of ecojustice philosophy (Bowers, 2001, 2002; Tippins, Mueller, van Eijck, & Adams, 2010). Ecojustice merges social and environmental justice theory by promoting awareness of the obvious connections between environmental degradation and areas of diversity and poverty. The overarching idea of ecojustice allows the natural connection, which exists between social/environmental inequities, to be addressed in a more holistic manner. By extension, ecojustice, as argued in this paper, creates an intersection for teaching social and environmental equity along-side science content and pedagogy. Ecojustice philosophy served as the guiding framework for the pre-service science teacher preparation course which provided the setting for this research.

This research represents one example of science teacher preparation. By no means is it argued as the only right way of practice. It should be read as a potential direction we, as science teacher educators, could take in helping prospective teachers become better equipped at meeting the needs of all of their students. It should be read as a possible direction for science teacher education that considers knowledge at a community level, encourages learners to become aware of their surroundings and participate in science as a process for sustaining their livelihoods.

Background

Science teacher preparation consists of several larger ideas which are common across many teacher education programs. Fraser-Abder, Abell, & Trumbull (2009) describe several characteristics that are common to many science teacher preparation programs: understanding of subject matter, knowledge of the histories that have shaped education, development of a variety of teaching strategies, participation in fieldwork prior to student teaching, involvement in supervised student teaching experience, and the completion of some type of capstone project. Likewise, Darling-Hammond (2000) discusses the need for introducing a variety of teaching strategies designed to help prospective teachers become effective educators. However, many teacher educators would agree that teaching entails so much more than knowing your subject area or your student population (Aikenhead, 2007; Cone, 2009; Smith & Newsome, 2004; Tobin, Tippins, & Gallard, 1994; Wilson, Floden, & Mundy, 2002). Teachers have to be prepared in ways that encourage exposure to diverse cultures, multiple ability levels, curriculum development and use, and the logistics of actually teaching hundreds of students. Abell (2007) and Fraser-Abder et al. (2009) emphasize that much of the learning associated with 'being' a science teacher starts in the teacher preparation programs.

Research in science teacher education indicates that prospective teachers often revert back to the familiar, to the ways in which they were taught as students (Wilson et al.2002; Windschitl, 2005). While the argument positions the k-16 classroom as the primary place where knowledge about teaching arises, science teacher preparation courses provide an opportunity to challenge pre-existing ideas and help prospective teachers develop new understandings of teaching and learning (Zembylas & Barker, 2002). Specialized coursework often provides alternatives that strengthen the repertoire of teaching skills for pre-service teachers as they encounter new ideas, while encouraging science teacher educators to recognize the value of preconceived beliefs held by their students. Zembylas and Barker (2002) point out that science teacher preparation courses must address pre-service teachers' conceptions of teaching and learning and introduce experiences that enable them to question their current assumptions. They emphasize the importance of providing opportunities for the pre-service teachers to be removed from the comfort of the familiar through participation in situations and experiences that promote awareness, challenge assumptions, and foster the development of skills which could be beneficial in helping them learn to teach. Similarly, Aikenhead (2006) calls for science teacher preparation which promotes an awareness of diversity, develops pre-service teachers' abilities to integrate different knowledge sets into the classroom, and expands on traditional forms of instruction.

Rethinking science teacher preparation

Considering suggested changes presented by the aforementioned researchers, teacher preparation can be altered in many ways that challenge pre-service teachers to consider new approaches of learning and teaching about science, such as the inclusion of diverse settings. Diverse settings have been used for science teacher preparation with positive outcomes - these often include non-classroom environments. Organizations such as zoos, aquariums, and botanical gardens are often used in science teacher preparation, at varying levels that include elementary, secondary, and university students and faculty (Klein, 2006; Miele & Powell, 2010; Olson, Cox-Petersen, & McComas, 2001). Some science educators, in these varied settings, promote involvement with science education methods courses by having prospective teachers prepare science units for in-service teachers; they also encourage the use of their facilities for class-meetings. Klein (2006) mentions collaborations with both the Houston Zoo and the St. Louis Zoo with science teacher preparation courses. The Houston zoo, for example, invited pre-service teachers to help create lessons which were piloted by in-service teachers. The St. Louis Zoo has a long-standing relationship with science teacher educators in local colleges with an effort to, according to Klein (2006), encourage the use of their facility in science education and provide community resources.

Considering ecojustice philosophy

Researchers such as Bowers (2001 & 2002), Mueller (2008), Mueller and Bentley (2007), and Tippins et al. (2010) have described multiple components of ecojustice philosophy. These researchers present ecojustice philosophy as a way to: make the global more local, encourage decision-making skills, challenge cultural assumptions, and promote an increased awareness for the use of language. In terms of science teacher education, these researchers maintain that ecojustice philosophy helps in creating democratic learning environments with learning taking place as a mediated process to encourage participation by multiple parties (Tippins et al., 2010). Ecojustice philosophy opens a door to learning in different contexts and utilizes multiple formats for encouraging both individual and group development. The essence of ecojustice is the relationship between society and ecological awareness, preservation, and sustainability. Ecojustice philosophy is concerned with environmental issues in a variety of social ways including equity in relation to non-Western cultures, abuse of indigenous groups through land exploitation, economic prosperity in conjunction with land use, and modifications to lifestyles in ways that benefit the environment (Sachs, 1995; Tippins et al., 2010). Many researchers address the larger philosophy of ecojustice through pedagogical frameworks such as citizen science, which is defined later (Bowers, 2002; Glasson, Frykholm, Mhango, and Phiri, 2006; Mueller, 2008). Karrow and Fazio (2010) argue that citizen science appears to present itself as a viable approach to teaching science in ways that make it more relevant to the actual needs of a society. They propose that citizen science promotes learning science at a community level by encouraging learners to become actively engaged in their world.

Science teacher preparation using citizen science pedagogy

When thinking of the possible directions for science teacher preparation and the suggestions of the aforementioned researchers, the consideration of citizen science pedagogy provides a potential avenue for preparing prospective teachers. The principles of citizen science reflect learning and doing science in the community by discovering concerns that exist, working to solve problems through the inclusion of local resources, and fostering an appreciation and awareness for all types of knowledge (Brossard, Lewenstein & Bonney, 2005; Tippins & Mueller, 2009; Trumbull, Bonney, Bascom, & Cabral, 2000). Citizen science promotes daily involvement in the community with decision-making occurring as an ongoing learning enterprise as citizens work with experts, including teachers, in diverse disciplines. Citizen science has the capacity to create opportunities for the community to participate in science activities that benefit the local area in a multitude of ways, such as: increasing awareness of the role of scientists, helping people understand the nature of science and problem-solving, and improving the environmental, physical, and emotional health of the community - all while empowering often marginalized populations (Braschler, 2009; Cooper, Dickinson, Phillips & Bonney, 2007; Jenkins & Jenkins, 1999).

Ellen and Harris (2000) propose that as early as the sixteenth century, researchers, physicians and the upper echelons of society were utilizing the knowledge of local people to learn about various plants and medical treatments that previous texts did not include or had proven ineffective. European botanical sciences were transformed by the knowledge provided through interactions that were taking place between Asian and Middle-Eastern locals with floral and faunal researchers (Ellen & Harris, 2000). One of the main constructs in citizen science is the involvement of scientists with local people to develop greater knowledge and understanding of the processes that occur in particular areas (Silvertown, 2009). Local people are critical to citizen science discourse because they usually have the interest of the community at heart.

Citizen science can be represented through many different activities, one project depicting the knowledge gained by local bird enthusiasts was represented in the 1993 Seed Preference Test. Trumbull et al. (2000) discovered varying degrees of scientific literacy reflected in letters written in conjunction with the 1993 Seed Preference Test (SPT). The purpose of the SPT was to provide large quantities of scientific data - information collected by citizens who observed the bird species in their local habitat and recorded an apparent preference for specific seed types. The participants involved in this citizen-science project provided demographic data, indicating that citizen interest in science exists across a diversity of backgrounds. Many participants were high school graduates, with almost 70% of the citizen-scientists involved in collecting data having some level of college exposure, several with advanced degrees. As a result of this project, a large number of citizen contributors wrote letters to the Cornell Lab of Ornithology describing the data they collected, the scientific processes they performed, and additional hypotheses or suggestions which they developed through the collection of data (Trumbull et al., 2000). These written contributions were analyzed to gain an understanding of why people participated in the project and subsequently wrote letters about their citizen science experience. The analysis provided a strong indication that inquiry occurs when people are encouraged to do science in their community. In their study, Trumbull et al. found that individuals, with limited guidance and varying degrees of experience, were able to construct scientific understandings through their participation in citizen science. Roth and Lee (2004) describe another component of citizen science as its focus on communities rather than individuals. They present citizen science as intergenerational, providing opportunities for people of varying ages and walks of life to work together. Organized citizen science monitoring or remediation programs encourage teens, adults, and the elderly, to work together solving problems. Bonney et al. (2009) outline the value of using citizen science as a tool for increasing science literacy and knowledge. Focusing on the Cornell Lab of Ornithology citizen science projects, Bonney et al. suggest locating a science concern, training participants to work with scientists, educators and others in developing test protocols and conducting studies. A final aspect of the project design suggested by Bonney et al. (2009) is collaboration within the community to interpret the collected data and disseminate to a larger population for greater understanding, participation, and advocacy.

Is it possible that science teacher preparation can be re-structured to promote greater degrees of learning, by building relationships with local places and communities and giving value to sustainable science rather than science for the profession? That is a question yet to be answered, but calls for action by those in positions of power who care about change and progressive ideas which consider diverse cultures and communities.

Rationale for the study

Science teacher preparation must continue adjusting to accommodate the needs of society, as it has done historically (Atkin, 1983; Cahoon & Richardson, 1950; Jackson, 1983; Tobin, 2006). In the second decade of the 21st century, it could be argued that science teacher preparation should be inclusive of various subjects and cultural experiences, beyond the current expectations of the scientific community (Aikenhead, 2001, 2006; Barton, 2000; Glasson, Frykholm et al., 2006; Tippins & Mueller, 2009). The case for science education that allows for decision-making, community-based problem solving, and construction of applicable science knowledge is strong and begins with preparation of science teachers well-versed in theory and experienced in practical utilization of what they have encountered (Ball, 2000; Kelly, 2000; Olson et al., 2001; Roth & Lee, 2004; Smith & Newsome, 2004). Hurd (2002) argues that we must prepare individuals for living as a part of their world and functioning as decision-making citizens within the society they inhabit, rather than only preparing them for possible careers in science. Science can be taught in ways that increase relevance and, according to Aikenhead (2006), enable students to make better decisions about their world, while building their comfort and ability to communicate in ways that incorporate technology, social action and cultural self-identity. Orr (1992) presents an argument, related to science teacher preparation that depicts the role of teacher as one who prepares students to make decisions and live in harmony with their surroundings by acknowledging culture and community in ways that promote scientific literacy. According to Orr, the inter-connectedness of content, society, and ecology make for an education that could (and arguably should) be present in our system of teaching and learning. Ecojustice philosophy closely aligns with these beliefs. From an ecojustice perspective, prospective science teachers need to be aware of the impact of their individual and collective actions and how they can be positively involved in changes that must happen if we are to have a sustainable science education future.

One such study that argues for learning with a cause, conducted by Wilson and Stemp (2010), promotes the inherent value in exposing both pre-service secondary teachers and k-12 students to alternative learning opportunities. Through a project taking place at an alternative school in Australia, teachers and researchers made observations regarding attendance and interest in science specifically when it related to the local community. Their argument was that projects which are based within communities could enhance the value of student populations who are marginalized and gain the interest of students who are often not involved in education (Wilson & Stemp, 2010). Secondary-level students in Australia, described as 'at risk' for a variety of reasons and consistently absent from school, demonstrated a phenomenal response to the inclusion of a citizen science project as the central part of a month-long curriculum. First, teachers reported higher than average attendance – even while social/familial concerns were documented as higher than normal. Second, the students were more engaged in learning – responding in ways that suggested a higher than average interest in the project. Lastly, as the citizen science project progressed, students became more obviously excited about what they were doing. This excitement was noted by the researchers as evidenced through the questions students asked during the project about the environmental learning they felt their work represented, and in the recognized changes they noted as taking place within their own communities. Studies like this highlight the value of involving learners of all ages in citizen science endeavors that enable them to gain scientific understanding while making a difference to what matters in their local community. While the focus of the study conducted by Wilson and Stemp (2010) was on secondary student learning, this research provides encouragement for preparing teachers in ways to better accommodate instruction that includes community project and varied learning opportunities.

Purpose of the study

Positioning pre-service science teachers to learn in diverse contexts and challenging their inherent assumptions of teaching, learning and curriculum may provide the impetus for a change to the educational structure which so many researchers have faulted (Klein, 2006). Accordingly, the purpose of this study was to uncover how pre-service science teachers came to understand the teaching and learning of science in the context of a secondary science teacher preparation course organized round the tenets of citizen science. A subsidiary point of this research was in understanding how participants began to make sense of citizen science, and what accommodations were made in an effort to provide instruction based on ecojustice philosophy and citizen science as a pedagogical framework.

Overview of the Study

Context of the study

The research for this dissertation was conducted in a science teacher preparation course at a major southeastern university. All individuals seeking a teaching certificate in science are required to participate in this course, creating a diverse student population with multiple science content backgrounds. The fall 2009, Method of Teaching Science course, which was selected as a context for this study, is unique in that the university professor structures his teaching around the philosophy of ecojustice and positions learning events which are framed within citizen science pedagogy. There were 23 student participants in the course, serving as either a primary or secondary participants (the distinctions will be addressed in chapter two, with additional information about the selected research setting).

Research Questions

Since the focus of this research was to gain an understanding of what took place in a pre-service secondary science teacher preparation course organized around the tenets of citizen science, the following research questions emerged to guide the study:

- What can be learned when citizen science is used as a framework for teaching and learning in a secondary science teacher preparation course?
- How do participants make sense of learning to teach in a secondary science teacher preparation course designed around the organizing framework of citizen science?

Methodological and theoretical perspectives

Hermeneutic ethnography served as the guiding framework for this study. The nature of hermeneutic ethnography places it as both a methodology and a way of developing theoretical understanding. At its very essence, hermeneutic ethnography is a theory of understanding, both of others and self, that takes place through interpretation of meanings assigned to objects or encounters (Geertz, 1973; Michrina & Richards, 1996; Vanhoozer, 2006). The primary interest in doing hermeneutic ethnography is to understand what is behind particular behaviors, actions or expressions, what meaning and purpose they hold for the participant. Through intensive interaction with participants, the opportunity to ask questions allowed the researcher to make better sense of how the participants were experiencing the course. From this perspective, it is vital to consider that the observer can never be completely isolated because he/she also holds personal meaning for specific actions while being concerned with the existence of multiple interpretations. Certain groups may hold specific meaning for a behavior, meaning that may differ in other groups; differences in meaning may exist between the observer and the observed. Hermeneutic ethnography is intended to help the researcher gain a better understanding of how meaning unfolds. The nature of hermeneutics encourages the researcher to focus on how relationships are developed and on how individuals develop meaning both from personal and interactive experiences.

Methods of the study

The research was conducted over one college semester, with events centered in and around the science teaching methods course. There were four primary student participants in this study, as well as the instructor of the course. These five individuals took part in three separate in-depth interviews which occurred in regular intervals between August and December. Other student participants were encouraged to attend the focus group discussion; seven pre-service teachers attended the single, two-hour discussion. The researcher attended every class meeting, making field notes which were later expanded into detailed observations. The primary student participants made their class assignments available for review and analysis. Additional sources of data included email interactions, out of class encounters, and after class discussions with the course instructor. During the process of data collection, observations and transcripts were read for understanding and provided opportunity to develop questions which aided in the sense-making process. At the conclusion of the semester, all of the data was compiled and thoroughly read prior to beginning analysis. Further analysis provided evidence of connecting ideas which were designated as themes. The data was then grouped within themes, in terms of similarity and how they functioned to answer specific research questions. The combined data was more deeply analyzed with tensions being developed from the findings. These tensions were then written to discuss connections to the larger body of science education literature.

Salient terms of the study

The following terms will be used commonly throughout this study and are described briefly so the reader better understands how findings and interpretations were situated within data and current literature.

Citizen science involves people participating in the processes of scientific inquiry and doing science. It has been used to describe grass-roots efforts of environmental protection, aimed at supporting complete scientific data collection. Citizen science serves as a tool to get the public interested in issues within their community, making them advocates for rights and decisions that directly influence their way of life.

Co-educator is used to describe any individual who had a role of instructor in the methods course in this study. These people are typically content experts that are brought in to provide additional instruction while the course instructor is present.

Ecojustice is a philosophy which focuses on the intersection of social justice and environmental justice. In essence, this philosophy serves as a way of considering not only the people of a place, or the place of place, but also promotes a relationship between the two. This relationship is what encourages action and protection.

Ethnography is a method of in-depth research which involves extended time within a community of individuals, observing their actions and becoming part of the culture to gain an understanding for how the group makes meaning.

Formal education refers to the classroom environment which is familiar in the United States – desks filled with students of varying backgrounds. It involves learning which is structured specifically around an accepted curriculum that may be based on national standards.

Hermeneutics relates to a theory of understanding in which the researcher is required to consider his/her role in behavior and interaction that occurs through participation, and how the presence of a researcher may modify those actions.

Informal education refers to learning which takes place outdoors or not within a regular classroom setting. Within the scope of science education, it typically refers to learning which takes place at museums, zoos, nature centers, farms, or similar locations.

Method is a term referring to strategies, techniques, skills, and other tools which typically become part of a teacher's pedagogical repertoire. Generically, it refers to 'how things are done'.

Overview of chapters

In an attempt to provide the reader the opportunity to experience this ethnographic study, data is not reserved for only findings and discussions. Throughout the body of the dissertation, the setting, the participants, and the interactions are described in an effort to promote understanding and depict a clear vision of what happened throughout the course of the semester-long study. Footnotes are used to provide further explanations for terms and actions which may not be familiar but are necessary for processing the action being described. At times, the voice of the researcher is largely heard over others because the nature of hermeneutics requires self-reflection and identification of self within the process of representing and understanding behaviors and conversation.

Chapter one provides a brief introduction and rationale for the study. Research questions are introduced along with an overview of the theoretical and methodological perspectives which guide the study. The methods of the study are described, including a portrait of the context of the course. Citizen science, and the related theory of ecojustice, is defined in relation to current activities in the science and the education communities. A brief overview of each of the remaining chapters is included within chapter one to provide guidance and easy reference for the reader.

Chapter two details the theoretical/methodological framework which guided data collection and researcher engagement with participants. Hermeneutic ethnography is discussed, with excerpts from the researcher's 'notes' used to inform and provide greater understanding of what the theory represents and how it informed the progress of the study. Hermeneutic ethnography is detailed as it influenced observations, actions, and behaviors in relation to the context of classroom; personal subjectivities are included through interpretation of data as well as in chapter three. Theoretical aspects of worldview are discussed in relation to their guiding role in shaping my hermeneutic understanding of the interactions observed over the course. Procedures for data collection, participants, study site, and the process of data analysis are also discussed in this chapter.

Chapter three introduces the participants of the study. Profiles are used to describe key personality and background characteristics of each of the primary participants. These portraits are included as a way for the reader to come to know the participants and how they contributed to my understanding of what the course meant in terms of pre-service science teacher preparation.

Chapter four provides an overview of the data collected which is organized around particular themes relating to the data interpretation. The course expectations are represented from the viewpoint of the instructor and the participants prior to the unfolding of the conditions which would define the fall 2009 methods course. Shared from the viewpoint of the participants, the information in chapter four is critical for the reader to establish a relationship with the research.

Within **chapter five,** literature is discussed in relation to tensions which emerged from the major themes evident in the data presented in chapter four. Drawing from these tensions, literature regarding practice-theory and theory-practice, embodied learning, and other relevant ideas are shared in terms of how they served to shape interpretation of this methods course. This overview of literature specifically considers what other science educators deem beneficial in terms of science teacher preparation and how these ideas relate to the fall 2009 Methods of Teaching Science course. Finally, implications for teaching, theory, methodology, and future research directions will be addressed. Implications for teacher preparation address ideas specific to the use of co-educators and the inclusion of diverse learning contexts; theoretical implications suggest value in embodied learning as a 'method' of increasing advocacy; methodological implications highlight the benefits and draw-backs of using hermeneutic ethnography. Lastly, implications for future research are discussed as potential directions which could be addressed for bolstering the findings from this body of work.

CHAPTER TWO

Methodology, theory, and creative analysis

Chapter two introduces the reader to the methodology and the theoretical framework utilized in the completion of this study. An explanation is provided for why these frameworks were selected and how the study was guided by my understanding of the broader qualitative concepts relating to hermeneutic ethnography. Chapter two also provides a thorough description of the setting, the process of participant selection, procedures used for completion of research, progression of data analysis, and a discussion on the presentation of the research findings.

Context of the Study

Research for this study took place at a major southeastern university, in a pre-service secondary science teacher preparation course with citizen science serving as the organizational framework for instruction. Classes were held in a variety of locations which included the "traditional" university education classroom (a structured building, with tables, chairs, and regulated temperatures), a nearby botanical garden (Piedmont Arboretum), a local farm cooperative (Luna Farms), a university science laboratory (microscopes, lab tables, scientific equipment), and an environmental complex (off-campus facility, set within a wooded area). Further information about individual locations, activities, and participants will be discussed within the methods of the study.

Theoretical and methodological frameworks

The methodology guiding this study was hermeneutic ethnography, which was used to build an understanding of participant interactions within the secondary science teacher preparation course. The questions[1] guiding this research moved beyond identifying the culture of a group and involved understanding the conditions and processes through which individuals make meaning of their experiences (Geertz, 1973). Ethnography, according to Hammersley and Atkinson (1983), focuses on interactions within groups and what those interactions represent, and requires that extended time be devoted to the group being 'studied'. For the purpose of this study, a hermeneutic lens was employed to enhance the interpretive and reflective qualities of ethnography (Geertz, 1973). Hermeneutic ethnography, as described later in this chapter, provided a way to build on the intensive time spent with the participants in the research setting, allowed for continued self-reflection and analysis, and promoted opportunities to revisit questions regarding interactions and meanings that were established as the course unfolded.

Hermeneutic ethnography

In some class, at some point in our personal history, we are required to 'know' something - to commit something to memory. Imagine that everyone had to learn the same thing. Year-after-year students may learn the same verse – for me it was in the first grade. We had a printed verse that had to be recited at the end of the week - "If at first you don't succeed, try, try again." Over twenty-five years later, I can still remember the classroom, the teacher, and the recitation of that verse. Every year since, that one idea has stood out for one reason or another. Every child in my first-grade classroom had a verse or poem to remember. Imagine that all of the students who attended this school were asked to learn the exact same phrase. Over time it would become common, known by a larger and larger group of people. All the students who had been with "that" teacher or

[1] Research Questions are provided near the end of chapter two.

attended “that” school would have had a very similar experience. By no means should this be considered a prescriptive form of education, think more of it as a common experience had by multiple individuals. A memory of learning that can be shared across generations. Now, move beyond that school and imagine the students in a school nearby learning something different, something unique to their area (geographic or cultural) - knowledge about their world that allows them to interact successfully within their selected social group, or ‘culture’ if you will. It could be said that one school group had a cultural experience different from that of the neighboring school. The group of students in my first grade class all have the similar experience of having to learn a poem, the memory may have remained and helped establish cultural foundations which are unique to ‘our class’. In other words, those with whom we associate often have similar knowledge, beliefs, and systems of understanding that they have learned to navigate from within. However, on a much larger scale the effect is less apparent. In most cases, people gain multiple experiential opportunities which broaden their horizons and allow them to become knowledgeable about the surrounding world. Experiences and the development of beliefs can be viewed and sense-making attempted through the use of hermeneutic ethnography. Hermeneutic ethnography provides a theory of understanding that takes into consideration the individual effects of diverse cultural groups in situations where individuals experience events alongside others who may not share similar cultural backgrounds. By using hermeneutic ethnography, we are encouraged to make sense of what we are seeing, while considering our own cultural experiences and abilities to interact with others taking part in these events. Hermeneutics provides a framework that supports reflection of how these experiences are shaped by the group and how each individual, including the researcher, influences the making of meaning as each attempt at interpretation of these events (Bauman, 1978). Similarly, at any point in ethnographic research, we might also reflect upon an earlier event and attempt to incorporate what we have since learned in an effort to negotiate a new meaning or further the development of our existing understanding. Michrina and Richards (1996) state that hermeneutic ethnography encourages constant interaction with the participants, self, and one's own attempt at understanding what was meant by the participants in any given situation. Placing oneself within the social group, while still avoiding imposing of self, is essential to interpretations that reflect the most probable understanding of the participants.

Specific to this research, hermeneutic ethnography concentrated on what could be learned through a close examination of multiple encounters. The encounters being examined included the researcher and researched, instructor and students, student and student, the way in which the context and the topic of citizen science affected them all, and the meanings that emerged from these interactions. According to Goodall (2003), hermeneutic ethnography involves a personal relationship with all sources of data during the process of research, an acceptance and integration of different ideas, and reflection upon personal beliefs and perspectives that might influence understanding and attempts at making meaning. Specific to this research, part of the appeal of hermeneutic ethnography was working within the frame that nothing was absolute. As the ethnography progressed, greater degrees of knowledge became available with the potential for further questioning and the possible development of understanding. This type of research supports the idea that meaning-making could vary greatly between individuals doing the same research, under the same conditions. Hermeneutic ethnography allows the researcher to account for her own understanding and encourages the process of self reflection, in an attempt to delve further into what the participants actually meant. Ideas and interpretations of the researcher provide greater insight for the reader, considering that hermeneutics entails constant processing and re-visiting of ideas to address alternative meanings as a way of exhaustive interpretation (Bauman, 1978). It must also be considered that the interpretations are directly related to the researcher's ability to take part in and understand the context, the interactions, and what the participants deem valuable, making the notion of "thick descriptions" necessary[2]. "Thick descriptions" are discussed in greater detail, later in this chapter, but refer to the presentation of data in detailed accounts which may allow the reader to 'experience' how the context and interactions occurred and were interpreted (Geertz, 1973).

Through detailed accounts of what took place, the researcher can begin to attempt an understanding of what individuals involved in the setting thought was actually occurring and why the information mattered. According to Flyvjberg (2001), the extent to which we present the data and the detail we have included, within the context of our study, are what enable others to be part of our story and make their own meaning of encounters. The description, written as an outsider, means that interpretation cannot be taken as 'Truth', it can only serve as *one* perspective. Our own experiences are what guide our ability to interpret action, according to Geertz (1973), but what we interpret may contrast the true meaning that an action has for the participants with whom we are working. However, through a rich account of the experiences, the reader can be placed within the story and allowed to see what the researcher sees, going through the process of

[2] Reflective journaling will be discussed in greater detail as it relates to making sense of being within the ethnographic study.

seeing through the eyes of the researcher and understanding things as the researcher came to understand them (Geertz, 1973). Truth can exist only in what can be seen and not in the unique interpretations of the researcher, since meaning may be ascribed differently by the reader who may have distinctive life experiences.

Others must be able to place themselves within the context of the story and experience events so that interpretations make sense. The excerpt included below presents how events might be interpreted in a variety of ways, and begins to examine how gathering new evidence and reflecting on prior assumptions becomes essential in interpretation.

She rolled her eyes? (A story of a 'mis' interpretation and seeing oneself in others)

> The granite rock was shaded by tall deciduous trees that were holding on to a few of their last leaves as winter approached. Some students stood around the base of the rock, others sat in assorted positions on its peak – huddling together and talking about assignments or the weather. Shivering together in our jeans and fleece jackets, we watched the instructor move through the gardens, carrying stacks of books and papers. Morgan suggested to the class, 'why don't we move over to that gazebo?' During the walk over, he told me that the sun would come out and warm things up and that 'the students will really start to appreciate that we are outside'. I thought to myself- 'you are from the north. Down south, we don't appreciate the cold that much'.
>
> It was nearing eight-thirty on a cold fall morning towards the end of September. It was a cool morning for Georgia, somewhere in the low to

mid-50’s. We huddled under or around the gazebo, in the vegetable garden, where the sun couldn’t reach us. Some sat on the concreted ground under the gazebo, others on benches grouped together in three’s or four’s, with yet more students standing. Notebook in my lap, I leaned against the supporting post of the gazebo which appeared to be strategically placed in the center of this particular garden. Looking around at the pre-service teachers…I asked myself, ‘are they paying attention? Do they think it’s strange that we are having class on the ground?’

Morgan was lecturing about grading policies, how he didn’t believe in assigning grades because final products don’t always indicate the work that goes into their completion. Morgan explained that grades don’t always represent what he believed to be a good teacher, adding that “good teachers will use citizen science.[3]”

Thirty minutes into a class lecture, we had yet to utilize anything around us. My butt was cold, but birds were chirping. I wondered ‘what kind of bird is it? Did he hear it? Did they hear it?’ The sun started to emerge above the trees and I began thinking to myself. ‘It’s still cold, I’m cold. I’m tired of sitting here. Why couldn’t we do this in the classroom?’

Morgan told the group ‘Being outside in different situations gives you experience so that you can learn how to deal with different conditions, with implicit learning outcomes such as how to dress appropriately, or what to wear in certain circumstances.’

[3] Double quotation marks will be used to denote exact wording. Single quotes represent the general conversation, but may not be precise commentary.

> The lecture moved to resources that could be used in the classroom with Morgan sharing, 'technology is a great tool, but you have to be careful not to let it take over.' Books began to move through the group. Materials that Morgan had carried around the garden were shared with the students – books and publications that gave ideas about how to teach various ideas, sources for teachers. Sheri had one in her hand a teachers' guide from NOVA, a publication associated with Public Broadcasting Station (PBS) and focusing on tools for education. She turned it over, reading the back of it. The book moved on to her neighbor as Morgan began talking about mapping the school grounds, the activity which would take place in class that day. 'Find something in the area that tells a story. Look at it. Study it. Create a story about it. When we come back as a class, you will share your story. Get creative. This is something you could have your students do in your own classroom.' Students began looking around the gazebo, the wall, and the vegetable garden. Sheri looked at me and rolled her eyes. (Classroom Observation 10)

Within hermeneutics the researcher is encouraged to question what they see and how they are a part of the process. The excerpt above provides a glimpse into how I was feeling throughout the classroom presentation and how my own experience could have clouded my perception. I initially assumed that Sheri rolling her eyes was a negative response to what Morgan wanted the class to take part in, but time spent gathering more data and developing relationships with Sheri and other participants increased my interpretive skills and allowed me to see the action as something more positive. My understanding of Sheri rolling her eyes changed as the semester progressed. Without the experience of seeing this action, hearing her story, and talking about this with her, I would have decided that this one event represented something negative. With time, I realized that Sheri wasn't being disrespectful, that my initial thought of negativity was something I imposed on her. My feelings during the activity were being transposed to Sheri. I viewed the activity as a waste of time, and assumed her eye-rolling indicated a similar response. Through deeper analysis and self-reflection I began to realize that my own interpretations needed to be better developed and more concerned with what the pre-service teachers were actually experiencing and thinking. The nature of hermeneutic ethnography encourages complete immersion in experiences so that the fullest levels of meaning can be attained. In this case, understanding the interactions and behaviors of pre-service science teachers with the course instructors and the framework of citizen science was the primary goal. However, the interpretations and presentation of data are a direct result of what I experienced. Regardless of how I attempt to paint the portrait from the participants view, they are the result of my experience and are my interpretation. Particularly valuable in the process of hermeneutics was the act of challenging my views in relation to what I began learning from my own participation and interaction with others. Being 'forced' to analyze my personal responses and become more involved in the meaning ascribed by the participants challenged the process of doing research but also provided the foundation that made this study a hermeneutic ethnography.

A primary challenge involved with using hermeneutic theory is that we tend to develop interpretation based upon our own experiences, which often cannot be separated from what we are 'in' at the moment. Being 'in the moment' may involve our experience with the participants and their encounters, yet may also revolve around things happening in our personal lives which have nothing to do with the research but may shape our understanding nonetheless. In attempting to present accurate interpretations of these encounters, researchers must be aware of their personal subjectivities and potential alternative interpretations that may exist. The practice of constantly monitoring and recognizing self within the unfolding research aids in what could be considered a circular process of re-evaluating, reviewing, and making additions to the current data. Hermeneutics requires the researcher to address personal issues, challenging initial conceptions and misunderstandings by way of thorough immersion in the data. As a way of addressing subjectivities and developing deeper levels of understanding, Michrina and Richards (1996) encourage hermeneutic researchers to maintain a reflective journal that documents progress, initial conceptions, and the process involved with gaining new understandings. In an attempt to understand myself in the process of this research, I kept a journal that, while not daily, did allow for personal discussion on issues that arose through my encounters with the participants and various ideas represented in the course. When a particular idea was especially challenging on a personal level, I met with a committee member versed in hermeneutic theory to discuss my perceptions and to attempt at fully immersing myself in the research from the perspective of others. The excerpt which is included below is pulled directly from my early journaling and highlights some of the issues I had to address on a personal level.

> Rather than comparing the course to my own experience, which could be skewed because it was so long ago, maybe I truly need to 'become' a student again. Is it possible that I just feel very negative about Morgan's

> way of teaching? Is it my own experience that causes me to become agitated at his methods? I really need to try and see things from the perspective of the pre-service teacher. After the interviews are done, maybe it will be helpful to delve into sections where the students are very positive about what they are learning. How can I create a balance between expressing the views of an experienced teacher and a novice teacher? Will that difference alter how I make meaning of what I see? (excerpt from researcher journal, September 2009)

Michrina and Richards (1996) suggest reflective journaling because it provides time for self-analysis and continued processing. Through self-monitoring, the researcher can identify bias and work towards addressing personal issues that better allow concentration on participant expectations and actual events. The use of a reflective journal potentially results in more thoughtful interpretations which are based upon the actual events rather than possibly skewed perceptions. The reflective journal was very influential in my attempted understanding of the participants and their experiences over the semester, and is discussed throughout this and other chapters as it is related to my growth and ability to make meaning through the eyes of the 'other'.

Hermeneutic ethnography served as the basis for this study and has been briefly discussed in this chapter. However, in an effort to provide background on hermeneutic ethnography and present how it was understood by the researcher, individual descriptions of ethnography and hermeneutics are provided. Ideally, the reader will be further encouraged to contemplate the natural connections which exist between the theory and methodology. Supporting theories which were utilized in this study are described in direct relation to how they were used in making sense of a citizen-science framed secondary science preservice teacher preparation course. Specifically discussed in this chapter are ethnography, hermeneutics, and worldview theory. Within this study, ethnography was framed by the researcher as the process of collecting data, of getting involved with the participants, interactions, and ideas that unfolded. Given this conception of ethnography, hermeneutics served as the guide which was utilized in understanding the connections that emerged. Understanding this research as a hermeneutic ethnography meant considering the process of making sense of what was seen and experienced; later interactions were considered in light of previous encounters with understanding being based on learning through the progression of experiences. Worldview theory is also discussed as it aids in understanding the way an individual's prior beliefs shape their ongoing interactions with the world. While these theories often have universally accepted 'expectations' within research, specific components will be discussed in terms of furthering my understanding of how the pre-service teachers made meaning of the course and in relating the smaller ideas to the larger structure of a hermeneutic ethnography.

Ethnographic research

Ethnography is aptly defined as a long-term study of a particular culture in which the researcher becomes a participant in the activities of that culture with the intent of developing relationships that strengthen the understanding of interactions between group members (Geertz, 1973; Spindler & Spindler, 2000; Wolcott, 1982, 2002). Rooted in anthropological studies, ethnography typically refers to the situated, empirical description of peoples and races (Hammersley & Atkinson, 1983; Spindler, 1982). Ethnography helps “us understand how particular social systems work by providing detailed descriptive information, coupled with interpretation, and relating that working to implicit patterns and meanings which members of society hold more or less common” (Wolcott, 1987, p. 52). In essence, ethnography allows a culture to become familiar, while maintaining an emphasis on the qualities and aspects of the culture that make the people or group unique. Other terms used for similar processes include fieldwork, qualitative sociology, and participant observation - all describing a method for “reconstructing the actor’s own world-view, not in a lordly way but faithful to the everyday life of the subject” (Rock, 2001, p. 30).

Ethnography is about seeing things, asking questions, and accepting that our eventual understanding may not accurately portray the real purpose behind the action (Geertz, 1973). Since the focus of this type of research is to represent lived experiences and attempt to find meaning as ascribed by the participants, intensive time and resources must be allocated for collecting as much information as possible. Peshkin (1982) and later Wolcott (2002) emphasized that with ethnography, attempting to understand the behaviors of others can be done through research using a variety of methods, encouraging the researcher to consciously remain impartial, yet maintain an awareness of personal subjectivities while concentrating on the group as a whole. At the core of ethnographic research is a quest for deeper meaning. An understanding of the culture and the connection that develops between the researcher and the participants promotes meaning making that is potentially more true to the original intent (Geertz, 1973). Ethnographers participate in the activities of the culture while observing and recording details, both significant and insignificant, following up with individual interviews and focus group discussions, and spending time within the circle of members to become familiar with who they are and what they represent. Per Wolcott (1987) and Spindler and Spindler (2000), ethnographers engage with the group in a way that positions culture as the focal point of research, including the inner dynamics of why people act within certain parameters, what those parameters are, who defines them, and why they are maintained as such. Goodall (2003) suggests depicting events as they unfold and making an effort to address personal interactions as influential in making meaning (purpose of the reflective journal). Through participation in the group, asking questions when things don't make sense and taking time to self-reflect, it is possible to portray what was seen and suggest possible interpretations for why something happened. By no means are these interpretations conclusive, nor should they be perceived as such.

Meaning is very individual, which is why detailed, expansive descriptions are necessary to allow others the opportunity to form their own interpretations. Geertz (1973) promoted the researcher attempting to develop an insider view of an often outsider relationship by establishing connections with the participants that allow for questions and encourage deeper levels of recognition through an attempt at interpretation of meaning. According to Geertz (1973), interactions occurring between people and objects are relationship-oriented and the meaning associated with these is what makes ethnography such a necessary part of understanding our world. As will later be discussed, hermeneutics, as a theory of understanding, aids in the researcher's attempt to understand these meanings which become established within cultures and are dependent upon these interactions.

The constant transitioning between data and analysis aids in the open-ended aspect of ethnographic research and lends to a degree of uncertainty in the outcome. The narrative below, which is a personal dialogue, serves as an introduction to 'doing' ethnography as I understood it in the beginning- what I anticipated as my role and how my thoughts transitioned as I began to revel in the experience of the class.

Becoming an ethnographer (How I 'understood' in the beginning)

> How do you know what to write down? This was one of the first questions that I asked myself. What really matters and how will I know it matters? I answered with 'whatever you see that looks important. It is ethnography. You need to tell as much of the story as possible, so other people know where you are. They need to know why it matters.' So, I wrote down everything. My brain was exhausted from going in so many directions.
>
> 'What is the real point to your research? Who are they? What are they doing? How do you make sense of anything?' The process of hermeneutics and many periods of self-analysis, of thinking I had another set of people in my head, helped me realize that I needed greater focus. I needed to be guided, not by what I was thinking and feeling, but by what my participants wanted me to see. I needed to allow what was happening through the eyes of my participants to be the biggest influence.
>
> Challenging my thinking about relevance and painting the world through what I saw, heard, smelled, and touched was the only way to get something meaningful. So, I wrote down everything… again. The eye-

rolling when they had to write a short, creative, story...the excitement about climbing the wall for capturing a wasp nest…the constant repetition of Morgan wanting them to "think more fully" became a continuous story, forcing me to think outside of the box.

Mixed in with 'seeing everything' were my interpretations, my ideas of whether or not this made sense to the students. 'How did they understand what Morgan said? Did they think it was useful?' Writing down everything meant I could look back and ask questions of both myself and the participants. And I did, I asked question upon question, of myself and others, to attempt to have it all make sense. The first interview opened my eyes to what it really means to think hermeneutically. It became apparent that the students were really considering what Morgan had said to them, they really were thinking about how his ideas could unfold in their own future classrooms. Up until this point, I held assumptions about what they valued, but began hearing them ask questions of what they were being taught. They questioned 'how could I change my ideas of teaching to include citizen science?' I realized that it mattered to them. My initial belief, perception, 'attitude' that it would seem useless to them was wrong. It seemed useless to me as my experiences promote a different type of learning and style of instruction.

> But they were considering his words and actions. These pre-service teachers were being open to a new idea, so in order to see the world through their eyes I had to let go of my concept of teaching and learn along-side them. (Excerpt from reflective journal)

As a researcher, we see something that may be instantly recognizable within our culture, but our understanding could contrast the true meaning it holds for those with which we are working. Goodall (2003) encourages that ethnographers observe, record, and later make meaning while attempting to avoid cultural biases regarding action or inaction, rather relating the experience to the context in which it was intended. Throughout the literature presented in this chapter, much has been explained about how ethnographers collect data and the underlying purpose of amassing information – yet the question remains about what to do with it? How do you put forth, for others, what you saw and allow them to develop their own understanding? Geertz (1973) answers this through "thick description" as he addresses the notion of a wink, and the need to analyze actions per cultural norms. As first shared by Ryle, but referenced in Geertz (1973), a story unfolded about observing how one child rapidly closed and then re-opened his eye. Ryle debated the technical definition of whether it was a wink- with some social meaning, an involuntary twitch, or an act of copying someone else. The specifics behind what the action meant could only be made sense of within a context using cultural interpretation, and could not be understood when removed from the 'scene'. What could be constituted as a wink by one person may be seen as a twitch by another, or mimicry by yet another. It is the existence of many different interpretations for one action and our cultural experiences that enable varying levels of interpretation. Differences in our ability to make sense of an action are based upon our experiences and observations and rely heavily upon the context in which they occur.

Context is a necessity for interpretation, as it often defines how individuals assign meaning to interactions or objects. Cultural bias and the defined action in one context may differ in another; interactions cannot be seen or interpreted separate from context because it serves as one tool utilized by the researcher in attempted understanding. Meaning can only exist within a specific context, it is not transferable to other times or encounters; though it may influence other interactions, it is unique and potentially changeable in any given situation or social interaction. Brice Heath (1982) and Spindler (1982) stressed that context could be acquired through observations, discussions with participants, and personal reflection, thereby allowing for meaning to be situated in relation to a specific set of circumstances. The interactions of these members can only be recognized and documented, with understanding attempted if studied in close proximity; then, only with extensive time and questioning can a researcher attempt to understand 'what happened' (Goodall, 2003; Peshkin, 1982). Researchers have theorized that people interact with the world based on some meaning they have assigned to it, either due to personal belief or influenced by societal expectations (Benzies & Allen, 2001; Prasad, 2005; Rock, 2001). While meaning may be limited by our societal role, it does evolve over time, through experience, reflection and evaluation. Socially accepted meaning is something negotiated within a group as a result of interactions with others and objects.

Hermeneutics

Historically, hermeneutics dealt with the interpretation of text, primarily in the study and interpretation of meanings within biblical studies (Crotty, 1998; Vanhoozer, 2006). In order to make sense of what the author intended when constructing a particular text, the researcher had to consider many outside influences. According to Vanhoozer (2006), only through understanding the situation in which the text was created could the researcher begin to truly make sense of the intended meaning. Prasad (2005) described those who interpret text as requiring prior knowledge about what they are attempting to interpret and an understanding of the developing of a relationship between self, the object being studied, and the context within which that object exists. Although many theorists use historical hermeneutics in their interpretive work, hermeneutic theory has been radically altered since Heidegger's 1962 publication of *Being and Time* (Gallagher, 1992). According to Gallagher, this text opened a whole new way of looking at interpretation as the relationship between an individual and an object, rather than assuming meaning exists within an object. In this expansion of hermeneutic interpretation, researchers used aspects of hermeneutic theory to make sense of cultural action, encounters within groups and what meaning was assigned to these interactions. Hermeneutic theory can be an essential tool when attempting to understand what happens during studied interactions – in attempting to understand the intended meaning of an action within a given context. In re-iterating Vanhoozer (2006) and Freeman (personal communication, August, 2010), context remains critical in attempting interpretation because without a frame of reference one cannot make sense of the intent or assumed intent of an action. Context allows for understanding, because as was discussed in ethnography, without a way of connecting action to intended meaning, there is no real way of making sense.

Hermeneutic study leads to understanding "the meanings, intentions, motivations, and reasons that stand behind the expressions and actions of human beings" (Smith, 1993, p.184). By moving beyond the participant to consider the whole picture, which may be unveiled through observation, questioning, and constant interaction with all aspects of understanding, the researcher is better able to decipher possible explanations for what happened. Gallagher (1992) argued that the ultimate goal of the hermeneutic researcher is to be exhaustive in questioning as a way of gaining the deepest level of understanding. A naturally integrated aspect of ethnography, hermeneutics encourages one to make sense of the cultural components of interaction and how, as a participant, the researcher may have influenced what happened and the ensuing interpretations which arise (Bauman, 1973).

Hermeneutic theory is based on three major assumptions (Smith, 1993). First, meaning exists within interactions and the role of the researcher is to attempt an interpretation of this meaning. Second, meanings are situated within historical contexts or worldviews. Smith (1993) argued that over time, behaviors have been commonly accepted to represent certain things, with group members being aware of the accepted norms which may be accounted for within a specific worldview. The challenge in attempting interpretation across multiple worldviews and accepted norms is that the researcher has his or her own worldview, which may or may not enable access to the meanings inherent in the current context of the group with which he or she is working. A third assumption of hermeneutic theory is that meaning exists as a changeable framework that may be altered when new information becomes available, or when individuals encounter alternative perspectives. These assumptions indicate that meaning is not a static object; it changes with integration of new knowledge, perceptions, and further questioning. According to Smith (1993), hermeneutic theory is thereby concerned with the ability to understand everyday situations and contexts when the available resources for interpretation are dynamic, historical, and varied. Interpretation, given the prior description of hermeneutics, revolves around our background and innate ability to make sense of situations within our contextual understanding and experience in similar situations.

Worldview theory

Allen and Crawley (1998) propose that worldview has roots in "cultural anthropology" and allows us to approach circumstances in different ways, to make meaning of situations and position ourselves effectively for understanding and survival. "*Worldview* may be defined simply as the way people think about themselves, their environments, and abstract ideas such as truth, beauty, causality, time, and space. Worldview and culture are closely woven together" (Allen & Crawley, 1998, p. 113, italics in original). They direct one's thought processes by defining self and what is not self, and providing a construct upon which we might evaluate and understand actions. Cobern (1996) argues that worldviews determine and are the standard for how we behave, make decisions, and organize our lives in relation to other objects. Our interactions within the world are influenced by our ability to justify and explain our established system of beliefs and make meaning of them. Worldview is the basis for our individual reality and how we perceive events, people, knowledge, and other beliefs; it allows one to make adaptations to their current presuppositions (Cobern, 1996). Researchers such as Cobern (1996), Kawagley, Norris-Tull, and Norris-Tull (1998) point out that worldview is derived from background, culture and environment, the often unspoken set of beliefs and understandings are unique to that group because of the history, education and other societal functions of which they have all participated Allen and Crawley (1998) contend that worldview provides the structure by which individuals attempt to form interpretations and is involved with cognition, learning, perception, and behavior.

Worldview theory was substantial in the initial framing of many questions that arose during the research and analysis of data. This theory of 'belief' revealed an opportunity to study how culture and background could potentially influence the integration of citizen science pedagogy and ecojustice philosophy, within the pre-service teachers' assumed worldviews. In light of the instructor's emphasized attempt at altering the pre-service teachers view of what was necessary within a secondary science class, and his desire to expose them to a 'new and different' philosophy, worldview theory provided an especially relevant lens through which to gain deeper understanding of the pre-service teachers' experience. Given the focus on citizen science, awareness of possible differences in background and understandings seemed valuable in attempting to make sense of how the pre-service teachers' responded to the instructor and his framework for teaching the course. Morgan's 'worldview' might also have influenced his belief system about teaching and how citizen science was used as a framework in classroom presentation. In attempting to make meaning of interactions and behaviors exhibited by those other than self, it was essential to account for variations in response between individuals and the researcher. Further enhancing the theory of hermeneutics, worldview theory indicates the multitude of possibilities that exist within interpretive studies and reiterates the need for presenting a clear and detailed portrait of the researcher's process of meaning making.

Philosophical hermeneutics, the basis of this research, was grounded on the precept that understanding is our primary reason for being and involves constant conversation between the researcher and that which is being interpreted (Smith, 1993). Meaning comes into being because we make an attempt at understanding, with Geertz (1973) suggesting that when we attempt interpretation we assign significance to an encounter. Meaning does not exist within an object, rather it lies within the relationship we have with the object. Constant conversation allows questioning of the actions from all directions; according to Holliday (2007), this on-going dialogue becomes exhausted only when we have asked all of the questions. Lake (2006) asserted that "asking questions is thus not a method, but an *orientation* toward knowledge" (italics in original, p. 84). Meaning comes to be because we decide that it exists within a given context, and only through questioning of the context and all its contributing influences, can we begin to understand. The researcher must constantly interpret the meaning behind actions, as understood by the group, but also as understood and influenced by self. Social interactions are comprised of many nuances, and making meaning of these requires the researcher to accurately portray what happens, his/her role in its unfolding, and how he/she came to understand what was seen. The interest is in figuring out what prompted particular behaviors, actions or expressions and what meaning or purpose they hold for the participants. The observer is never completely isolated because of the existence of personal meaning for actions- knowledge that must be addressed before we can step outside ourselves and our ideas to embrace, and often become, the 'other'. In attempting to see things through the eyes of others, the researcher must reflect and question himself/herself and what he/she knows; hence, the reflective journal played an active role in helping to process participant understanding rather than researcher bias being the predominant influence. The extension of personal belief as it relates to understanding action encourages the researcher to make sense of his/her own worldview, in relation to that of the participants.

The remainder of this chapter is devoted to methods utilized in gathering, organizing, analyzing and presenting the data. Included are detailed descriptions of setting, participants, and data collection methods.

Methods of the study

Setting

This research study took place at a major southeastern university in a pre-service secondary science teaching methods course required for all individuals wishing to obtain a teaching certificate. Students planning to teach secondary science can enter the science education program as an undergraduate during their junior or senior year, or as a graduate student in the Master of Arts in Teaching program (MAT). The Department offers three different master-level degrees in science education, with the MAT being designed for students already holding a degree in one of the sciences and wanting to become a certified teacher; all graduate students in this course were working towards an MAT degree. Both graduate and undergraduate students in science education are required to enroll in what is called the Block I series. Block I is comprised of three separate, co-requisite courses, in science teacher preparation: (SciEd 4460) Methods of Science Teaching, (SciEd 3450) Practicum in Science Education, and (SciEd 4450) Science

Curriculum and Learning.

(SciEd 4460) Methods of Science Teaching

This study takes place in and around the (SciEd 4460) Methods of Science Teaching course, taught from 8:00 am – 11:00 am on Monday, Wednesday or Friday from August 18, 2009 – December 4, 2009. The dates of observed class meetings are included within the appendix. The table below provides a breakdown of where classes were held, how many at each location, and which co-educators were present. A more detailed description of each location is provided below in **Error! Reference source not found.**; chapter four further describes the locations which are introduced within the presentation of data.

Table 1. Class location and co-educators

Location	Number of class meetings	Co-educator
Piedmont Arboretum	5	Patricia (2 meetings) Cane (1 meeting) Joni (5 meetings)
Luna Farms	1	Rick
Environmental Complex	1	Inside fire-instructor Outdoor fire-instructor
Ecology laboratory	1	Bonnie Andy
Education classroom (Lafayette Hall)	8	Joni (8 meetings) Mary (1 class meeting)

Over the course of eighteen weeks, the time-span of one college semester, classes met at the Piedmont Arboretum, a local farm cooperative, a traditional university classroom and laboratory and at the University environmental complex[4]. The Piedmont Arboretum, the location of five class meetings, has hardwood forests, engineered gardens, and both paved and natural trails which encompass a vast array of habitats. Every class meeting

[4] Chapter four discusses other aspects of the farm, the classroom, and the arboretum – with each described in greater detail as well as they relate to different aspects of the research.

held at the arboretum had some outdoor component, many days the students were outside for the entire class period. The University environmental complex provided a non-traditional classroom for fire-safety instruction and a same-day field-component for the students to take part in fire suppression under the supervision of two university firefighters. Participants met in a large, carpeted room with tables arranged facing a projector screen for the initial safety presentation; individuals moved to an over-sized attached garage with fire equipment and a rolling door opened to a grassy area designated for starting and putting out fires for the final activity of extinguishing fires. Luna Farms, a local farming cooperative, served as the field-site for one class meeting, allowing the students to observe activities occurring on a working farm designed around sustainable agricultural practices. One class meeting began in the traditional, on-campus classroom with students then walking to laboratories located in the Ecology building on the main campus for the final portion of class. During this meeting, students worked with microscopes, gloves, and other identification equipment in a science laboratory which also contained monarch enclosures and live butterflies. The remaining eight class meetings were held in a traditional classroom in Lafayette Hall, on the main university campus. The traditional classroom had two sets of windows along one wall with black lab counters along the same wall and opposite wall, with tables situated to accommodate two to four students – with groups facing two dry-erase boards.

Participants

Participants for this study were all involved with the Methods in Science Teaching course. At the beginning of the semester, there were twelve males and eleven females enrolled in the class. Of these twenty-three students, seven were classified as undergraduates with six in biology (4 males, 2 females) and one in chemistry (female). Of the remaining sixteen graduate students, twelve were in biology (5 males, 7 females), three in chemistry (2 males, 1 female), one male in physics, and one female in earth science.

The study began with five primary student participants, representing diversity in gender, degree level, and scientific discipline. However, one male biology graduate student withdrew from the education program and his information was removed and will not be used further in this study. The course instructor served as a primary participant, with the graduate assistants and ‘other’ course instructors considered secondary participants. All participants, primary and secondary, were briefed regarding the study during one of the first class meetings. Involvement was optional, with no incentive being given for participation. Participants signed a consent form agreeing to either be involved as a primary or secondary participant, with differences explained and protection of identity discussed for the final writing up of data. All of the students/instructors agreed to take part in observations, and most agreed to deeper involvement. Based on the level of interest, selection criteria had to be utilized in determining primary participants. These guidelines described in

Table 2. Student participant selection criteria were established prior to introducing the research to the class, in an effort to prevent researcher bias in selection of participants. All participants in the class were required to sign consent forms indicating their willingness and level of involvement; since all agreed to at least participation in the study through consent to being included in classroom observations, all relevant interactions are included within this data. Chapter three is dedicated to providing a thorough introduction to the participants in this study.

Selection

Participant selection was based upon level of agreement (willing to participate fully or observation-only), scientific discipline, degree-level, and gender. Students with different science content areas were selected for participation in the study, because it was assumed that the content areas may have an affect on how citizen science was understood in terms of teaching practices and relevance. Since citizen science, as previously defined, has origins in biology and environmental science, it was assumed that classroom connections may be more relevant for the life science students. Initially, teaching certification was considered a factor, however since students were either undergraduate or graduate, there was an attempt to include each degree level equally. To eliminate concern relating to gender, there was an attempt to include an equal number of male and female participants.

Table 2. Student participant selection criteria

Criteria	Description	Justification
Agreement level	The primary participants will be those who have agreed to fully participate, rather than agreeing to only observation or no involvement as is optional in the research.	
Discipline area	Minimum of one participant from each discipline area represented (ex. Biology, physics, geology, and chemistry, others as determined by class composition).	The origins of citizen science lie in life and environmental sciences and may not appear relevant to all subjects. Inclusion of 'other' science content areas will limit bias and provide a more accurate understanding of how the citizen science framework influences learning and teaching for students of different backgrounds.
Degree/ Certification	Representation from graduate and undergraduate population, as well as those who are seeking certification in science education.	Prior work and educational experience may be a factor in understanding of interactions and the interpretation of the classroom learning experiences.
Gender	Representatives of both genders will be included.	It is possible that how people develop worldviews reflect gendered constructions.

Who are the participants?

All participants included have been given pseudonyms, but the descriptions are true to their actions, responses to observations, and discussions throughout the semester. **Error! Reference source not found.** serves as a brief introduction to the primary and secondary participants. Explanations for the symbols used within the table are included at the bottom. Those participants with an asterisk are primary participants and have a detailed profile found in chapter three; participants with two asterisks are secondary participants with less detailed descriptions in chapter three as well.

Table 3. Participant information (*denotes primary participant)

Pseudonym	Gender	Discipline area	Status	Race	Focus group member
***Sarah**	F	Chemistry	U	C	X
***Rose**	F	Biology	G	L	O
***Bernie**	M	Chemistry	G	C	X
***Paul**	M	Physics	G	A	X
***Morgan**	M		I	C	O
***Stacey**	F		R	C	
Molly	F	Biology	G	C	X
Beverly	F	Biology	U	C	X
Alan	M	Biology	G	C	X
Eli	M	Biology	G	C	O
Emma	F	Chemistry	G	C	X
Sheri	F	Biology	U	B	O
Joni**	F		I	C	O
Lee	M	Biology	G	C	O
Kelsea	F	Earth	G	C	O
Lance	M	Chemistry	G	C	O
Selleck**	M		I	C	O
Mary**	F		I	B	O
Leah	F	Biology	G	C	O
Lizzie	F	Biology	G	B	O
Heather	F	Biology	G	C	O
Tiffany	F	Biology	G	C	O
Buford	M	Biology	G	C	O
Beth	F	Biology	G	C	O
Nolan	M	Biology	U	C	O
Houston	M	Biology	U	C	O
Joel	M	Biology	U	C	O
Bonnie**	F		I	C	O
Patricia**	F		I	C	O
Phillip**	M		I	O	O
Simon*	M		I	C	O
Meg**	F		I	C	O
Rick**	M		I	C	O
Cane**	M		I	C	O
	M=male F=Female		G=graduate U=undergraduate I=instructor R=researcher	C=Caucasian L=Latina A=Asian B=Black O=Other	X=denotes participation

A brief introduction to the primary participants

While a more thorough profile of the primary participants will be included in chapter three, developing a relationship with these individuals is important and might elicit a greater understanding of their unique life perspectives. These short descriptions highlight the differences which were obvious among this group of course participants.

Bernie

A traditional, white, middle-class, suburban family background describes Bernie, a pre-service science teacher. He had an older brother, parents that are happily married, and experience travelling the world. Coming across as slightly quiet, he was not shy about explaining what made him tick and why he thought as he did. Appreciation for different ideas, beliefs, and life experiences created a master’s student who tended to be more contemplative than immediately expressive. A self-defined athlete, he expressed experience in nature as riding bikes, hiking, or playing sports. Outside was a setting it seemed, but not something for which he had extensive knowledge. Abundant travels created an inquisitive and deeply thoughtful person, one who chose chemistry because it allowed him to incorporate math while having the possibility of blowing things up. Bernie laughed when he talked about his interests as a child and teen. Taking things apart to learn how they worked, building rockets, and working with electricity were how he defined his science background.

Morgan

A self-proclaimed philosopher, Morgan, the course instructor, came from an urban environment with childhood encounters in nature being few and isolated to what was close to his home. As an adult, he came across as slightly reserved yet passionate about nature and philosophy. Experience as a former middle school science teacher, member of the military, and police detective provided an interesting level of diversity which helped to guide his current actions. Highly involved in the lives of his children, encouraging their involvement and activity with nature, he was not shy about discussing the merits of maintaining a relationship with nature. A caring nature permitted him to ask questions and converse with students in ways that encouraged relationships to develop. The military background appeared to sometimes battle the apparent caring side.

Paul

A self-proclaimed recluse truly did describe this physics education master's level pre-service teacher. Originally from a university town in Georgia, everything seemed quiet about Paul. Wearing a dark trench coat, always traveling with a thick novel, and buried in reading whenever stopped tended to isolate him from the crowd. 'I don't talk much to the people in class, I'd rather be alone.' Not shy about speaking up and sharing, usually sarcastically about something he felt strongly about, he was not your typical recluse. Paul was thin and pale, with a very engaging mind that liked to ask the questions and guide the conversation. Getting him to open up about what he thought was not easy, but having him share techniques for bomb-making created an excitement that was refreshing yet disconcerting.

Rose

A master's pre-service teacher with a love for biology and environmental science, Rose had a background steeped in experiences that fostered a love for the earth. Upon graduation from a local college with a degree in biology and not knowing what the next step would be, she began working for a friend who ran a pre-school. 'I never liked kids, and never thought of becoming a teacher until I spent time with these kids.' Experiencing the lack of interest from other teachers in working with the children, she looked into a job working as an informal environmental educator. Three years working with camp kids, science content, and teachers lacking basic science experiences prompted her to enroll in the science teacher education program. The first in her family to obtain a college degree, her immigrant parents instilled a respect for education, family values, and independence. Life in a farming community, close relationships with similar cultures, and family connections helped shape her views of the world.

Sarah

'I lived in the middle of four farms, and was surrounded by chickens, cows and farm equipment. I grew up as a tomboy.' Sarah came across as very mature, aware of her surroundings with an intuitive side that made for interesting interactions. An undergraduate chemistry major pre-service teacher, she had life experiences different than many of her peers. Marrying young after becoming pregnant with her son, losing a father at a very young age, and being raised in a farming community in rural Georgia didn't automatically lend to success at a major research university or in becoming highly involved in chemistry education. Confidence exuded from her reserved appearance, reservations that existed only until she got to know you and form a connection. Once she accepted you into her circle, sharing and hugs were a common order of the day. In her early twenties, Sarah was very involved with her faith, her son, and a husband who works for the park service, and in becoming an effective chemistry teacher. She proudly talked about entering into a discipline that many consider 'too hard'; she viewed teaching as an avenue allowing her to share a love of chemistry with students who lack the confidence in themselves and in their ability to ‘master’ chemistry. Sarah liked routine, but underneath found great pride in being good at what she did.

Stacey

Being a researcher and participant observer in the class was a difficult role to define and occasionally proved challenging. Pre-service teacher participants asked questions about my experiences as a teacher, with responses being somewhat limited but still at a level that would encourage confidences and allow me to gain an understanding of who they were and what mattered in their world. Having taught for seven years, my understanding of science teaching was still nominal but more than what they knew. Maintaining the role of a researcher was easier with the primary participants, because they learned to ask questions and were encouraged to get to know what mattered in my world.

Data collection methods

Specific methods used to collect data included participant observation, interviews, focus groups, and artifact analysis. The primary participants were interviewed three times each using the protocol included in the appendix, observed during scheduled class interactions, and provided classroom artifacts which were completed during the semester to the researcher for analysis. The primary instructor was interviewed three times, observed during scheduled class interactions, and took part in after class discussions which were either audio-recorded or the product of electronic correspondence. As was previously discussed, a reflective journal was maintained during the research process and used to identify possible questions and themes emerging from the data, researcher biases, and others areas of special attention. A detailed account of data collected can be found in

.

Participant observation

Participant observation allowed the researcher to become part of the group, recording interactions which provided a basis for making meaning of conversation and action in a given setting, identifying salient themes to the research, and attempting to seek out interactions that answer who, what, when, where, why, and how. Preissle and LeCompte (1984) position participant observation as a research method allowing for gathering relevant data - accounts of interactions that can later serve as a basis for understanding how participants view ideas and make meaning of encounters with others and with course materials. Emerson, Fretz, and Shaw (1995) recommend becoming immersed within the participant routines, inconsistencies, personality, and language so that one can make sense of experiences to 'see' what may be deemed important by the participants. Through in-depth field participation the researcher was afforded a better understanding of events that led to more accurate interpretations.

There were sixteen-scheduled classroom times in which the activities were observed and recorded. Observations were done in the university classroom, the arboretum, the environmental complex, Luna Farms, and other labs on the university campus. Additional observations include a camping trip organized by one of the students, a visit with the primary instructor to the schools during the practicum experience, and group lunches after class. These observations, field notes, and interviews (audio-recorded) were typed and used to guide further participation and questioning.

Focus groups

Morgan (1997) identified the use of focus groups in ethnography as a supplement to other methods of data collection, providing an addition of the secondary participant voices and possible alternative viewpoints. Within the focus group discussion, the moderator typically allows the group to direct conversation towards ideas and encounters that are relevant and meaningful to them, uncovering or solidifying interpretations previously developed. Bradbury-Jones, Sambrook, and Irvine (2009) described focus groups as comprised of selected individuals with similar interests or commonalities which encourage group interaction; they note that the inclusion of focus groups may enhance clarity in the research by providing supplementary data.

Focus group discussion was incorporated to gain a better understanding of how the class met the needs of the students present, and how the experiences were understood in terms of ideas about future teaching. Initially, two focus group discussions were planned; however, requests for participation and student availability limited contact to one 90-minute meeting. The focus group served as a forum that enabled the researcher to question classroom events and interactions for deeper understanding. The focus group meeting occurred late in the semester with three primary participants and four secondary participants.

Interviews

Interviews provided a tool for gaining a better understanding of experience and the meaning individuals place on this experience; however, they are best utilized in conjunction with other methods. This study used a modification of the three interview series presented by Schuman and Dolbeare, as cited in Seidman (2006). They suggested that participants be interviewed on three different occasions, allowing for experiences to be contextualized and further developed over time to gain greater understanding of what it may have meant to the participant. In this ethnographic study, the series of three interviews allowed for a developing relationship between the researcher and participants and for opportunity to question events that happened over the semester. Uncovering how the participants made meaning of experiences that happened over the course of the entire semester required an opportunity for discussion and reflection between the researcher and participant. deMarrais (2004) emphasized that interviews should be about on-going relationships, exchanging views and attempting to establish a rapport with participants through frequent and extended contact. Through the process of interviews, co-constructing of information was common and allowed the researcher to ask questions about what was seen developing.

Details regarding interviews can be found in the unit description located in . The preliminary interview protocols are located in the appendix. All interviews were audio-recorded and transcribed.

Artifact/Document analysis

Documents may situate certain dynamics within a particular context, often serving as a rich data source that enables the researcher to gain a better understanding of how the participants are making sense of, or taking part in, some learning experience. Documents, or artifacts, are social products that encourage the researcher to view the boundaries and context in which they were created, in an attempt to decipher the intended meaning (Prior, 2003). These products may serve to reinforce social norms, generate categories for analysis, or help identify socio-cultural patterns and trends.

For this research, documents which were analyzed include course materials created by the instructor, such as the syllabus and class emails, as well as specific assignments completed by the students. Classroom activities which were analyzed included a reflection essay, a photo-essay, and an introductory letter/syllabus created by each of the primary participants; materials created by both primary and secondary participants include responses to questions posed by the instructor during class, an individual definition of 'lived curriculum', and a small-group definition of citizen science. The classroom artifacts which were analyzed are included within .

Reflective journal

Michrina and Richards (1996) provide a brief discussion of the structure, content, and benefits of using a reflective journal in hermeneutic research. They argue that the reflective journal is comparative to interviews and observations because it provides insight into how the researcher made interpretations. On a personal level, and evidenced by Michrina and Richards (1996), the reflective journal enabled interaction with the participants, interactions, and specific data by allowing conversation with self regarding values assigned and possible transference of personal belief. If understanding is to be attempted in a hermeneutic study, Michrina and Richards (1996) argue that a reflective journal is essential. Reflective journaling allowed for a more inclusive role for the researcher, allowing consideration of personal influences in the analysis of data.

My reflective journal shares the progression of thoughts, personal arguments, and decisions relating to direction of focus over the course of the study. Reflection (i.e. personal conversation, arguments with self and data, growth through observations) continued to promote delving deeper into the data and allowed for the evolution of meanings. The journal was used to inform my understanding of events and grow as a researcher, with aspects being using throughout the dissertation for maintaining and/or detailing my interpretation of the hermeneutic process.

Table 4. Description of data collected is an organizational framework for the methods of data collection used during this study. Codes are included along with a description of the event, the date it occurred, and where it took place.

Table 4. Description of data collected

Unit 1 data			
"key word"	**8/19/09 - 9/25/09**	**Location**	**Code**
Observations		Total: 9	
First day	August 19, 2009	UGA, classroom	Observation 1
Small group introductions	August 21, 2009	UGA, classroom	Observation 2
Hand-raising & cit science	August 28, 2009	UGA, classroom	Observation 3
Hike	September 2, 2009	Botanical Garden	Observation 4
Magazines, types of intelligence	September 4, 2009	UGA, classroom	Observation 5
Sex question	September 11, 2009	UGA, classroom	Observation 6
Fire training	September 16, 2009	UGA Environmental Complex	Observation 7
Rain, GEN	September 18, 2009	Botanical Garden	Observation 8
Probe demonstration	September 25, 2009	UGA, classroom	Observation 9
Interview 1		6	
Morgan	September 10, 2009	Office, UGA campus	Morgan A
Sarah	September 16, 2009	UGA	Sarah B
Rose	September 16, 2009	UGA	Rose C
Bernie	September 22, 2009	UGA	Bernie D
Paul	September 21, 2009	UGA	Paul E
Class assignments			
Student Reflection Essay			CA1
Define citizen science – class activity			CA2
Syllabus assignment			CA3
Introductory letter			
Response to after quiz reading			CA4
Additional artifacts			

Pre-class discussion with instructor	August 18, 2009	UGA office	Morgan 1
After class discussion with instructor	September 4, 2009	UGA office	Morgan 2
After class discussion with instructor	September 11, 2009	UGA Office	Morgan 3
After class discussion with instructor	September 18, 2009	Botanical Garden, classroom	Morgan 4
Researcher journal			ART5
Unit 2 data			
“key word”	**8/19/09 - 9/25/09**	**Location**	**Code**
Observations		Total: 6	
Journaling	September 30, 2009	Botanical Garden	Observation 10
Taking pictures	October 2, 2009	Botanical Garden	Observation 11
Mars & CSI	October 9, 2009	UGA, classroom	Observation 12
Butterflies	October 14, 2009	UGA, classroom & ecology lab	Observation 13
GEN presentation	October 23, 2009	Botanical Garden	Observation 14
Garlic	November 2, 2009	Full Moon Farm	Observation 15
Interview 2		5	
Morgan	October 28, 2009		Morgan F
Sarah	November 4, 2009	UGA	Sarah G
Rose	November 10, 2009	Coffee shop	Rose H
Bernie	November 3, 2009	UGA	Bernie I
Paul	November 4, 2009	UGA	Paul J
Class assignments			
Garden Earth Naturalist presentation	October 23, 2009		
Additional artifacts			
Notes from field practicum	November 9, 2009		Morgan 6
After class discussion with instructor	September 30, 2009	Botanical Garden, tailgate of my truck	Morgan 7
After class discussion with instructor – via email	October 3, 2009		Morgan 8
After class discussion with instructor – via email	October 14, 2009		Morgan 9

Researcher journal			ART5
Unit 3 data			
“key word”	**8/19/09 - 9/25/09**	**Location**	**Code**
Observations		2	
Lesson boxes	December 4, 2009	UGA, classroom	Observation 16
Camping trip	November 13, 2009	Local state park	Observation 17
Interview 3		5	
Morgan		UGA	Morgan K
Sarah	December 10, 2009	My house	Sarah L
Rose	December 10, 2009	My house	Rose M
Bernie	December 11, 2009	UGA	Bernie N
Paul	December 11, 2009	UGA	Paul O
Class assignments			
Safety plan and lesson box			
Photo-essay			
Additional artifacts			
Focus group interview	November 20, 2009		ART10
After class discussion with instructor – via email	December 5, 2009		Morgan 11
Researcher journal			ART5

Data analysis and interpretation

Inductive analysis, according to the description provided by Strauss (1987), was the most logical form of analysis for this body of data. Induction is a process of working through the data to uncover a relationship between existing conditions and known, published, and/or widely accepted positions. Analysis is a progression of induction, in which the researcher attempts to identify key ideas and develop some hypothesis which is then verified by further time spent in the data. These inductions result as the researcher uses personal experience, knowledge and belief in relation to the research, to make sense of what the data may represent. The nature of hermeneutics, the spiral of interpretation-reflection-understanding as discussed by (Debesay, Naden & Slettebo, 2008; Michrina & Richards, 1996; Smith, 1993), further validates using inductive analysis. Moving through the data, throughout the semester, new information was uncovered revealing a more accurate picture and understanding of what really happened and what that means for the overall picture of the course.

Researcher experience, including the bias that each person maintains, may add value to the analysis with an understanding that other interpretations do exist. For interpretations to even be remotely similar to the intent, the researcher must become deeply involved with the community being studied. As mentioned throughout this chapter, context is a key component to making sense of the data. The context had to become familiar, meaning that the researcher, in turn, took on some characteristics of the participants in order to make meaning as they do – all in an attempt to allow actions to become second-hand and the researcher to be immersed in the perceptions of the others. At the same time, the researcher must maintain knowledge of alternative directions and dialogue regarding why one path was selected over the other while remaining cognizant of his/her position in making sense of things. Throughout this dissertation, an attempt was made to include dialogue relating to decisions which influenced the direction of the data and the interpretations established by the researcher. Pursuing questions that address all angles helped promote a deeper understanding. By addressing the issue from all angles the researcher may decrease the level of bias and personal influence (Debesay, Naden & Slettebo, 2008). The following table provides the research questions guiding this study and data sources which were used to inform each question.

Table 5. Research questions and relevant data
Research Questions

Q1. What can be learned when citizen science is used as a framework for teaching and learning in a secondary science teacher preparation course?
Q2. How do pre-service teachers make sense of learning to teach in a secondary science teacher preparation course designed around the organizing framework of citizen science?

Data Source	Q1	Q2
Classroom Observations	**X**	**X**
Outside discussions and Researcher's reflective journal		**X**
Interview 1	**X**	**X**
Interview 2	**X**	**X**
Interview 3	**X**	**X**
Focus Group Discussion	**X**	**X**
After class discussions with instructor	**X**	
Classroom Artifacts	Defining CS Fire Training Photo-Essay	Reflective Essay Introductory Letter Fire Training GEN presentation Lesson Box

The research questions and data included above should not be considered using a linear method of analysis. All components of the data were used to inform each research question. However, the after class discussions guided a deeper understanding of the course structure, focusing more on logistics and the course instructor and less on how the pre-service teachers made sense of the course.

Hermeneutic research, as mentioned previously, requires the researcher to become highly involved in the data, in collecting, developing relationships, and making sense of how everything fits together. Given the description below of the hermeneutic process, it should be easier to comprehend how each of these data sources was used to inform the study.

Hermeneutic circle

Mentally picture a circle. All parts are connected and influence the opposing side, each component continually flowing into one another, and back to an arbitrary beginning for yet another cycle. One's positioning in the cycle, movement through each idea over and over again, encourages becoming part of the setting and allows a beginning at understanding what happened and the possibility to anticipate what may happen next. Spiraling from one idea to another, back and forth as new information becomes available, furthers one's understanding and ability to anticipate the actions and enhancing the ability to make sense within the circle. Consider that the circle represents the environment, people, questions, actions, and other unseen, but experienced, events that a researcher encounters. The idea of positioning self within the context of the research, within the context of this hermeneutic circle or spiral, encourages deeper levels of reflection. Movement from personal belief, to data, to generalizations, back to specific interpretations and continually addressing why specific interpretations were reached enables a thorough understanding of behaviors and allows the presentation of possibly more accurate interpretations. Gadamer's goal for hermeneutics was to enable individuals to discover how to better understand and make interpretations, the methods of how one would attempt insightful analysis of situations (Debesay, Naden & Slettebo, 2008). According to Smith (1993), there is no distinct process for interpretation, rather the "referent point for judging whether an interpretation is correct or incorrect must ultimately reside in the other" (p. 189).

The double hermeneutic, as explained by Giddens (1982), refers to one's ability to describe the interactions of humans, requiring an existence within a context, and maintaining the belief that social science goes beyond immediate behaviors. The argument of a double hermeneutic encourages the creation of a new level of interpretation, one that is based upon the larger social norms, as well as those of a specific individual or group. Giddens (1982) argued for placing value not in the observer, but in understanding the action of what is being witnessed and the meaning of that which is observed. Giddens (1982) explains that the constant interaction which is allowed to happen between the social scientist and the body of 'work' they are studying encourages this deeper level of interpretation. A double hermeneutic involves the subject being the object and having the ability to cycle back within the data, forming interpretations of 'their' own. Attempting to understand means acknowledging all aspects of an event, including how the 'self' is posited, with the awareness that all things are social and may be defined differently by others. The diagram provided below represents how I considered the double hermeneutic, a circular process involving constant transitioning between self, participants, and other sources of knowledge. In attempting to make sense of a situation or interactions, I would begin at position B, interact with my own experiences or those found in position C, or position D. This constant transitioning from one position to another enabled, what I consider to be, a deeper understanding of meaning and how the pre-service teachers made sense of the course and the interactions in which they were taking part.

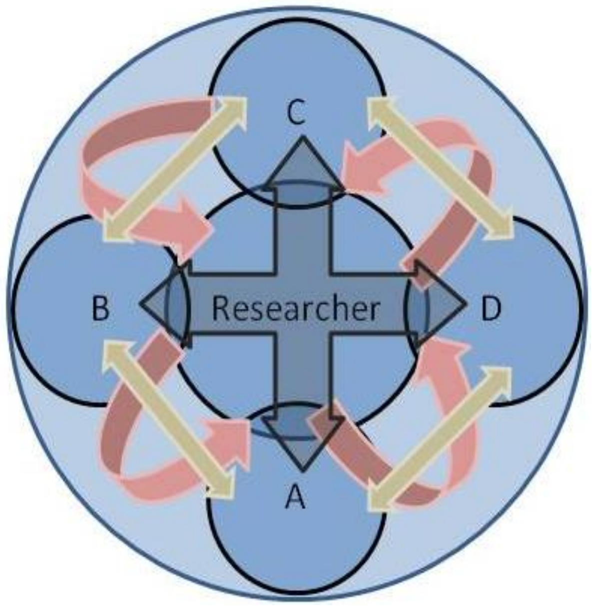

Figure 1. Researcher interpretation of a hermeneutic spiral

Distinguishing between personal accounts and allowing bias to guide and question action was essential in progressing through the circle and growing in understanding as well as ability to look past the self and towards how others enter and exit the circle, making sense of things for themselves. Debesay, Naden, and Slettebo (2008) make the argument that researcher prejudices and cultural beliefs or expectations must be addressed through the act of moving within the hermeneutic circle. One of the greatest challenges faced by the hermeneutic researcher is the inability to limit interpretation to the experience of others, rather than the experience of self. The circular approach encourages the researcher to address personal bias, enabling a more complete immersion in the actual data. The highly philosophical nature of hermeneutics is dependent upon the researcher, understanding that interpretations may not mirror that of another who differs in background and life experience. However, interpretation tends to be accepted because it represents something that has been reached after analysis and re-analysis, and serves only as the researcher's interpretation of events.

In order to attempt to comprehend what is really going on, one must consider that meaning exists in many realms. When something happens, we as the observer may relate that occurrence to a past experience of our own; this action is to be expected. However, in doing this, we must consider the context in which the behavior took place- who was present and what other possible meanings those individuals may have for the behavior. Neither the individual behavior nor the context is given greater consideration – both should be assessed equally with the understanding that 'things' could have happened differently. Part of this consideration consists of knowing how to 'be' in a situation and still move forward. Social constraints and power dynamics exist and influence actions, meaning that the interpreter must be aware of appropriate behaviors within the group or individual and the 'why' behind this knowledge. In this research study, the researcher journal was an attempt at maintaining a relationship with the data and the participants on a deeper level and served as a way of making sense of the encounters through the eyes of others. As a way to maintain self within this study, a researcher commentary is continued throughout the presentation of data; this commentary serves to highlight issues which were especially significant as I documented and attempted to make sense of the experiences in which I participated. Giddens (1982) explained the innate awareness of social constraints as "all those things which the members of society know about that society" (p. 9). He emphasized that cultural norms, long-standing, broadly understood, and commonly-accepted socially conditioned ideas of thought and action are essential components of hermeneutic ethnography. Understanding why certain things matter brings us back to the idea of individuals having specific understandings of their world, based upon past beliefs or experiences with and around objects. The process of hermeneutic ethnography, aided by worldview theory, enabled the researcher to attempt to make sense of what happened in this pre-service science teacher preparation course framed around the notion of citizen science.

How the analysis and writing up of data actually happened…

The data was divided into three relatively equal chronological units, with each including one interview with student participants and a formal interview with Morgan, after class discussions with Morgan, student assignments, email correspondence, and classroom observations. A description of these units can be found in . After each interview was transcribed, and field notes transferred to an electronic format, the researcher completed a preliminary set of notes. An inventory was created by reading over each set of notes, listening to each interview, and formulating an outline to serve as a reference when dealing with the data. From this point, each transcript was printed and coded for initial thoughts about what was being said and general ideas emerging. Many of these transcripts were coded for the first time with a committee member in an attempt to create awareness for bias and broaden the interpretive analysis. The process of working with another researcher was incredibly beneficial in that being forced outside of the data, rather than viewing self only as a participant, truly provided an alternative in many situations.

The primary themes emerging from unit one were addressed in a separate write-up prior to beginning analysis of unit two. Data from unit one were grouped according to challenges or themes that emerged during the first analysis; once these were categorized, the data were then transformed into logical sequence as it related to chronology or similar ideas. Multiple categories existed for unit one, but as units two and three were analyzed, the categories became obviously related. Data were grouped according to larger ideas and then more closely analyzed in an attempt to make sense of what was really being represented. Initially, the process was to analyze the units individually, in an attempt to delve deeper into the intent of specific ideas and allow for closer connections with the data. It was thought that treating each ‘unit’ individually might decrease the potential for ideas and meanings to be lost in the process. After analysis began, the process of analysis was modified. Rather than analyzing units two and three individually, as was initially intended, they were combined with emerging themes grouped according to categories from unit one with outliers being placed separately. In an attempt to make sense of the progression, and what was actually happening, a journal was used to detail the ideas as they developed. Once something new arose, an argument would ensue, with ideas being recorded. The process of arguing ideas on paper, then attempting to combine or confine ideas depending upon the argument, was documented as a way of better understanding the process. The constant conversation also aided in the idea of hermeneutic understanding. After all of the data were analyzed and compiled, categories were grouped according to what I thought each portion of data best represented. The table below indicates progression in category development over the course of data analysis and compilation:

Table 6. Categories from unit one data analysis

Initial categories from unit 1	Actual categories after unit 1
Autonomy/Responsibility	Pre-service teacher understanding of class
Challenging "traditions"	Addressing ecojustice philosophy
Experiencing community	Pre-service teacher understanding of class Contextual learning
Nature as a classroom	Contextual learning
Role of a teacher	Pre-service teacher understanding of class
Learning through modeling	Pre-service teacher understanding of class Contextual learning
Instructor	Class structure Implementing citizen science
Assessment and Standards	Class structure Pre-service teacher understanding of class
Citizen Science defined	Implementing citizen science Addressing ecojustice philosophy
Routines and classroom management	Class structure Pre-service teacher understanding of class

After analyzing units two and three, I revisited the categories for unit one and asked myself questions about what the theme I had created really represented. What question did it address from the perspective of the pre-service teacher? From this, I grouped the initial categories, after realizing that many more were emerging from the remaining data, and began assembling the new groupings under questions which they appeared to provide support in answering. In considering my initial research questions, these categories expanded and diminished constantly until I reached an agreement on how the data could best be organized to be inclusive and as representational as possible. It was very important to stay true to the words and actions of the group; while my interpretations influenced the arrangement of ideas, the information needed to speak for itself. Below is the final grouping of ideas which developed after analyzing all of the data and allowing the participants to speak through what I had documented. I have included within these larger categories sub-questions relating to specific information I gleaned from the data, themes which naturally seemed to fall into these larger categories and are evidenced within chapter four.

Table 7. Final organizing concepts emerging from data analysis

Final groupings after unit 3

Organizing for a Citizen Science Approach
• How did Morgan structure the class?
• What thoughts went into organizing the class activities?
• How did ecojustice philosophy influence activities and structure of his discussion?
• What role did national standards play in the course structure?
• How is CS defined by the instructor? How does he foresee it unfolding in the class?
• How did the instructor justify a course structured on CS?
 	
Actions Speak Louder than Words
• What role did context have in emphasizing the goals of CS?
• What took place at each location that was different and valuable?
• How did the outdoor classroom influence student understanding of science teaching?
• What challenges arose through the use of non-traditional context, the outdoors?
• How was teaching represented in the planned activities?
 	
Learning by Doing
• How did the assignments foster an understanding for CS?
• What role did classroom activities have in challenging student perceptions?
• What was expected in terms of pre-service teacher participation?
• What happened during the semester?
 	
Students Engaging with Citizen Science and Making Meaning
• How did pre-service teachers interact with CS pedagogy?
• What understandings developed in relation to CS?
    o How was CS defined by the pre-service teachers?
    o What examples did they include for use in their future teaching?
• Is CS an approach they would consider implementing?
• What relationship did the pre-service teachers see developing in terms of community?
 	
Challenges in Considering Citizen Science as a Pedagogical Organizer for Secondary Science
• "Isn't this a methods course?"
• What relationship did the pre-service teachers see between their content area and using the outdoors to teach science?
• What connection does CS have to the state science standards?

In writing up the data

Incorporating the idea of thick description (Geertz, 1974; Holliday, 2007) and a "rich sense of understanding of the experience (Gubrium and Holstein, 2009, p.204)", stories were often used to represent findings in the data. As mentioned earlier, the interpretation of the researcher is only one representation; the data is presented to tell a story of the participants' experiences and provide a clear, detailed portrait for the reader to agree, disagree, and possibly develop their own interpretation. Chapter four is divided into five larger sections. Each of these sections includes an introduction which frames the upcoming data and situates the reader for better understanding what is to come. Each of these larger sections is told primarily using the data which emerged from the study, with narrator emphasis provided for clarity. A researcher commentary concludes each section, providing an overview of the critical ideas found to be especially relevant. This commentary serves as a brief introduction to the larger scope of discussion which will take place in chapter five. Tensions which emerged from continued review of the data are presented in chapter five, with relevant supporting literature used to further the understanding of how this type of course has the potential to influence science teacher education.

CHAPTER THREE

Participant Profiles

Historically, qualitative research was built on the foundation of participant interaction. Qualitative researchers take part in activities, relating those experiences to other similar and different encounters as a way of making sense of the event under study. The many individuals mentioned in this research study were instrumental in uncovering meaning, fostering a deeper appreciation for the diversity in the classroom, and helping the researcher, and others involved in the setting, make sense of unfolding daily events. Depending upon their level of involvement, participants were identified as either primary or secondary. Essentially, primary participants were those who took part in all components of the research (i.e., interviews, observations, and artifact analysis); secondary participants were those individuals who took part in the class, are included in many observations, and may have been involved in the focus group discussion. Participants profiled in this chapter were elemental in the analysis and presentation of data; these profiles highlight how the participants responded during various encounters and provide a glimpse of how meaning making took place over the semester. The participant profiles are the result of interviews, personal interactions with the individuals, and observations over the course of the semester.

Secondary Participant Introduction

Secondary participants are those individuals who played a role in the construction and implementation of this course but were not formally interviewed. The involvement of these participants enhanced the learning experience in the classroom, and provided another dimension for making sense of the pre-service secondary science teacher preparation classroom. Throughout chapter four many of the pre-service teachers are included in classroom observation discussion to provide a more comprehensive picture of the setting and activities which took place. Secondary participants include both pre-service teachers (PST) and co-educators, who were critical to the successful completion of the course and influenced the pre-service teachers in a variety of ways. Considering their role as secondary participants, descriptions are concise with greater details appearing in later chapters.

Table 8. Secondary Participants for Science Teaching Methods, Fall 2009 (PST=Pre-service teacher)

Secondary Participant (function/assignment)	Description of role
Alan (PST)	Biology masters student who went on camping trip.
Beverly (PST)	Biology undergraduate who's mother was an in-service teacher at the Garden Earth Naturalist workshop.
Bonnie (university faculty in ecology)	Co-educator selected by Morgan; she taught the pre-service teachers about monarch butterflies. Bonnie planned a tour of the lab facility, demonstrated handling of butterflies, spoke about teacher projects involving the Monarch, and gave a general overview of butterfly health and migratory patterns.
Buford (PST)	Biology masters student
Cane (university faculty in biology)	Co-educator selected by Morgan who worked with the pre-service teachers on documenting science in the field. He worked with Morgan to create a Bee Hunt article/activity for teachers and shared with the pre-service teachers how cameras could serve to aid in gathering data that could be used by scientists.
Emma (PST)	Chemistry masters student with physical limitations.
Frankie (PST)	Biology undergraduate who participated minimally in class.
Houston (PST)	Biology undergraduate who had to leave class early many times.
Joel (PST)	Biology undergraduate who taught carpentry as a science activity.
Joni (graduate assistant)	Graduate student who was assigned to work with the class for the entire semester, including the practicum in which the students were assigned to local schools. Joni was a retired high school chemistry teacher who worked extensively with local schools and was very knowledgeable about current teaching practices and local 'traditions' in education. For this course, she was responsible for leading discussions on reading materials, organizing time outside of class for preparing the technology assignment, and served as a sounding board for the pre-service teacher concerns.
Kelsea (PST)	Earth science masters student who took part in another research project.
Lance (PST)	Chemistry masters student who was eager to be an over-achiever.
Leah (PST)	Biology masters student who had children and favored environmental activities for teaching.
Lee (PST)	Biology masters student who went camping.
Lizzie (PST)	Biology masters student who went camping.
Lynn (PST)	Biology masters student with a young daughter and a background in business.
Mary (graduate assistant)	Graduate student who was assigned to work with the pre-service science teachers during their practicum visit. Mary led

	a class discussion on multiculturalism and the types of students which might be found in the high school classroom and how the pre-service teachers could anticipate different learners, ability levels, and parental involvement. She had a background in teaching high school chemistry.
Meg (graduate assistant)	Graduate student who was assigned to work with the curriculum course and had little interaction with the methods course. Meg was a resource which the pre-service teachers found valuable in planning the technology lesson and discussing components of teaching science. She had a background in teaching secondary level life sciences.
Molly (PST)	Biology masters student who went camping.
Patricia (arboretum faculty)	Co-educator selected by Morgan to work with the pre-service teachers on the Garden Earth Naturalist (GEN) project which took place at the arboretum. Patricia had a science background, with experience working with elementary programs that integrate science into after school activities. She served as key facilitator and had sole responsibility for making sure the pre-service teacher groups prepared teaching activities appropriately for the GEN in-service teacher training. Morgan described her as the authority on what would be considered acceptable for teaching.
Phillip (graduate assistant)	Graduate student who collected data in Selleck's (see Selleck below) class with the same group of pre-service teachers. He was mentioned by the pre-service teachers as someone they could go to for advice on teaching practices. Phillip had a background teaching chemistry to high school students and 'teaching' courses at the university.
Rick (farm manager)	Co-educator selected by Morgan who taught during the farm visit. Rick served as the caretaker/manager of the farm, planned how the tour would take place and what the pre-service teachers would experience on their visit. He was an expert in local knowledge about farming practices and shared these with the pre-service teachers in planting garlic, introducing them to animals, and discussing the aspects of the farm which serve in research and economic productivity. Rick worked closely with the university to educate the public about sustainable farming.
Selleck (university faculty in education)	Instructor of record for the Block I Curriculum course. Long-term faculty member in the department who taught all areas of science education. Collaborated with Morgan on the structure of Block I and the standards which would be addressed in each course. He was mentioned often by these pre-service teachers because of their experiences in his class. Selleck did not teach any portion of this course, but was the instructor of the course which ran parallel to the methods class. The joint calendar

	created between Selleck and Morgan is included as an artifact in the appendix.
Simon (university faculty in education)	Professor in the department who served in an advisory capacity for some of the pre-service teachers. Taught primarily the middle school methods courses, not courses taken by these students. Simon did not come in and teach any portion of the course.
Tiffany (PST)	Biology masters student who did a lesson box presentation on bug bites.

Primary Participant Introduction

Introduction to primary participants will be done through descriptive portraits which are presented in an attempt to provide an overview of beliefs and background experiences participants shared over the course of the class and give an idea of how they view the world. These profiles are not comprehensive, as would be difficult considering the diversity and experience found in the group, but are included to allow the reader an opportunity to 'get to know' the intriguing people who make up this study. As stated in the introduction to this chapter, primary participants were those individuals who took part in all interviews, classroom observations, and made available their classroom assignments for review.

Bernie

Bernie was a chemistry master's level graduate student, a participant in his early-mid twenties. Being raised in a Caucasian two-parent home, having a stable family life with consistency in action, economics, and belief are factors which Bernie felt had a strong influence on who he was and what he valued. Growing up in a suburb of a large southeastern city, he described what he referred to as "the all-American life" of playing baseball in the back yard with his brother and other boys from the neighborhood, raking leaves in the fall, and sneaking over to the neighbors to play video games because his mother wouldn't allow those things in the house. The time he spent outside didn't necessarily help foster an interest in nature, an appreciation yes, but not a yearning to learn more about the trees or animals. Bernie shared stories of using magnifying lenses to burn ants, building and releasing rockets with his brother, and constructing electronic toys. He played with circuits and described wanting to build a remote controlled bomb, until he realized that others might think he wanted to destroy stuff and then he just stopped. Humor was evident in the fact that he worried that others would be concerned about world-safety because of him; he seemed very non-descript and very much a rule-follower. Always making good grades, seeking to excel, Bernie was never completely excited nor encouraged in his science classes. Yet he continued to follow his personal expectations for excellence.

Describing science teachers as some of the most interesting people he has ever known, with a 'piercing and comprehensible view of the world', he considered his own potential as a teacher. Bernie talked about learning being a process of discovery, describing it as an exciting endeavor that he wanted students to join him on. Bernie shared his early love of how things worked and how that led to an interest in chemistry. Yet, he felt that projects leading to a master's degree in chemistry took away some of the wonder and discovery he experienced in chemistry, so his career path changed after the initial bachelor's degree. Realizing his love of chemistry and the fascination with how different things interact made him rethink his educational experience. The ideas that unfolded led him to believe that maybe he could encourage the same interest for science, in others…resulting in his taking education classes. Talking about Piaget and how he planned to structure a classroom geared towards constructivism, he shared excitement in his plans for the future.

Giving off the appearance of a regimented soul, Bernie was somewhat reserved and very intelligent. A love of travel and curiosity for what the world holds encouraged him to live abroad and work in impoverished countries, instilling a greater awareness for cultural diversity and strife that helped him develop into a caring individual with the potential to greatly influence the lives of his future students. His own travels were encouraged through mission trips with church or enjoyment with his family, exposing him to a wide array of concerns and making him aware of the differences between himself and others. While not agreeing with racist comments which were common during visits to grandparents, he acknowledged that these relatives were from a different generation and a vastly different part of the world than he knew. Bernie was very accepting of others, forgiving, and attempting to see the best in every situation. In describing a visit to India, he shared how shocking it was to see so many people living in one small space and how astonishing it was to consider how Americans would react to living in the same circumstances. "You didn't see people who were bitter, people live without modern conveniences…we tend to be self-focused and you realize that in the US we are tremendously blessed." Bernie was a pre-service chemistry teacher with a vast array of life experiences.

Morgan

Morgan, the course instructor and participant, shared stories of poverty, solitude, and a lack of awareness that he was anything different than other children. Growing up in the Pacific Northwest and spending time outside alone with the animals encouraged a consciousness that could be described as akin to connecting with the spirits of the crows, ants and trees in his neighborhood. A naturally inquisitive personality he described an early realization that non-human things were not inferior just because they were not human. “There was a crow that used to sit on my house when I was a kid. He would fly down, pick up my sandwich I was eating and take it away. Then I learned after that to sort of protect my sandwich. But I sort of made friends with the crow, he would come down and I would feed him, then I made friends with a squirrel and I had ants…Even rocks, you now when I was a kid... So it is really, I was really in tune with my natural world all the way through my life and surfing took it to that next level.” He developed mental and physical connections to place early in life. These connections continued to influence how he functions as a father, teacher, and philosopher. For Morgan, establishing relationships and taking on the characteristics and beliefs of what he conceives as valuable, helps him grow.

An actively engaged father, Morgan creates opportunities for his children to be outside and become introduced to the natural world, the concerns, and interests of the community in which they live. In sharing a relationship with nature, he described standing on the side-line in the falling rain while his son practiced soccer. 'Be one with your environment, accept and celebrate moments that seem uncomfortable because they make you more aware of the world and its challenges. Know where you live, where your livelihood comes from and what impact you as an individual want to have on the world.' As an individual, sharing a vulnerable side matters in the world he resides. Being excited about the moment in which you exist, in the ideas which you support, and openly sharing them with the understanding that criticism may be your only response presented Morgan as a caring being, one who was not afraid to take chances when it matters. "I want to learn first, I want to hear the voice, I want to hear…. the other, for me 'other' encompasses other human beings but also nonhuman species, rocks, physical environment. I want to hear those voices, like I want it to talk to me first. I want to understand what it is about, and how it influences me, and then that shapes my teaching experience."

Teaching was part of how he defined himself, part of who he is. In talking about one of his students, he described metaphorically living outside of the box while knowing what made the box. Morgan found value in understanding the constraints of society, attempting to live within the boundaries yet pushing the borders to be more inclusive. In a deeply philosophical conversation, he questioned how far a teacher should go to ensure the success of his/her student, how far the border should be stretched to encourage students to think outside the box. Accommodating the beliefs of others and respecting their knowledge are values he talked about supporting through his teaching; providing opportunities for urban students to be responsible for others safety while hiking in remote areas and listening to the cultural wisdom they shared which was a part of their culture were emphasized as important to his teaching. He openly expressed value in experiences shared by students - presenting him with leaves to smell, sharing the traditional use of a plant in their culture as integral to the learning process. Morgan elaborated, "learning the knowledge that comes from living in a place and having experience of hundreds of years, thousands of years that are being passed down to kids. That really influenced my science teaching."

Admitting that transitioning to the university academic environment from a K-12 setting was challenging. He described it similar to pushing a rock up a hill while he learned the process of what others expected for his classroom, and fought with personal expectations for what he envisioned. After a period of following the expectations of others and not getting positive responses from his students, a change took place in which he acknowledged his own unhappiness in following the rules of others and not following who he was. Listening to his own beliefs, appreciating his own strengths as a teacher prompted a change in how he taught- a change that incorporated ecojustice philosophy. Being a philosopher by nature, he allowed this to guide his teaching and structure the future of his classes. For Morgan, it's about sharing the world and embracing 'responsibility for our attitudes and behaviors towards others and the natural world'; it's about paying attention to what has been ignored.

Paul

A physics master's level graduate student, Paul was a primary participant in his early twenties. A Chinese-American growing up in a home with parents and family who were not often outspoken or even talkative with one another, a family who believed in sharing culture and language, was how Paul described his early years. 'My parents made me speak Mandarin with them…and of course the grandparents. The best way to help your kids keep a language is to keep them speaking it.' Growing up with an awareness for his culture made him more accepting of those who express ideas which are different from his, 'as long as you are not repulsive and don't smell, I don't have a problem with you.' As a child, he rode bikes with other children in the suburban neighborhood in which he grew up, before video games became popular and took them inside. Paul's experience with animals as a child usually meant seeing something dead on the side of the road; he had no pets growing up. Describing himself as a hermit, admitting to being somewhat cold and distant, more sane that most, and preferring books to social interactions. In addition to being labeled as 'different' from the other kids in his elementary school in terms of his ethnicity, Paul noted that having to change schools when the city restructured to increase diversity probably negatively influenced his ideas about the organization of public education.

Graduating with a B.S. degree from a well-known university specializing in engineering, Paul admitted to having a memory for little known facts and a yearning to share his love of the less well-received subject. Considering the lack of pleasure others gain in chemistry and physics, he owned up to a unique fascination with the world and what can be learned from reading books. Acknowledging the different personalities that are found in the teaching profession, he confessed to likely not being described as a caring or very personable teacher – something he attributed to a limited ability to being able to read others; admittedly, he felt this might limit his effectiveness in the classroom. Paul was accustomed to lecture halls and reading assignments, and acknowledged that his future students may consider his class to be uninteresting. However, it seemed that his vast knowledge of chemical reactions and knowledge of the subject would make class exciting to watch, even if meant a student in his class would experience a lack of democracy or inquiry-based processes.

Reflective and solitary, Paul was not afraid to speak up in class when he had an opinion. He often mentioned things that were directly at odds with what other people indicated believing, yet he gracefully accepted their ideas. Highly intelligent, with his nose buried in a book, there was little obvious interaction with people in the class. Partnering with one of the less well-liked students in one of the group projects, he was never really fazed by negative input or the social expectations of others. Paul stays true to what he believes and it would be hard to imagine his survival, in front of a group of high school students.

Rose

A Latina biology master's level graduate student, Rose was a participant in the study who was in her mid –late twenties. A naturally caring person, Rose showed concern for the well-being of others as she talked about people simply appreciating all that they had and not being jealous of others. She mentioned the rich cultural heritage of Mexico where her family was from and she spent many years of her life. Rose valued tradition, yet respected those who expand the rules and continue to remain true to who they are and what they believe. Parents who were supportive of whatever choice she made in life, gave her a base from which to consider who she wanted to be and what she wanted to do – even though it meant going against the typical 'getting married and having babies.' A family with one younger brother, an older sister, and happily married parents, are what she attributed to her current view on life. "They made me what I am." She always excelled in school, with little effort or input from her teachers. Rose indicated that early in her life she lacked confidence in her ability to succeed, but one day realized that whatever decisions she made about life would work out. She was ready to start living and not being afraid of what the future did or did not hold.

Rose originally never considered being a teacher. All through high school and college, while focusing on a degree in biology, she tutored her friends and developed a deeper love for the environment. Yet, after graduation she moved home because she couldn't find a job and didn't really know what she could do with her degree. She had a friend who ran a day-care and needed help, so Rose stepped in to assist and fill some time until she decided on what she really wanted to do. Playing with the children and answering the multitude of questions they asked caused strife between her and the other 'teachers'. 'They told me not to play with the kids or answer questions, because if I did it then they would have to as well.' She explained that she "never wanted to be around kids." Yet, the experience with the pre-school children, their excitement and inquisitive nature, and with the negative teachers forced her to remember what high school was like.

None of her teachers really cared about whether or not she succeeded. It seemed that the daycare and the children helped to reinforce the need for better teaching. After she became employed at a local outdoor environmental education center, working with teachers and students in an alternative setting, she became aware that a different type of teacher could exist. Falling in love with outdoor education, the kids asking her questions and seeing them becoming excited at things she was teaching, further developed her interest in taking her teaching to a different level. 'I didn't know teaching could look like that – that teachers could have fun in the classroom or that kids could matter.' A love of animals and nature are components of science she imagined including in her future classroom, bringing in 'pets' that might often be considered as scary, so that her students gain awareness and diminish their fears about the natural world. Rose felt that teachers need to be confident in something and know they are prepared; part of her confidence lies in knowing who she is, and embracing the environmental components of her teaching experiences to help encourage a love of nature in her students.

'It's important to make a difference, to share your passion with others and allow the enthusiasm you have for life to be evident in everything you do.' While grounded in the real world, Rose presented an idealistic side that may be necessary for her in teaching. A diverse background, growing up in a predominantly rural, African American community as a child of Mexican migrant parents who worked in the fields instilled a fierce determination to succeed and change perceptions. The world is not about just fitting in for Rose, nor is teaching about having your students regurgitate facts. It's about making a difference in the lives of those around you, about leaving your world better off than how you found it.

Sarah

Sarah, an undergraduate chemistry major in her early twenties, was the final pre-service teacher participant in this study. Sharing a need to help students fit in through her teaching, Sarah indicated a need of her own to be accepted. A Caucasian who-described band geek, she was raised in a home where her father committed suicide and her mother struggled to make things work. Sarah presented a very accepting and realistic persona which instantly made you feel comfortable in the knowledge that she will say what she thinks but never hurt your feelings. Learning about life the hard way, growing up on a farm with extended family nearby, she valued the little things and encouraged deeper connections with those she cares about. Admitting that she was never a big fan of Barbie dolls, preferring to make mud pies or ride four-wheelers, she was very much a tomboy. With meaningful experiences in nature, she hunted for deer and held very strong opinions about pleasure hunting versus hunting for survival. Her mother greatly influenced how she viewed nature, taking her on walks when she was younger and answering questions about the things she encountered. Sarah considered value in growing up between a farm and the woods and having what she considered a well-rounded and grounded life. Religious faith plays a large role in how Sarah defines herself, openly talking about her beliefs and how God has influenced her life. She shared the excitement she feels at being a mother to a three year old, and the disappointment she felt from others when she got pregnant out of wedlock when she had barely turned twenty. To many, that would never be an issue. However, deeply ingrained in her very southern nature was a need to please others and in her small community, with her family, pregnancy was not okay without a father. She has been married for several years now, and describing her wonderful little boy who experiences nature in much the same way as his mother.

A very intelligent young lady, Sarah noted her participation in the gifted program of her school which provided opportunities for her to experience challenges which were not always available to others. She was a big fan of differentiated instruction because of her experiences in classrooms where there were distinct ability levels and some students were not addressed in terms of learning. Heavily experienced in project learning and creative endeavors used to assess her understanding of science, she indicated a preference for getting students involved in science that matters to their own community-science that is relevant and meaningful.

Yet another who didn't really want to teach, Sarah accepted the opportunities which presented themselves for helping others learn chemistry. Part of why she worked so hard was because a teacher told her once that chemistry was a hard subject, she wanted to prove them wrong and share her zest for learning chemistry with the rest of the world. In talking about the teacher who discouraged her, "I wasn't one of her favorites…We did a lab at the end that was supposed to take two weeks. We had to determine the combination of elements in our sample through different kinds of tests. I ended up doing it two different times. I got it right both times." Her goal was to help others understand a subject that many find intimidating but she feels is rewarding. College opened her eyes to a world where she mattered, and her experience and love of chemistry was rewarded by a caring professor who gave her opportunities to succeed and share that passion for science with others. Sarah believed that fostering a bond with students, in an attempt to emulate the bond her professor developed with her and the graduate students in the chemistry program, was essential in helping students gain confidence in learning science. Sarah mentioned the joy she felt during the visit to the farm at the excitement she saw in many of her pre-service teacher colleagues during their first experience with pigs and cows. She didn't take things for granted, and appreciated those around her having the chance to become excited and curious about their world. A naturally caring person, as a teacher she expressed the need to have her door open to all of her students and actively encourage them to pursue their interests and gain esteem in their own abilities.

Stacey

As the participant researcher, introducing myself may allow for the reader to gain a critical understanding in how I took part in the classroom activities. The role in which the pre-service teachers unknowingly placed me in and my perceptions of what teaching and learning should include, from experience as a seven-year secondary science teacher trained in a certification program as an undergraduate, often weighed heavily in how I formed meaning. The following introduction aligns with the style of the other primary participants and is included because I was a major participant in this study. Omission would have negated a major aspect of knowledge that promoted understanding.

Growing up the only daughter in a white, lower-income family of five instilled a deep appreciation for getting dirty. Being outside constantly as a child, playing with bugs, cows, pigs, and flowers helped develop an inquisitive adult that tends to be somewhat rebellious. I never wanted to be inside, and living on a farm for the very 'formative' years promoted my early interest in how the world worked. My parents never really sheltered my brothers or me from how life occurred (through birth or death) or the struggles that many people face simply in trying to survive. I consider myself a country girl, even though we moved from the country into town when I was in elementary school. The move introduced me to books and reading became my new passion. Involved in school because it was expected and told often that scholarships were going to be a must if I planned on going to college, I tried to make good grades. Attending college was never questioned, my parents supported each of us to do what made us happy with the understanding and life experience that proved to us 'in order to get ahead in life you have to have an education'.

I never wanted to be a teacher. When I started college, I had no idea what I wanted to be; but I knew I had to attend and figured it would come to me eventually. My love of nature helped me see a path to becoming a biologist; my need for college funding led me to find teaching. With a minor in education, I could still be a biologist; and if I agreed to teach for two years I could get money to pay for school. Once I got into the classroom, I was hooked. I fell in love with being able to combine my love of science with wanting to make a difference in the world (and secretly have the rest of the world fall in love with science). My method of having students experience science included covering the expectations of the state with lots of time outside, mixed in with the more traditional ways of teaching thrown in. Several years at the same school helped me realize I needed to expand my boundaries, so I changed schools and worked with a small native population. With this experience in an indigenous Alaskan community, teaching science became something more than getting across content standards; it became a question of why does this subject matter to these students. Prior to teaching in Alaska, I was involved with teacher training, presentations at conferences, and working to educate others and get them excited about teaching, but this experience made me question what science teaching should be about. Graduate school helped to answer some of these questions, while developing more that may take a lifetime to answer.

I consider myself to be naturally inquisitive, stubborn, caring, and intelligent. These are qualities that serve a teacher well when they are working alone or in a leadership capacity. However, they proved to be somewhat challenging during this research study. Knowing how I had been taught to teach (by someone who I deeply respect and consider ‘one of the best’), how I taught my students, and what I consider to be good teaching greatly influenced my initial thoughts about this class. Learning to develop an open mind had never been a challenge, or so I thought. After participating in this experience, it is something I am much more able to do. Awareness comes in so many different packages and I greatly appreciate how this research made me more conscious of the diversity I had yet to completely acknowledge or accept.

Summary

There were many individuals introduced in this chapter who reappear in chapter four. Without these specific participants, the dynamics of the class would have changed and I would not have learned the same life lessons. In reading the remaining chapters, these profiles should serve as a referent, allowing for consideration of these individuals and encouraging personal interpretations to be formed.

CHAPTER FOUR

Research Findings

In an attempt to tell a more descriptive story that encourages reader involvement in this journey, each section will begin with a narrative as told from the perspective of the researcher. These narratives will attempt to provide context, a way of situating oneself in the current reading; a secondary component of these narratives is to allow my voice as a science teacher and participant researcher to become evident. At the end of each section is a final reflection, a conversation if you will, of the events and factors which seemed significant within the experiences discussed in that section. These final reflections will provide a glimpse into the broader tensions that will be explored in chapter five. In an attempt to limit repetition, and make the reading experience more personal, these introductions and reflections found in chapter four will be told from my point of view, the viewpoint of a participant researcher.

Organizing for a Citizen Science Approach

Imagine you have an idea that you want to share with the world, an idea that you feel could potentially transform how people treat one another and the world around them. An idea that, if shared and implemented, is capable of making the world a better place. Now, imagine you have a platform for which to accomplish the goal of ‘educating’ the world, a place and opportunity for sharing the value in your grand idea. Imagine being given open reign to interact with others, allowing them to experience your belief in action, and with ample time to reflect and hone your skills of persuasion so that your idea has a greater chance of being accepted and enacted. As teachers, we are granted a captive audience every time we enter the classroom. Our students provide us with opportunities to share what we think and what we deem valuable. We practice what we are going to say, perfecting the examples we give, and determining the most effective way to present to our willing public the actions we will encourage them to take part in. All of this happens year after year, class after class, all in our attempt to bring them over to our side – to convince them of the merits of thinking like us. Whatever our ultimate goal, we learn how to perfect our argument for maximum effect.

Most teachers follow particular guidelines often in the form of district, state, or national standards, which provide a general sense of the “big ideas” students should understand by the time they leave our class. In many cases, this process is no different at the university level. Those who prepare science teachers, have certain expectations. These expectations typically correspond with some set of national standards that explicate what teachers should know and understand by the time they are faced with their own set of students. In addition to the ‘department criteria’ or “standards”, these expectations typically include ideas that have special significance for the instructor. In the college course which served as the research setting for this study, the instructor had both specific criteria that he was expected to address and ideologies, such as ecojustice philosophy, which he deemed valuable.

Consider the ultimate goal of a college course as the “big ideas” we hope students will come to understand. One way to think of this ‘ultimate goal’ is as a destination, the end of a trip that everyone is responsible for taking. In the teacher-centered classroom often common to the university setting, the course instructor decides the path which all students must travel to reach this destination as she considers questions like: how are students going to get there? What things are along the path they should see? What should the travelers to remember from this trip? What will make this trip memorable? How will students handle detours? Inevitably, there will be passengers who need more breaks, those who want to spend more time at one point than another. Sometimes more expansive directions are needed for those who are slower or additional time for others to explore and have 'experiences' before you meet again for the next 'stop'. At other times, you may bring in guest narrators to share with your travelers the special features of a location. These "co-educators" help you learn more so that you can better plan for the next trip. Using the metaphor of a 'tour guide', the course instructor decides what types of expeditions would be valuable for students. He/she decides what the 'guests' get experience, but not how. The underlying assumption is that these excursions will somehow contribute to learning outcomes that reflect the expectations of all participants.

As the tour guide, the course instructor makes decisions about the most effective paths to follow, recognizing that not all students will reach the end in the same way or with the same understanding. While students have to be 'on the tour', they don't have to take part in each stop or reach the final destination in the same way. As the tour guide, your job may be to help convince students of the beauty which lies in exploring different paths, and the value of experiencing and appreciating everything along the way. Students may become changed along the trip, more intuitive as a result of the observation and conversation. At the 'final destination', there is recognition that all of the travelers followed different paths and experienced the adventure in different ways. It can be assumed that the travelers will compare notes and learn from each other. Even as the tour guide, you will make notes, reflect on the experiences, and adjust expectations/excursions for the next trip.

With this description in mind, think of this course as focusing on the path rather than the destination. Designed specifically by Morgan to meet his underlying goal of exposing students to ecojustice philosophy, the final destination may have been similar to what other instructors of this course envision. The difference lies in the journey; the challenge lies in developing a philosophy.

Course structuring

At Devonsville University, Methods of Teaching Science[5] is one of three courses required of all pre-service secondary science teachers. The three courses, commonly called Block I, consist of a curriculum course taught by Selleck, a methods course taught by Morgan, and a practicum taught primarily by Morgan with input from graduate assistants. The groups of pre-service teachers who start the series of classes in Block I remain together until the semester ends, many continuing through the student teaching process together in Block II. Following the Block I courses, the students enroll in Block II, which includes student teaching and a reflection course which generally take place the semester they plan to graduate from the program.

"Methods of Science Teaching" is taught every fall and spring semester as part of the science teacher preparation program at Devonsville University. Within the curriculum of the department, different instructors are given opportunities to teach this secondary pre-service methods course; it could be argued that many have their own intrinsic beliefs about what makes a 'prepared' pre-service science teacher. Morgan shared his belief that an ideal science teacher preparation course should help future teachers learn about what

[5] Devonsville University Bulletin – course title

they will be accountable for as educators, including classroom and time management, as well as curricular issues. In discussing what his version of the Methods of Teaching Science course included, Morgan described safety and ethics, classroom management, diversity and meaningful science learning environments as key ideas he was responsible for addressing during the semester. As with many other courses, student input was included and the course syllabus was continually under revision throughout the semester. Revisions to the syllabus included modifications to assignments (providing more detailed descriptions), calendar changes for attendance (shared calendar for methods course and curriculum course), and assigning specific dates for additional events that were determined after class began. In designing the course and determining specific topics which Morgan would cover in the course, meetings ensued with the curriculum course instructor (Selleck). Prior to the beginning of the course Morgan and Selleck divided up the ten NSTA standards, with Morgan's responsibility lying in addressing standards four (science, technology, society), five (general teaching skills and multiculturalism), and nine (safe learning environment). These standards, which were determined well before the start of the class, served as the overarching frame which Morgan would be held responsible for covering. He shared with the pre-service teachers an outline of the National Standards and what they would 'experience' over the semester. This discussion and outline of the standards occurred fairly early on in the methods course and served as an introduction to what the pre-service teachers could expect and how the goals of meeting the standards would be achieved during the semester. Although standards four, five, and nine were the primary focus of Morgan's methods course, he indicated that pre-service teachers would also have exposure to the remainder of the ten standards. The chart below details the standards as they are found in the 2003 Standards for Science Teacher Preparation publication, and serves as an explanation of how Morgan discussed them as he planned to address them in the class.

Table 9. National Science Education Standards for Teacher Preparation

Standard	NSTA/STPS Description	Morgan's discussion of how this would be addressed in the course
1	"Teachers of science understand and can articulate the knowledge and practices of contemporary science. They can interrelate and interpret important concepts, ideas, and applications in their fields of licensure; and can conduct scientific investigations."	Expected knowledge in place prior to course. Arts and Sciences content courses should provide this information.
2	"Teachers of science engage students effectively in studies of the history, philosophy, and practice of science. They enable students to distinguish science from non-science, understand the evolution and practice of science as a human endeavor, and critically analyze assertions made in the name of science."	Discussed in Selleck's class (Curriculum course for Block I).
3	"Teachers of science engage students both in studies of various methods of scientific inquiry and in active learning through scientific inquiry. They encourage students, individually and collaboratively, to observe, ask questions, design inquiries, and collect and interpret data in order to develop concepts and relationships from empirical experiences."	Being engaged in investigations (both courses)
4	"Teachers of science recognize that informed citizens must be prepared to make decisions and take action on contemporary science- and technology-related issues of interest to the general society. They require students to conduct inquiries into the factual basis of such issues and to assess possible actions and outcomes based upon their goals and values."	Science, Technology, and Society (STS) and community – developing the ability to relate science to the community
5	"Teachers of science create a community of diverse learners who construct meaning from their science experiences and possess a disposition for further exploration and learning. They use, and can justify, a variety of classroom arrangements, groupings, actions, strategies, and methodologies."	General teaching skills and multiculturalism
6	"Teachers of science plan and implement an active,	Discussed in Selleck's

	coherent, and effective curriculum that is consistent with the goals and recommendations of the National Science Education Standards. They begin with the end in mind and effectively incorporate contemporary practices and resources into their planning and teaching."	class (Curriculum course for Block I).
7	"Teachers of science relate their discipline to their local and regional communities, involving stakeholders and using the individual, institutional, and natural resources of the community in their teaching. They actively engage students in science-related studies or activities related to locally important issues."	Science in the community (farm visit, citizen science, etc.)
8	"Teachers of science construct and use effective assessment strategies to determine the backgrounds and achievements of learners and facilitate their intellectual, social, and personal development. They assess students fairly and equitably, and require that students engage in ongoing self-assessment."	Discussed in Selleck's class (Curriculum course for Block I).
9	"Teachers of science organize safe and effective learning environments that promote the success of students and the welfare of all living things. They require and promote knowledge and respect for safety, and oversee the welfare of all living things used in the classroom or found in the field."	Addressed in Morgan's class, however there was no discussion (similar to the other standards he addressed) on how this would be covered in his class.
10	"Teachers of science strive continuously to grow and change, personally and professionally, to meet the diverse needs of their students, school, community, and profession."	Introduction to the Garden Earth Naturalist program

The organization of the Block I and Block II courses around the NSTA standards for teacher preparation was a significant factor in Morgan's decision about course content. In a discussion of Morgan's use of safety, he indicated that this topic served well for framing the course since there was such diversity in pre-service teachers' science content preparation and background disciplines. Morgan argued that it would be impossible to 'meet all of their different [backgrounds]…unless you have a specific course'. Thus, Morgan perceived that the topics of "safety" and "ethics" could serve as unifying elements with the potential for incorporating different science disciplines. He emphasized that another important goal of the course was to provide opportunities for students to have authentic experiences outside the realm of the "traditional" methods courses. Sharing his excitement for mixing ethics and safety in the class activities, Morgan provided a justification that ethics is so often ignored in methods courses. An essential component of Morgan's teacher preparation course was opportunities for pre-service teachers to have experiences which promoted critical thinking skills. The inclusion of ethics as a theme afforded the opportunity for Morgan to prepare the pre-service teachers for making decisions about right and wrong, with the underlying idea that decision-making would become a component of their future teaching. Morgan considered the safety focus to be especially useful for the pre-service teachers. Safety in the science classroom is included within standard nine of the NSES, and therefore an essential topic in a teacher preparation program. The emphasis on safety within teacher preparation prompted activities, assignments, and discussions throughout the course that may have provided the pre-service teachers with a deeper understanding of its relevance for their own teaching.

In beginning a class, many students typically attempt to gain some perspective on what they will learn. At Devonsville University, every course that was offered had a brief description in the university bulletin, an overview of the 'goals' that should be achieved. These expectations are often outlined within the course syllabus prepared by the instructor of record for that course during a given semester. The university course bulletin describes the course, which is titled "Methods in Science Teaching", as one that provides "science instructional strategies and classroom assessment for students in grades 7 through 12 [to include] classroom management, lesson planning, and safety in the science classroom" (DU Bulletin, 2009). When confronted with the university description of the course, he responded "it does say methods, but it is illogical to think that it is a philosophy class…for me [presenting the course as something illogical] makes sense. [The course, for me] is about developing their philosophy. They can look at any method then and frame it… (Morgan K)." Within the course syllabus, the expectations are somewhat more descriptive while allowing room for modifications. The course description for "Methods of Science Teaching" during the Fall 2009 course taught by Morgan were:

> What pedagogical tools and instructional strategies will equip new teachers to teach in rich, academically rigorous, multicultural and environmentally sensitive ways? This course emphasizes science teaching methods, teaching issues, multiculturalism, the role of the local communities and environments in science teaching, and professional development. This course emphasizes the essential elements of classroom management, asking questions, guiding activities, and engaging in community and environmentally-centered projects through science education for community development. This course is also unique in that you will be asked to critically analyze environmental literacy resources related to science teaching and further develop your understandings of teaching investigation, writing, nature journaling and observation, safety and ethics. This course emphasizes how teachers work with students to foster sustained scientific interests, and become informed such that they

> will have greater access to environmental decision-making. (Fall 2009 syllabus)

While presenting a general overview of what could be expected during the semester, Morgan promoted his environmental 'agenda' with the course description suggesting an experience which would introduce the pre-service teachers to his ecojustice philosophy. Aspects of Morgan's intended focus were evident in the course syllabus. The pre-service teachers' anticipated learning objectives became evident in their introduction to the course instructors through the "Twenty-Minute Morning[6]". Researcher field notes were used to create the following description of what the pre-service teachers shared as their expectations for the course:

> *Groups of three to four students, instructors, researchers, and teaching assistants meet in one of the regular university education classrooms. This preliminary meeting allows everyone to get to know one another on a more personal level – and to find out what kind of goals they have for this semester. Block I faculty, representing the curriculum, practicum, and methods courses participated in the "getting to know you portion of the class." Instructors asked students: What do you want to learn? What goals do you have and how can we as instructors help facilitate learning and achievement of these goals?' A very common response coming from many members of the group seemed to be learning how to gain control of the classroom and remain in charge. A synopsis of each of the small group meetings is below…*

[6] Described in greater detail later in section one.

Group 1*: Emma is strong in chemistry, really knows how to run a laboratory but is worried about her ability to manage students. How do I make sure the student really learn science and still have an active classroom? Paul wants to be motivating as a teacher, but has no actual teaching experience – the only things he knows are what he saw as a student. Lizzie wants to feel more confident about content so she can be prepared as a science teacher.*

Group 2*: 'I had a life-changing experience working with a high school student many years ago. I got involved with her through tutoring and she came to rely on me for many things, but I just couldn't help her get past some of her life issues. She dropped out of school. It was very disappointing for me, but she is part of why I want to be a teacher.' Lynn feels that she 'is a good tutor, but I also want to make sure I can meet the standards.' Bernie is concerned with his ability to create an interesting curriculum that is well timed and doesn't overlook the needs of students who have different needs.*

Group 3*: Mostly, we all just want to make sure we can be taken seriously as teachers. Things like planning for different types of learners and not just relying on notes as a way of teaching.*

Group 4*: Lee shares his concern of being able to use technology effectively and actually keeping the attention of the students. Tiffany needs 'to learn about discipline, classroom management you know, because I have to teach in a high needs district.' How do I keep the kids interested?*

What about timing and learning how to actually 'teach'? Buford is highly concerned with keeping the kids disciplined, a sentiment openly shared by two other members of the group.

Group 5: *How do I challenge my students? How can I keep from being outsmarted? 'I don't want to be walked on, so I need help with classroom management.' How do I establish and maintain authority?*

Co-educators

Considering the diverse background of pre-service teachers in this course, the inclusion of collaborators had the potential for providing support to the various content disciplines. Within the scope of the fall 2009 "Methods of Science Teaching", collaborators were considered to be any individual that served in the capacity of 'teacher'. Co-educators for the course included invited guests or department assigned assistants; these collaborators typically taught while Morgan was in the 'class' with the pre-service teachers. According to Morgan, these collaborations increased the diversity in instruction and encouraged dialogue. Experiences with co-educators took place in a variety of settings which included the outdoors, science laboratories, and the traditional teacher education classroom[7]. Morgan described the relationship he anticipated the pre-service teachers developing with co-educators as one designed to encourage community development and foster an understanding that everyone has a role in the course and could potentially be considered a teacher. Morgan explained the importance of co-educators for

---

[7] Similar to other university campuses, buildings at Devonsville University have classrooms designed for unique requirements, such as a chemistry laboratory with a fume hood, eye wash station or various other safety apparatus. Due to the location of particular courses, i.e. education building, biology building, the classroom layout can vary tremendously in relation to what the occupants need to accomplish; the methods course was taught in the education building, in a classroom with rectangular tables better suited for lecture or group activities.

enabling pre-service teachers access to multiple sources of knowledge – and enhancing their understanding that everyone has different strengths. A list of co-educators are included in the participant description table located in chapter three, but are described in greater detail as the experience of their instruction appears throughout this chapter.

Of greater significance to the course, primarily because of her constant presence and vast experience as a classroom science teacher was Joni. The assigned graduate assistant for the course, she was responsible for creating, grading and discussing quizzes with the students, in addition to leading occasional group demonstrations. Joni used modeling as a teaching tool by demonstrating and discussing specific techniques, and encouraging the pre-service teachers to share what they were learning. Joni's role in the class was especially evident during a class demonstration which took place at the Piedmont arboretum. During this presentation, Morgan stood to the side while Joni led the class, though he spoke up occasionally to make sure the pre-service teachers were aware of techniques Joni was using. She divided the class into four teams of students, prior to the demonstration. Joni held up a two-liter clear plastic bottle containing 'beads' in three different colors, about 30 of each color which had settled to the bottom of a liquid solution. As she shook the bottle, she asked the group to observe without talking. After a few minutes of silent observation, watching 'beads' settle in different locations in the bottle, Joni encouraged the groups to discuss their observations. The pre-service teachers were asked to come up with an explanation for what they had observed in the bottle. After five minutes or so of discussion the groups were called together to share thoughts. Those pre-service teachers who thought of additional scientific concepts which might be illustrated with the demonstration shared their ideas with the class. Morgan also shared alternative ideas for how the plastic bottle demonstration could be used – all of which were environmental in nature. There were occasions during presentations by Joni and other co-educators when Morgan stepped in and took over the discussion, explaining that he wanted to be certain the pre-service teachers got as much as possible from the moment. Later, in one of our short discussions, Morgan shared how much he values educational partners (co-educators) and explained that he had met with Joni outside of class many times to discuss ideas she wanted to teach. He shared that “even the GA’s are treated to me like equal partners, like professors.” Joni was one of the only co-educators assigned to the class and not selected by Morgan.

It seemed that the pre-service teachers appreciated the diversity in the instruction they received as questions were prevalent during the collaborator experiences. There was also the added bonus of pre-service teachers having a larger number of resource experts available for guidance. Rose indicated that the level of interaction with many of the co-educators was a very positive experience. She explained how communication was encouraged between pre-service teachers and the other educators in ways that made her more confident in asking questions and helped to alleviate some fears she felt about grading and other tasks typically done by a ‘teacher’. She shared how being able to openly talk to all of the instructors encouraged a level of comfort that prevented her from becoming overly stressed about her ability to succeed.

Modeling in the secondary science teacher preparation course

Morgan frequently used modeling techniques to show the pre-service secondary teachers different aspects of learning and instruction. Bruning, Schraw, Norby, and Ronning (2004) describe modeling as a process of demonstrating and discussing a skill to a beginner. Modeling played a large role in the course learning environment and was a seemingly constant strategy used to prepare the pre-service teachers. An example of modeling occurred during one of the first class meetings, in what was called the "20 minute morning". Students signed up to meet in small groups with the instructors, where they shared their personal background and goals for the Block I courses. Morgan later explained that the purpose of "20 minute morning" was to better equip the instructors for meeting the needs of the pre-service teachers throughout the semester. It was intimated that this meeting might prompt the pre-service teachers to develop relationships with their future students so that they would have a better understanding of background and learning experiences.

The use of thematic teaching was also modeled by Morgan, through his structuring of the class around outdoor learning and citizen science. Morgan's consistent use of nature as a setting, and citizen science as the frame for instruction, provided an example for the pre-service teachers on the inclusion of thematic based instruction. During one class discussion on teaching strategies, Morgan specifically encouraged the pre-service teachers to plan and organize thematically. He indicated that thematic instruction encouraged a greater focus on science with less emphasis on the time constraints which are inherent in many classrooms.

Although not mentioned by Morgan as modeling the pre-service teachers were exposed to many other 'strategies' which could be mimicked in their own classroom. Other ideas which Morgan modeled during the semester were teacher actions (management), the use of varied assessment, and the collaboration of co-educators throughout the semester. As an organizational strategy, the pre-service teachers were often told what to expect for future class meetings. An example of this occurred during one of the early class meetings on campus. Morgan reminded the class of the photo-essay assignment and the need for taking pictures throughout the course; Lance immediately took out a camera to take a picture of Morgan. Early on Morgan cautioned the students 'that at times they may feel like a student in middle or high school because he felt it was important to model what should happen in a classroom' (Classroom Observation 5). Classroom management techniques, strategies such as hand-raising as a way of encouraging wait time, were first modeled and then discussed. Morgan described wait time as an opportunity for all students to think of a response. Morgan used wait time, alongside other techniques to demonstrate what the pre-service teachers might do in their future classrooms. Repetition of techniques took place over the entire semester, with some examples being emphasized more often than others.

In classroom discussions, Morgan mentioned the importance of being consistent and fair with all students – and later shared that if he did not reprimand the pre-service teachers, then he would not be consistently reinforcing expectations. A fairly common occurrence was for Morgan to chastise the pre-service teachers when they didn't meet his expectations. When asked about this, Morgan shared that he was often calling them out on their actions in an effort to make them aware and to help keep certain actions from carrying over into their future classrooms. Morgan discussed what might be perceived as the demanding nature of his course, explaining that he felt it was important to be serious, as too many teachers attempt to befriend their students. He indicated in one of our after class discussions that he attempted to be strict in the beginning of the course, only to loosen up later in the semester, maintaining that he used this technique of modeling so that the pre-service teachers would have an idea of what approach might be used in their future classrooms. Morgan explained that he wanted the pre-service teachers to learn the importance of being fair and consistent, while maintaining the professional role of the 'teacher'. While much of Morgan's actions might seem condescending from an outsider's perspective, they served as a representation of what might be seen in the secondary classroom. It could be argued that when he came across as disdainful, he was actually modeling a classroom management strategy.

Teacher as mediator for learning

Another aspect of Morgan's instruction which could be construed as modeling was his emphasis on the teacher serving as a mediator. When teachers serve as a mediator they function as facilitators, individuals who guide students in asking the appropriate questions or designing experiments which more aptly enable them to construct knowledge. Morgan noted that an essential role of the secondary science methods course instructor was to serve as a mediator of learning, explaining that 'they [the instructor] should be knowledgeable about the local and encourage pre-service teachers to challenge their currently held assumptions'. Accordingly, he felt it was important for him to model this meditational role so that the pre-service teachers could take on similar roles in their future classrooms. He stated emphatically that many things are taken for granted in daily life and seldom questioned, indicating his concurrent goal as one of increasing their awareness in the lesser acknowledged components of community and learning of science. He further appealed that a mediator was needed to "help a student examine what cultural assumptions they are endorsing in their own life so they can see what they pay attention to" (Morgan 2). Explaining how individuals have experience that guide how they attend to thought and daily activities, Morgan shared his belief that these assumptions must be challenged so that pre-service teachers might grow personally and influence their future students. As part of his attempt at challenging these assumptions, and further serving as a mediator for learning and change, citizen science was incorporated as a class framework. In arguing for citizen science as a pedagogical frame for this course, Morgan discussed morals and ethics as being dependent upon an individual's background and personal beliefs. Classroom activities were introduced so that the pre-service teachers' could gain a background understanding of citizen science, positioning them to accept or refute the practicality of using this curricular organizer in their own classrooms. Morgan emphasized that his purpose and the activities planned for the course were done in an effort to change the philosophy of the pre-service teachers. He explained,

> …the idea that teaching is for citizen development. If you just view it as teaching science for financial success or getting kids into college or whatever then you are, you may never embrace or value this idea of citizen science. So this isn't really intended, I don't think it's realistic to think that all of the teachers in the class are going to go out and buy into science education for citizen development. But it really doesn't take all of the teachers doing that in the world to change the world – it only takes a few people who are really committed to this idea and then those people becoming advocates for others who may not have a voice. (Morgan 2)

The use of citizen science as a pedagogical framework for the course provided yet another source of modeling thematic learning.

Justification for using citizen science as a course framework

In a discussion before the course officially began, Morgan related that "science education is about learning science…it's not about teaching facts anymore" (Morgan A). In the same discussion, he indicated that science education should be for community life, sharing his belief that all members of a community should assist in educating students. Morgan argued for 'science education for community life' emphasizing that this idea encourages educators to view the community and life outside of schooling as having valuable knowledge for the education of students. He further explained that education that happens outside of school can be considered the lived curriculum and is influenced by everything connected to the student. Morgan made the argument in our pre-semester discussion that "schooling is just a small part of education" (Morgan 1). Arguing that education extends beyond schools, Morgan explained that the course design was intended to promote an interest in the community, the environment, and life-long learning. He further shared that these were components of his ecojustice philosophy. According to Morgan, organizing the course around citizen science provides a context for learning that encourages pre-service teachers to become aware of their surroundings. Included in his description was awareness for the issues taking place in their local environment, and the construction of knowledge that would ideally encourage them to seek ways of using science education to further the learning and community involvement of their own students. Citizen science, community-centered science, and community-driven science were terms used by Morgan to describe the same action of considering the location and working to protect it. The aspect of community science and awareness of the local could in all probability be considered aspects of ecojustice philosophy, which structured

Morgan's interpretation of citizen science. For Morgan, citizen science as a framework for instruction places value in teacher and student involvement in the community rather than on preparation for a test. In arguing for a citizen-science based approach to teaching science, Morgan shared his assumption that "70% of students need to be able to take refuge in their community or environment outside of a college-prepared environment" (Morgan F).

Citizen science relies on informal settings and non-traditional approaches to learning. Morgan contrasted formal and informal education, noting that citizen science and outdoor education are described typically as more informal methods. In making a distinction, he explained how formal education allows teachers to follow rules which keep things standardized, an apparent 'ideal' (Morgan 1). Beyond consideration for a formal or informal approach to learning, the focus appeared to be more concerned with community awareness and potential involvement with local 'issues'. The purpose of the course, Morgan explained, was to help pre-service teachers think about what it means to have their students participate in the community and consider the effectiveness of a citizen science approach to teaching in light of their current experience.

In discussing what he perceived as the strengths of the class, Morgan emphasized the development of a philosophy of teaching. He shared that while the class title indicated methods, from his perspective the course was about helping the pre-service teachers conceptualize a philosophy. It was apparent that Morgan had considered the course listing and description as a "methods" course but preferred the idea of teaching it as a philosophical process. He proposed that the pre-service teachers could use their newly developed (or slightly modified) philosophy to make decisions about the relevance of new methods that may be introduced to them. As described earlier, structuring the course as a philosophy class was at odds with the university description and required the pre-service teachers to self-reflect about what they should be learning. By promoting one particular philosophy of ecojustice, and by extension citizen science pedagogy, Morgan hoped to provide the pre-service teachers with experiences to purposefully develop their own ideas of what it means to teach. According to Morgan, once a personal philosophy has begun to develop, the pre-service teacher then has the skill-set to modify instruction and expectations to his or her own teaching philosophy. Rather than providing a set of methods, or access to teaching strategies, the course was designed so that when the pre-service teachers encountered a method, in any context, they could learn and use it for themselves within their own frame of reference. In light of Morgan's espoused ecojustice philosophy, citizen science was the primary teaching pedagogy used in the course. All of the course experiences aligned in some way to Morgan's perception of citizen science. The continued reinforcement gave the pre-service teachers an opportunity to consider ecojustice philosophy and its pedagogy of citizen science, amend it and make their own decisions regarding its relevance to science teaching and learning.

From Morgan's perspective, there were obvious environmental and educational benefits to the utilization of citizen science in preparing future science teachers. Morgan noted that pre-service teachers and their future students should be taught science that is meaningful and relevant to their lives. The following comment illustrates Morgan's view of the larger purpose of his course and introduces us to his perception of citizen science which was portrayed throughout the semester.

> Let's say …you could have either corn that could produce bio fuels or you could have some wildflower that is endemic only to this area. But the wildflower only has aesthetic worth, I mean it is just beautiful but it has no other value to people, economically or other than its aesthetic and some people really value it and it needs an advocate or it goes away, right. So the students have to learn about their ecosystem they live in, they have to learn about that wildflower. Why is that wildflower important? What worth does it have that goes beyond the economic system? Then participate with other policy makers. So, the students, I want them to become stakeholders, I see citizen science as a way to produce or develop stakeholder-ship, like become a stakeholder in your community, so that you own a stake, you are investing in it. You understand it well enough to invest in it, and then you can help make and shape the decisions about trade-offs that I know are coming. I mean we are facing, we are out of time, like no other time in history where students and people who are growing up now will face different challenges than their teachers or their parents or anybody ever faced before… but like if we can help them develop as stakeholders, then I think they would be prepared for it, but there are going to be things that don't have a voice in policymaking, right, like the wildflower. So it needs an advocate, it needs some students who are going to take its position, you know, to a town hall meeting or else

> who will advocate for the wildflower? So I see citizen science as a democratic way to like really think about local issues, local problems, and local tradeoffs and for me it can be scientist-driven, if that is what like starts the process, that's great. But I also want it to be democratic, so I want science to not just be owned by the people with the professional hats. I want students to be thinking scientifically, too. I want people, citizens thinking scientifically…. (Morgan A)

Introduction to citizen science pedagogy

While ecojustice served as the theoretical basis for which Morgan organized the course, citizen science was the pedagogical framework used to address his philosophy. Morgan emphasized the potential for citizen science to encourage pre-service teachers and by extension their students, to learn about their local communities. Unlike traditional approaches to science teaching and learning, Morgan's belief is that citizen science provides students with a base of information that 'helps them know about the health of their community'. Morgan elucidated his stance on citizen science as being about "citizen learning, becoming informed in a place and learning what they need to learn [so they can] participate more fully in decision making, policy making, and democratizing science" (Morgan 1). In characterizing his view of citizen science as "different than others in the field", Morgan seemed to suggest that most others describe it as an approach which relies more on scientist-driven projects, in contrast to his more individual/community-based perspective.

During our discussion before the beginning of the semester, Morgan frequently referred to a Cornell University web-site which is widely used for defining citizen science. This web-site describes some citizen science projects which reflect primarily a top-down approach. However, Morgan pointed out that some of the watershed projects listed on the site were driven more by community needs and reflected a more bottom-up approach to citizen science. He indicated his personal tension with the top-down approach, explaining that in these projects the students seem to be ‘just collecting data and doing nothing with it’. He described the top-down citizen science projects as primarily benefitting scientists, explaining that while students are collecting data and learning, it is not about their goals or interests. Morgan elaborated on how top-down citizen science projects limit the degree of change which can be made to protocols and collection methods, preventing students from designing their own research. Citizen science was presented as a pedagogical approach with varying degrees of community involvement. Based on descriptions from Morgan, the pre-service teachers, and first-hand observations, these approaches to citizen science could be classified as top-down or bottom-up. It was only through extensive conversation with Morgan that a clearer understanding of the different approaches to citizen science emerged. What follows is a comprehensive presentation of how Morgan explained this distinction:

> ‘a top-down citizen science approach refers to the belief that projects are only valuable if they originate from a scientist who is working on some form of research and needs data collected. Typically these projects follow a specific set of standard rules. Students or other community members collect the data and present it to the scientists, who in turn use this for research purposes with the community; the data collectors never have access to the larger picture. This form of citizen science involves

> community members becoming involved in science through prescriptive measures, gaining some level of scientific knowledge, but never applying the information for anything relevant to their lives. By contrast, a bottom-up approach is best described as individuals on a local level identifying areas that need 'study', organizing materials and members to collect information, and using the information for understanding scientific issues in their lives. Typically, a bottom-up citizen science approach to research involves the gathering of data, understanding the concerns and need for having knowledge of an area, and using the information to encourage decisions which influence community decisions and actions.'

Both approaches involve identifying problems and collecting data over time in the field, but the similarities end there according to Morgan. The specific citizen science approaches utilized by Morgan will be described in greater detail throughout section three of this chapter.

Describing the transient nature of students, Morgan argued that teachers must educate their students in ways which equip them to use a "baseline" of data for determining the health of their often changing environment. By teaching pre-service teachers methods of assessing the health of communities, via citizen science, he felt that they would develop tools that could transfer with them throughout life. An additional benefit of citizen science, according to Morgan, was the construction of knowledge that would allow the pre-service teachers to become involved in the local, consequently involving their future students. Morgan emphasized the term "local" in his argument because he felt the idea seemed to encourage more personal involvement in community and environmental issues, in contrast to the more abstract idea of a global-scale environmental crisis.

Morgan argued that teaching via citizen science promotes awareness of where one lives. However, he recognized the challenges inherent in attempting to help pre-service teachers develop an understanding of community, noting that they are only temporary residents of a place while university students. Through discussion of the course design, Morgan indicated that:

> the methods are organized around three tenets of citizen science. The first [tenet] is how do you get teachers and their students to become informed in such a way that they understand what the threats and vulnerabilities are to their cultural and environmental communities? (Morgan 1)

Community, culture, and environment serve as the basis for Morgan's citizen science perspective and provided the backdrop for his goal of helping the pre-service teachers develop a teaching philosophy which is integrative and action-based. Morgan's argument was not for teachers to know everything about their community or local habitat; rather, he felt that through increased awareness and education, individuals could develop greater empathy for their surroundings. "The second tenet [of citizen science] is a little bit more difficult… [to understand, but centers on the question of] how do you get teachers and their students to participate more fully in their community (Morgan 1)?" According to Morgan, knowing about the community is only one aspect of citizen science. Individuals have to be willing and informed to such a level that they can take part in what happens in their world. He explained,

> So now you have a group of citizens who know how to participate more fully. The problem is then that there is still going to be your community members, plants, animals, soil that can't defend themselves. I mean [those] that don't have a voice…even people who are affected that haven't been informed. They don't know how to participate more fully. So the third aspect, the third tenet as part of this class is how do you advocate more fully for those who are affected who don't have a voice? (Morgan 1)

Empathy and awareness for the 'other', and a willingness to act on their part was the final tenet of citizen science shared by Morgan. These tenets of citizen science were only discussed prior to the beginning of the course, and only during an interview. They were not repeated or mentioned explicitly during the actual semester with the pre-service teachers.

Basic tenets of citizen science as described by the instructor

It would appear that the tenets mentioned by Morgan were meant to be included within the activities of the semester, through implicit examples rather than obvious discussion. Pre-service teachers were encouraged to experience the semester and make self-determinations that may have enhanced their understandings and valuation of citizen science. The tenets of becoming informed, participation, and advocacy are further elaborated to the extent which they 'appeared'.

<u>Tenet 1</u>- Becoming informed

In the context of the class, Morgan expressed that the idea that becoming informed was about exposure to citizen science and being introduced to methods of instruction based on an ecojustice philosophy. He explained,

> So they sort of talk with each other about what it's like to be outside and start to build this understanding about what it would be like to teach outside. We are talking about the outdoor classroom and I am pointing out things like "Hey look at that butterfly or look at that hummingbird" you know those are teaching opportunities. I hope that students are learning about how to teach in the ways that I am sort of modeling. (Morgan 4)

Morgan emphasized that individuals have to learn enough about the community they live in to know when it is being 'degraded', explaining that having a base of knowledge about a place, what the area contains and can support, may provide a way to argue for protection or destruction. For Morgan, knowledge of place includes both environmental and cultural aspects. The process of becoming informed doesn't mean becoming informed just in one location. Morgan explained that ideally, once students are informed about one area they can move somewhere else and be able to use that same knowledge. He argued that it was about making a "sustainable or even life-long interest in learning" (Morgan A). It could also be said that becoming informed was a process that occurred over the life of the pre-service teachers, as knowledge is acquired through all actions in which they take part.

<u>Tenet 2</u> – Participation

From Morgan's perspective, participation is primarily about awareness and action. To some degree, decision-making was viewed by Morgan as an act of participation although it was not highly emphasized during the course. At times, according to conversations with Morgan, the idea of winning students over to the complete acceptance and integration of citizen science in their own teaching philosophy was overlooked in favor of having them develop some smaller level of understanding.

Tenet 3 – Advocacy

An apparent distinction exists between participation and advocacy, at least for Morgan. However, the idea of advocacy was not discussed in great detail during our conversations. Therefore, what is described here is my interpretation of advocacy, with selected data that establishes a deeper level of understanding as to what this tenet potentially represented for Morgan.

It would seem that Morgan's perspective of advocacy hinges on providing a voice for something and invoking action to protect it. In this sense, advocacy is much more involved than participation. From Morgan's point of view, advocacy is about making a conscious decision to do something about what you see and experience – it is about learning and becoming passionate about making a difference. Rose described how citizen science could unfold in her classroom, seemingly with a deeper understanding of why citizen science could be beneficial to students in terms of advocacy–

> …changes in the environment, their interactions in the ecosystem and why it is important that we do our part to save them more. How we are impacting it as well, so it is bringing something like that. Like you said it, it is not just like doing an activity but it is also bringing it back to the classroom, how they are going to learn from it and why they are doing it. It's not like just going to pick up trash, because you know, trash is ugly. Pick up the trash because an animal can eat it, they could die, and if we

> keep leaving it out there, these animals are going to get hurt and our environment is going to go down the hole, so it is like making them understand why they are doing something. (Rose C)

Morgan emphasized that action was only a small aspect of the equation. More importantly, from his perspective, knowing why action matters and having feelings about your role in doing something is essential to the process of becoming informed and helps shape students who are more aware of and involved in their local (and global) community. Through acceptance of all the tenets of citizen science, Morgan explained, teachers “buy into the idea that they should share some small part of what benefits their local community” (Morgan 1).

For community life

The idea of ‘citizen science for community life’ was emphasized by Morgan through discussion of student awareness of things in their community which are vulnerable - things like the environment, culture, and language - making clearer how citizen science aligned with ecojustice philosophy. According to Morgan, citizen science ‘cultivates community members who know how to become more informed, participate in decision-making, and serve as advocates for others’ (Morgan 1). Throughout Morgan’s discussion of the value of citizen science, these three tenets were emphasized and shown as connected although he never discussed specifically how they would play out in the classroom. Citizen science was described by Morgan as a larger frame for education which allows a variety of topics to be addressed with input from many different sources.

During one of the first class meetings, the pre-service teachers were asked to work in small groups to define the meaning of citizen science and determine what items actually did or did not have rights. In the description of citizen science Morgan shared with the group, one of the key aspects highlighted was its intergenerational nature. While he did not define intergenerational, it could be inferred that with use of the term he was suggesting the relationship of youth working with elders or children working with adults. The idea of working together for a greater good is hinted at in the following statement Morgan made during a personal conversation when he mentioned the value in helping pre-service teachers develop an ecojustice ethic.

> It takes time. But I think a few usually get it [ecojustice philosophy] by the end, and a few more get the whole idea of citizen science which works towards ecojustice. And then a few more get that teaching is about community-life. (Morgan 1)

In the statement above, he suggested that not all of the pre-service teachers would accept ecojustice but may consider some of the tenets of citizen science which he described as ideas framed by the larger philosophy. Repeatedly, at least in private conversation, Morgan noted that the larger goal of the course was to help the pre-service teachers become knowledgeable of ecojustice and accepting of the philosophy. Consistently, Morgan shared his belief that helping pre-service teachers develop an ecojustice philosophy could be achieved through the use of citizen science as a course pedagogical framework. He admitted that the idea of citizen science was somewhat controversial, and could potentially be viewed as something very negative. For Morgan, these tensions were understandable, as he perceived that the course provided teaching methods that contrasted with what the pre-service teachers were accustomed to or expected. He explained,

> I start to usually notice that students start to have these tensions about

> what is citizen science and is it – why does it contrast with 16 years of the way I have been taught science. Or how does it align with some of the good teachers I had that were teaching science this way? You know, keep in mind that I am sort of biasing citizen science as the right thing to do. But it's an ethic that is driving that, my ecojustice ethic, that I feel this is the right approach to teaching. I can evidence that in philosophy, so it's not a personal opinion but it is an ethic that I think. (Morgan 2)

Morgan stated quite often that good teachers will use citizen science, a comment that seemingly distanced some students from accepting the overall ecojustice philosophy. On a personal level, this statement lessened my desire to use ecojustice philosophy and citizen science as a pedagogical framework. The argument for 'good teachers and citizen science' seemed to portray the idea that there was only one right way to be a good teacher. Being constantly faced with the notion of ecojustice as being "right" made accepting any component difficult (if only from the researcher's perspective). Arguing against this being a personal opinion, Morgan maintained that it was an ethic he believed in, however it could be argued that the line of ethic and opinion are often blurred by action and belief.

Whether at the farm or the botanical garden, citizen science was the often unmentioned connecting thread. In learning from his experience with teaching previous courses, Morgan discussed concerns about 'frontloading' the students with citizen science theory. Morgan felt that it might be better to get the pre-service teachers outside and experiencing his brand of science education, rather than inundating them with theory and no application. He explained his belief that through experience students might be better equipped to develop an understanding and acceptance of citizen science on their own. He emphasized that the "methods of citizen science have to be explicit… [but] it could be anything" (Morgan F). When serving as a teacher educator, the concerns of others in your department and within your field of practice are often considered when designing and implementing a particular course framework. Within the scope of science teacher preparation, other science teacher educators are influential in decisions made about course implementation. It became apparent that, for Morgan, considering the role of 'others' was a never ending, and often daunting task. Describing citizen science as an advanced pedagogy, Morgan felt that it was sometimes under scrutiny by other instructors because 'pre-service teachers are not ready for this type of instruction'. He argued that citizen science provokes dialogue, action, and introspection "[that] repositions teachers in a way that [makes them] more indispensible" (Morgan 2). The process of having science educators buy into the idea of using citizen science as a framework for instruction was equated by Morgan as pushing a rock up-hill, pointing out that it was often made more difficult since he was 'biasing citizen science as the right thing to do'. The concession was made that some individuals would not accept the tenets of citizen science, or would accept a few, but never use them in their own classroom.

Summary

Embedded in this section is Morgan's rationale for using ecojustice philosophy and citizen science as a framework for the preparation of pre-service secondary science teachers. As a brief overview, the course was organized around NSTA standards for science teacher preparation to provide a level of programmatic consistency. The chart provided in this chapter delineated what Morgan expected of himself and included an overview of how the course was structured. As with most standards for education, there is a level of interpretation that allows for individualized instruction. In this case, individualized meant a focus on community, safety, ethics, and environmental issues, with citizen science serving as the thread tying them together. While the basic tenets which were outlined by Morgan are all interconnected and in some ways all addressed throughout the course they were never explicit nor were they part of an obvious discussion. Implicit behaviors and expressions of Morgan's beliefs may have provided the greater foundation for ecojustice philosophy and citizen science 'ethics' which can be construed as developing philosophies which are likely constantly measured and re-created throughout the careers of the pre-service teachers.

For the most part, the course organization was straightforward with Morgan providing a clear purpose and justification for basing it on a philosophy of ecojustice. The way in which citizen science was defined was key to many of the course activities and the structure of the class. As will be indicated in further sections, Morgan attempted to design the course so that knowledge would build through participation and lead to individuals becoming advocates for community, environment, and an ecojustice philosophy.

Through the eyes of the researcher: A commentary

Collaborators in the science classroom

Over the course of this semester, co-educators served as a valuable resource. The collaborators brought to the classroom a wealth of experiences and information that far exceeded what one person would typically know. The inclusion of multiple facilitators allowed the pre-service teachers to become more aware of how to incorporate 'field experts' into their own classroom, and provided an additional foundation in content knowledge. A potential concern regarding the collaborators was that most were knowledgeable about diverse aspects of life sciences. It might have been perhaps more useful had other collaborators with expertise in chemistry, physics or Earth science participated in the citizen-science based activities. Their inclusion could have addressed the pre-service teachers' perception that citizen science is primarily relevant only to the life sciences.

Modeling as a component of science learning

Of importance in this chapter is the use of the term modeling. Models are representations of something, an example of something deemed valuable. Within science education, models are often created to represent some abstract concept which is difficult to comprehend. However, in this study, modeling is used to represent actions of the instructor which were mentioned as 'strategies' which he would like for them to pay particular attention or suggested as something which they could emulate later in their own classrooms. Other terminology could be used to describe this 'phenomenon', but Morgan used the word 'model' in relation to actions he performed in class which could prove useful for the pre-service teachers. He often told them in very specific terms to make note of certain actions because they were ways of managing a class, introducing a science concept, or some other organizational strategy.

Interpreting the tenets of citizen science as proposed by Morgan

Morgan described three primary tenets of citizen science. My interpretation of his description developed from our conversations and through observations. The first tenet can best be described as providing individuals with a base of knowledge on which to act.

The second tenet emphasizes the idea that knowledgeable individuals must be given opportunities to become involved in scientific endeavors. Morgan identified this second tenet as participation. Finally, tenet three addressed the need for individuals to become advocates for the ‘other’; that ‘other’ could be a plant, animal, law, or any idea they felt strongly enough to act for. While an assumption, and not specified by Morgan, it would appear that an individual can’t achieve the second or third tenet until he or she has a solid foundation of knowledge about the ‘other’. Once knowledge is constructed, participation has to occur before one can become an advocate. In connecting my understanding to Morgan’s limited description, it would seem that without knowledge, advocacy would be inconsequential because individuals would not know what they were fighting for – be it language, habitat, cultures, or butterflies. My understanding of citizen science pedagogy, while limited to my observations and interpretation of Morgan’s description, indicates a strong reliance on understanding, on gaining the requisite knowledge to position oneself as an authority in a given area. An argument for citizen science pedagogy could conceivably be more accessible and accepted by a larger number of individuals *if* there was an established understanding that knowledge is valued and has to be constructed as a foundation upon which all other proposed tenets of are built. While Morgan’s intent for citizen science did not appear to be a focus on knowledge, others might quite conceivably see value in this pedagogy if presented with a description of some type of hierarchical relationship between the tenets. By positioning citizen science as hierarchical and built upon the foundation of content knowledge, antagonists would possibly have fewer arguments if they realized the knowledge based required for action and advocacy. This study seemed to indicate that understanding of citizen science pedagogy, in which advocacy is the quintessential objective, might enable the pre-service teachers to construct a teaching philosophy that has the potential to be more accommodating to a larger student population.

The remainder of this chapter identifies critical aspects of the course which may have fostered understanding and integration of ecojustice philosophy. A description of context and its relevance to class structure, assignments and theory development, along with related challenges of both teaching and learning will be discussed in detail.

Learning by doing

"Give a man a fish, and he will eat for a day. Teach a man to fish, and he will eat for a lifetime" (Anonymous). This saying is something we have all likely heard, at some point during our lifetime, but it is especially relevant to teaching. Many might agree that learning how to do something is often easier when guided by another who has experience. We can watch, we can listen, but until we actually do it for ourselves we may never completely comprehend what it means. Arguably, teaching is often about presenting information in ways that learners participate in at that moment and then are expected to remember later when faced with having to make decisions. Within the scope of the methods class, allowing pre-service teachers to take part in activities which reflected the tenets of citizen science promoted experiences that might be integrated within their understanding of what science, teaching, and learning could be.

Getting students to understand citizen science through individual and group assessment

Classroom assignments provide opportunities for students to express what they understood and how they were progressing in terms of understanding core ideas presented in the course. Assessment of pre-service teacher integration and understanding of ideas, both at the individual and group level, happened daily in the 'methods' class and involved both graded and non-graded activities. Several of the assignments in this course provided an opportunity for Morgan to obtain direct feedback about each pre-service teacher's background, beliefs, and acceptance of new ideas. Assignments which were described as directly related to citizen science are shared from the perspective of the instructor, from observations, and artifact analysis. For most students, a critical component of an assignment was how it would be assessed. Also discussed are general ideas about assessment in relation to detailed descriptions of specific assignments.

Assessment

Rather than using traditional assessments which typically emphasize an end product, Morgan designed his assessments to focus on the process involved in their completion. Morgan explained that he was able to assess the pre-service teacher's individual progress and acceptance of citizen science ideas through conversation with them, observation of their behavior, and other interactions. Formative assessments took shape through conversation and observations. Morgan provided an explanation for the pre-service teachers, indicating that some of his assessments would come from written products, illustrations, verbal presentations, and other non-traditional formats, emphasizing that he considered traditional assessment practices to be "demeaning" (Morgan A). Morgan's ideas about assessment, together with grading, were other assumptions he hoped would challenge pre-service teachers' preconceived notions. Challenging of assumptions was a key component to Morgan's description of citizen science pedagogy and was used as a way of getting at the pre-service teachers underlying beliefs. Assumptions will be addressed later in this section.

Assessment strategies for classroom instruction

During the class discussion on types of learners, the pre-service teachers were encouraged to use alternative forms of assessment. Each student was given an 'intelligence test', asked to create a bar graph of their results, and then discuss how this information could be useful in their future classrooms. Morgan used this example to emphasize the idea of looking at student performance rather than grading for correct answers, pointing out that many times there can be more than one correct answer. Sharing additional examples of alternative assessment with the pre-service teachers, Morgan suggested that their unit should include assessments for all types of students, emphasizing that different types of learners would have opportunities for success if given multiple forms of assessment. An example of an alternative assessment which Morgan shared with the class involved the creation of a musical arrangement or video based on a concept from class. He shared how middle school students he had taught created a video of a burning house, using their own kitchen as a representation of a crime scene investigation, noting this as an example of alternative assessment.

Considering the current focus placed on standards-based assessments in which there is often only one right answer, there is legitimate concern over how to successfully determine the knowledge of students. During our first interview, Bernie was questioned about his reaction to the statement made by Morgan that 'there was always more than one right answer'. In class, his reaction seemed to indicate that as a future chemistry teacher he might not agree. However, when probed about his perceived reaction, Bernie explained that he could understand the need to grade students on effort and emphasized that some level of comprehension should matter in assessment. Contrary to the researchers perceptions he reinforced Morgan's idea of assessment by sharing his belief that Morgan's intention was likely to have the pre-service teachers realize that when students complete assessments they put much effort into getting a product. Bernie further elaborated that even if the students don't obtain the correct answer, they put forth effort that should be recognized and celebrated.

Assignments, those items listed on the syllabus to be turned in, were discussed via examples from previous classes – but with limited emphasis on actual determination of 'grades'. Although Morgan stated his dislike for numerical grading, the pre-service teachers still expected that they would be assessed with numerical grades and wanted directions for how their assignments should look. While the pre-service teachers understood the overall goal of projects they were being asked to do to explore certain questions, many of them felt that the assessments were subjective and dependent upon whether they met an unknown criteria developed by Morgan. Not all students were as concerned with Morgan's lack of emphasis on grading, sharing their preference for the freedom associated with assignments in Block I. Rose stated that she "really like[d] that they [Morgan and Selleck] are not grading us on grades, they are grading on effort and how well we are trying…they want us to do well at the very end" (Rose C). Rose supported Morgan's expectations with respect to assessment, explaining that she felt [he] just wanted them to do their best. It was emphasized throughout the semester that Morgan maintained an explicit policy allowing the students to redo assignments, after gaining feedback until they met his expectations. From Morgan's perspective, when students had freedom to recreate assignments, without being tied to a structured rubric, it was easier to foster and maintain democratic ideals. Describing assignments as fluid, in that he expected each pre-service teacher to do his or her best, Morgan explained how his requests for students to "redo" an assignment were attempts at further challenging them. Morgan equally emphasized with every assignment the importance of doing the best job possible, sharing with the class that 'this is the most important assignment that you will do'.

In practice, however, this assessment policy was not carried out as smoothly as it sounds. Although Morgan wanted the best possible product, the process of gaining that result was questioned by several of the pre-service teachers. The philosophy he described in relation to the grading policies that accompanied each assessment was very individualized, and inconsistent. These inconsistencies led the pre-service teachers to express frustration when feedback was limited and expectations were often left unexplained. Sarah shared her feeling about feedback she received in conjunction with the lesson box/safety assignment:

> he really didn't give us that much guidance to begin with, and so it is just….nobody wants to ask him anything anyway because you never know when he is going to add something to an assignment and Lord knows we didn't need to add anything to the lesson box. Even if I had asked him he might have changed his mind and wanted something else…he is not consistent. (Sarah L)

In contrast to Morgan's espoused philosophy about grading, the pre-service teachers were given quizzes at the beginning of each class meeting. Quizzes will be further discussed below. However, Morgan explained that he was apparently required to give quizzes during each class meeting, even though he held the belief that grades didn't really matter. He was primarily concerned that the students were meeting the expectations of Joni, the graduate assistant who created and graded each of the quizzes.

Quizzes and reading materials

While Morgan was not a proponent of graded assessments, they were included as a component of the 'methods' course. At the beginning of each class, the pre-service teachers were given quizzes as a way of reviewing the reading assignments and encouraging attendance. Joni, the graduate assistant, was responsible for developing the quizzes, grading them, and managing discussion of the associated reading. However, Morgan proctored the quizzes and had very strict guidelines for how the pre-service teachers should conduct themselves during and after the quizzes. Writing time remaining on the board, asking them to remain quiet, showed that he expected that quizzes be carried out in consistent ways. Early on, Morgan instructed the pre-service teachers to bring in materials to read after completing a quiz, describing this as a good strategy for keeping the students in their future classrooms occupied and quiet during testing situations. During the fourth meeting, many students didn't bring in materials and were reprimanded by Morgan. Yet again in the 6th class meeting, many of the pre-service teachers did not have reading materials. In response, Morgan asked the class to answer the following questions, recording their thoughts on paper: 'what do you think of the idea of bringing reading material to class after the quiz? What do you think should be the consequence for a beginning science teacher who does not take seriously the idea that you should bring reading material after the quiz? What consequences should a college student face for not following instructions?' The responses by the pre-service teachers were very similar. Most pre-service teachers agreed that having something to do after the quiz was valuable, but several thought that drawing was an acceptable alternative. In a way that validated the requirement put forth by Morgan, some pre-service teachers stated that reading was an excellent way of increasing scientific literacy and general knowledge; most pre-service teachers agreed that it helped to keep the other students from getting distracted and therefore served as a classroom management technique. In terms of consequences for not following directions, the class was somewhat divided. Some of the pre-service teachers encouraged verbal reprimands, some indicated that they should have to explain themselves to the instructor, yet most did not feel that consequences were necessary. Those pre-service teachers who believed in consequences suggested that the lack of 'respect' for classroom rules could be reflected in future reference letters which Morgan might write. Many argued that if the 'pre-service teacher' did not participate in this expectation during a class they were taking, they would be less likely to enforce reading in their own classrooms (Classroom Artifact 4).

Quizzes were eliminated during the practicum experience[8]. Considering the percentage these quizzes comprised in the overall grading scheme, it was disconcerting to know that the graduate assistant created, graded and discussed these with the pre-service teachers. Although Morgan said he had conversations with Joni, private discussions with her indicated that she felt he was not involved when planning for quizzes. The table provided below gives a breakdown of the percentage each assignment was worth in the overall course grade.

[8] The Methods Course was interrupted for the practicum experience. The practicum involved the pre-service teachers visiting local secondary science classrooms for observations and additional activities; detailed information about the practicum is not included as it was not considered a component of the methods course.

Table 10. Overview of assessments described on syllabus

Title of assignment	Grading percentage
Reflective Essay	5%
Introduction Letter and Syllabus	5%
Fire Safety Certificate	5%
Garden Earth Naturalist Conference (Citizen Science Methods)	10%
Safety Plan and Lesson-Box for Teaching Safety/Ethics (Presentation)	20%
Reflective Photo-Essay	5%
Quizzes (Cumulative Grade)	50%

Pre-planned assessments: ‘Assignments’ described in the syllabus

Though Morgan felt that grades could potentially devalue the pre-service teachers’ efforts, he did acknowledge the tradition for a course to include ways of student assessment. Given the need for pre-established assignments, Morgan included diverse assessments in the course syllabus. Most of the assignments listed in **Error! Reference source not found.** will be discussed in this section; those that are not included were not available or did not prove significant in understanding the course in terms of citizen science pedagogy. Considering that graded assignments were only one form of assessment, daily class activities which provided opportunities for Morgan to evaluate the pre-service teachers are discussed under a forthcoming section titled ‘Pre-planned assessments: ‘Assignments’ not included in the syllabus’.

Reflective Essay

The first assignment described on the syllabus to be completed by the pre-service teachers was a reflective essay. As the name indicates, it was an opportunity for the pre-service teachers to consider their experiences in science classrooms and share an account of what influenced their learning and might impact future teaching endeavors. According to Morgan, this essay gave students an opportunity to write about what they knew about science teaching and what they intended to emulate for their own classrooms. A key purpose of this assignment was having pre-service teachers examine their experiences in the classroom as students and reflect on how those encounters shaped their current understanding of teaching. While specific written examples were not made available to the class, there was conversation about what the essay should and could include. The reflective essay was intended to shed light on the pre-service teachers' images of science teaching, shaped as a result of the sixteen years they were participants in science classrooms. Morgan shared that his intention for this assignment was to provide him with a baseline understanding of where each pre-service teacher came from and the experiences that could potentially influence their future teaching and participation in the class. Morgan reasoned that if their past experiences were very structured, then it could possibly be more challenging for these pre-service teachers to consider citizen science as a viable means of instruction - it may have contradicted everything they had experienced previously. Included below is the introductory paragraph to Paul's refection, and presents a considerable different perspective to teaching than what he argued for in later interviews.

> I enrolled in the science education program because I've always had a passion for science, especially physics and chemistry, and I want to share that passion and pass it on. There are a lot of wonderful (or at least strange and interesting) things that science can tell us about the world and I want more people to be able to see it. On a more abstract and less personal level, I recently got into a conversation that wandered onto the topic of the purpose of public education where I said that it should prepare students to

> become citizens capable of fulfilling their responsibilities. Beyond the classic Three R's needed for daily life, this entails civics education and some sense of how the world works, which science is uniquely suited to provide. With a society increasingly dependent on technology and science, and a nation continually facing issues where an understanding of science is necessary to make a decision, citizens need to develop some basic understanding of what science is and what it says.(Paul CA1)

Intentionally contradicting his overall attitude, Paul emphasized a connection between chemistry and physics that tended to focus more on the content knowledge than the connections between science and society. My analysis of these essays indicated that citizen science was more difficult for those pre-service teachers with chemistry and physics focus areas to understand and value. Some of these pre-service teachers noted that their previous courses were typically organized in lecture-based formats, rather than experiential, and that citizen science would be a challenging pedagogy for them to integrate with their current beliefs about teaching.

Syllabus and Introductory letter

Another early assignment required the pre-service teachers to create a class syllabus and introduction letter, with their future students serving as the intended audience. The purpose of this assignment was to communicate their expectations with future students and describe how the imaginary class would potentially be structured. Morgan viewed the course syllabus and introduction letter assignment as items that the pre-service teachers could use in their own classrooms. They also served as evidence which he used in assessing the pre-service teachers' competence in preparation for teaching science. Morgan described these assignments as "incredible", explaining how they tended to showcase the manner in which the pre-service teachers had been taught for the past 16 years. He noted that this assignment was often their first attempt at defining policies, procedures and a management plan of their own since the pre-service teachers were expected to develop a discipline plan with behavioral expectations. These plans often emulated an example provided by Morgan in which he suggested designing a classroom environment that would allow for democracy, even to the extent of "mapping out how their classrooms might look on their syllabi" (Morgan 1). In considering components which should be addressed, Morgan suggested that the pre-service teachers should include things about themselves in the letter, show confidence, and speak to the parent while writing to the student. During our interview, Morgan indicated an additional benefit of the assignment was that it provided information for him on what assumptions the pre-service teachers held. Having knowledge of these assumptions further enabled him to structure his own instruction to better frame citizen science. One example of an introductory letter is provided below as Figure 2. Sarah's introductory letter

McSmeyup County High School

9th grade Physical Science – Fall 2010

Dearest Parents/Guardians and Students,

First of all, Welcome! Welcome to the exciting world of high school and physical science! I am thrilled at the opportunity to explore and share the adventure of physical science with your child, and for the chance to get to know you as well. I hope that you as parents and guardians will keep involved with your child and this course throughout the school year. Physical science is a combination of physics and chemistry topics and is the "hows" and "whys" of many phenomenons you and your child may have experienced like a ball rolling down a hill and the differences between water and soda. This year I hope to help your child become more scientifically literate as we relate topics such as motion, energy, and elements to the world around us. I expect your child's **best** effort in understanding and applying the knowledge presented in this class, not only to the class work, but also at home and to their environment. I love to hear that I am helping students apply the information we talk about in class to their environment outside of our class room. I know they are capable of excelling in this class, especially if they have my and your support and encouragement in learning.

I am a recent graduate of the University of Georgia, with a Bachelor of Science degree in education, specializing in chemistry education. I have been married for 3 years and have a 2 year old son. I love to be amazed when my son learns and spending time with him, my husband, and my mom is my favorite thing to do.

I am delighted to have your student in my class and I plan for a year of scientific revelations they and I will remember. I have attached the syllabus for the class and ask that you please take the time to read it, discuss it with your child, and both of you sign it and return it me before the end of the week. If you have any questions or would like to contact me, my contact information is listed below. Feel free to make an appointment to meet with me as well.

Hopes and wishes for lots of learning,

Sarah Smith
Physical science/ Chemistry Teacher
McSmeyup County High School
Office – (555) 860-1000
E-mail – sarah@gml.com
Website - http://sites.google.com/site/sarahsmith

Figure 2. Sarah's introductory letter

Sarah's introductory letter included having individuals in her class develop their own classroom rules, indicating a level of ownership designed to encourage collaboration and partnerships among students. Her interest in having the students make suggestions for class structure was an indication that she imagined her classroom as somewhat democratic, with a focus on the needs and concerns of her learners while still being active and exploratory. Sarah’s letter also indicated a similar need for collaboration in academic and scientific processes, and was evidenced in her provision for class time for students to discuss their work with peers. Science was described as something that could explain daily phenomena, with her goal of having students become more scientifically literate through completion of projects, demonstrations, presentations and reports that would be completed in her class.

Paul indicated through his introductory letter that the students would be held responsible for behaviors and their own learning, and would leave his class with a better understanding of how science fits into their lives. Paul stated in his letter that students will “develop critical thinking skills and an understanding of the nature of science” (Paul Classroom Artifact 3). He indicated no tolerance for anything other than physics in his classroom, and emphasized that students would have to be on task at all times. While he encouraged reading when assignments were completed, there appeared to be no room for compromise in his plan; content seemed to be the focus of his ideal classroom, with the students having little input into the curriculum. Paul emphasized that learning should be a life-long activity, but did not represent what that would look like in his future classroom.

Bernie’s hope was to “motivate a life-long awareness of the importance of science in our modern world” (Bernie Classroom Artifact 3). His introductory letter was very encouraging with an explanation of why students were not simply empty vessels but were knowledge holders who needed to actively participate in science in order to really learn. Bernie anticipated his class as being active, with demonstrations, group work, labs, and analysis of current events carried out in ways that would guide students past misconceptions and help them develop an appreciation of science ‘as it happens in real life'. Bernie also stressed the importance of communication and interaction with parents as an essential ingredient for success in his classroom.

Rose shared her goal of having students 'engaged' in activities that fit with the curriculum of her class. Responsibility and respect were discussed as critical features of her future classroom and a key aspect in her decision to become a teacher. In the introductory letter, she also shared a love of nature and personal information with the goal of portraying herself as "real" and concerned for the welfare of her future students. She indicated a belief in communication and maintaining parental involvement, noting that 'it is one of the major keys to successful schooling" (Rose Classroom Artifact 3).

Lesson box and the safety plan

A final assessment activity in which the pre-service teachers participated was the lesson box presentation. During one of the last class meetings, each pre-service teacher was given the opportunity to stand before Morgan and their peers and present an activity they had planned for their future students. The safety plan (something which was included in the lesson box) was described as a major assignment on the course syllabus and required the pre-service teachers to create a completed safety plan. The safety plan was intended to "show what you have learned about the role of safety and welfare in science education, and the specific safety and ethical challenges related to your science content area. This plan should be designed according to the Safety Plan Rubric that will be provided in class" (Syllabus Fall 2009). The safety plan was a mandatory requirement for pre-service teachers seeking certification, in accordance with the NSTA standards for safety, and a component of standards that, according to Morgan 'are used to evaluate the department' (Morgan 11). The safety plan was to include a lesson that would be shared with the class as a ‘lesson box’. The lesson box was introduced by Morgan early in the semester with pictures and examples from prior classes and described as a pre-prepared set of materials which could be used by the pre-service teacher when they entered their own classroom. He indicated that the lesson box should contain a lesson plan for teaching the activity and any materials that would be needed for completing the activity with a group of students. Examples he shared from previous classes were actual boxes containing materials for teaching a group of up to 30 students, with all the necessary material which would be required for the teacher to understand the content.

In describing the lesson box, Morgan explained that it would not be graded individually, rather as a component of the safety plan. Sharing the lesson box with the class provided an opportunity for other pre-service teachers to learn from their peers and gave Morgan time to provide feedback so modifications could be made before the safety plan was turned in for a grade. In later conversation, he shared his hope that the pre-service teachers made the suggested modifications so he would not have to give them an incomplete in the class. Morgan emphasized that the safety plan would be the most important piece of evidence from the class and stressed that he wanted them to take ownership and ‘make it what you want it to be’. The group was provided with a template for completion of the safety plan, one that included in detail the expected materials which should be included; there wasn’t a template or specifications for the overall lesson box. In one class meeting during which Morgan discussed the model, the chemistry majors were directed to complete all components of the template which included material safety data sheets (MSDS). Other pre-service teachers, who were not chemistry majors, were informed that they did not need to know about material safety data sheets (MSDS) since they probably would not be using chemicals in the classroom. In later questioning, Morgan shared that the department decided as a whole that not all pre-service teachers would need to know about chemical safety; therefore he was not making it mandatory for anyone other than chemistry majors. Morgan described the assignment to the class as 'a lesson on anything that deals with safety and ethical treatment, it is your safety plan for your teaching and your class and a way of explaining that you know how to keep your kids safe' (Classroom Observation 13).

When the day came for the pre-service teachers to share their lesson box, their presentation unveiled different understandings of what the lesson box was intended to be, confusion which was not apparent until the day of the presentation. Morgan's awareness of the confusion was evident when he mentioned that "the lesson box should have been a lesson on safety as the main objective – and that most students got that" (Morgan 11). Conversation with Joni on the day of presentations indicated that the lesson box assignment had changed three times, and that it had ultimately turned into a safety lesson rather than a generic lesson box. During the break between presentations, the students indicated that every time they asked for clarification, Morgan changed the assignment. After further reviewing email correspondence and the syllabus provided by Morgan, it appeared that there was not a great degree of detail in what was expected. Reviewing emails and considering comments made in the class prompted a conversation with Morgan about the expectations for the assignment and the changes which were continually made. Morgan explained that he intended the assignment to give the pre-service teachers freedom and allow them to take part in making decisions about the direction they foresaw in the assignment. He related the apparent confusion on the day of presentations as an indicator that they were not prepared adequately. A snapshot of lesson box presentations is provided in the following paragraphs.

What happened during lesson box presentations?

In order to gain a more comprehensive understanding of what took place during the lesson box presentation, and to highlight the pre-service teachers' difficulties, it is necessary to discuss the events of the day. Not all presentations are included. However, those which are described give an overview of the diversity in student presentations and the comments which were made by Morgan.

Sarah

> Sarah planned for her lesson box activity to focus on acid/base reactions using cabbage juice, baking soda, and vinegar. During her presentation, she explained to the class of pre-service teachers that she would make safety mistakes and have the high school chemistry students correct her mistakes. The teacher demonstration that Sarah would do in her future high school classroom would serve as a way of testing her students on their understanding of safety guidelines, before allowing them to participate in lab activities. Explaining that after her high school students completed the lab activity in class, she anticipated brainstorming with them about substances commonly found in their own homes. A final aspect of this activity would include having the high school chemistry students determine what color changes would be seen if they were to test the household chemicals they identified. In the middle of her presentation, Morgan interrupted to suggest she scale back and conduct a preliminary lesson which focused only on safety and then move to ph as a completely separate lesson. While Sarah

attempted to share how this connection needed to be included, Morgan repeated his recommendation that she should maintain safety and ph as separate lessons.

Catherine

Catherine began her lesson box presentation with very graphic pictures of bug bites and stings. Catherine had prepared a deck of insect and plant cards which included pictures and descriptions, along with a homemade flag for marking potential hazards in this outdoor activity which she had planned for her future students. In addition to the cards and flag, Catherine shared a handout she had made on ways to ensure safety in relation to insects, plants, and other things that could be considered dangerous during the planned outdoor activity discussed in this lesson box presentation. The information table which went along with the safety handout was to be used by her future students, as they moved in groups, completing informational notes on harmful insects and plants as an indoor preparatory activity. As an added safety precaution, she included a letter encouraging parental involvement in the outdoor, field-based activity. "'Perfect' Catherine would get hired on the spot; this is a perfect interview box" Morgan responded once the presentation was over.

Leah

"I always look to nature for a hook", Leah commented as she began her lesson box presentation. Morgan interrupted her introduction to ask the class "did you all hear what Leah said? I like to hear that; that is music to my ears". As he walked towards the back of the classroom, he patted Leah on the back and smiled. Leah had created a large poster that she hung on the wall. Included on the poster were pictures of plants from a university web-site, with corresponding descriptions. Leah planned to have students learn about poisonous plants by creating flashcards for eight plants and their characteristics. She then planned to use field guides and the flashcards to guide student observations of the more than 60 poisonous plants in their natural outdoor setting. Morgan suggested using the flashcards as bell work, something the students could do at the beginning of the class period.

Joel

Joel presented a lesson box activity which involved his future students in constructing planter boxes. During his presentation Joel spoke of how the box would be built and the involvement of the community in the process, but there was no discussion included on how this idea related to any particular science concept or aspect of safety. Morgan praised the project repeatedly, even going so far as requesting that Joel share his project lesson plan for use on the instructor's web site as an example of "ecojustice philosophy in practice" (Morgan 11).

Rose

Rose discussed the general relationship between the instructor and mode of assessment as "he provided assignments, but he just didn't provide instruction" (Rose M). She shared that there was little clarity in Morgan's expectations, especially for the safety plan. When the pre-service teachers asked a question on what to include in their safety plan, and lesson box component, they were instructed to refer to their book on safety for guidance. Continuing with a discussion on the lesson box presentation, Rose shared:

He never specified what he wanted because he would change his mind. If you were to ask early on, all he wanted was a lesson box on safety – some kind of safety. But he just kept mixing it with content and safety, and they had to follow the standards and some were just like what? So I did my lesson box on content with safety involved in it. So when I was going to present it other people were presenting and [he] was putting everyone down. You know, ‘this isn’t what I want – I wanted you guys to focus on safety’. Fortunately, I was one of the ones that was like in the middle. So when [it was my turn] I played it more to the safety parts. I kind of stood up there and changed it so that it was all safety. And just took away the actual content of it, but it still involved content and safety procedures and steps and stuff – but I had to take away all of the hours of information that I put on. **(Did you still include that in your lesson that you had to turn in?)** No, I changed it. I had to go back and change everything because that is not what he wanted, he specified. He specifically said while we were teaching it, doing our lesson box in front of him… some people did it and some people didn’t do it correctly and fortunately I wasn’t the first one because I would have been in the middle [in terms of how my lesson looked]. Cuz

> I think I didn't have enough safety, I was going to talk…mine was about chromatography. So I had everything in there to do it and I was going to show safety on everything. But that is not what he wanted, he wanted safety overall. It was nice that we did it and he told us what was wrong and how to fix it, but it would have been better if it were from the beginning that way I wouldn't have spent hours trying to do everything that wasn't what he wanted. (Rose M – bold represents a question asked by researcher)

Again, this is not a comprehensive presentation of every lesson box, but does serve to highlight the ideas which were included by the pre-service teachers and the concerns which were felt to be relevant. Several pre-service teachers shared in a later discussion that as the class progressed they went into panic mode. Observing Sarah's presentation of her lesson box, one of the first to be shared, and hearing Morgan's feedback forced them to modify their own lesson box presentations. These comments suggested a very hurried attempt at adjusting their 'current plan' in an effort to have Morgan consider their lesson box presentation as acceptable. It was apparent that many pre-service teachers scrapped their original plan, with the intent of pleasing Morgan being the ultimate goal.

Morgan's response to the presentations was somewhat difficult to understand. Their hurried changes caused Morgan to doubt the level of serious consideration which should have been afforded to the completion of the project. He indicated in a private email that some students had really let him down and he worried about how they would do on their final safety plan. During the presentations, Morgan gave each pre-service teacher feedback with respect to how well the lesson covered safety. The idea of completely focusing a lesson on safety appeared to be new for many of the pre-service teachers. Morgan told the class half-way through that “the main goal is safety, not the activity,” indicating that the focus of the lesson box should be safety, not content (Classroom Observation 16). During a class meeting, Morgan threatened that the pre-service teachers needed to meet his expectations if they did not want to receive an incomplete for the class. When Morgan ‘offered suggestions, he expected [the student] to rework [the lesson] and make the corrections he requested’ (Classroom Observation 16). Sarah discussed her experience with the lesson box presentation:

> At first he just told us it was a lesson box just dealing with safety. Then Wednesday he told us that you have to put the safety in the lesson box. He never mentioned, he just said a lesson box, you just need to do a lesson box and he had showed us pictures earlier in the year of students last semester, their lesson boxes. A lot of them look kind of like the same thing that we did… The project changed, it was suppose to be a lesson box. There were no specifications; it was supposed to be just a lesson that incorporated some aspect of safety that we wrote about in our safety plan. But when we got there to present it, it had turned into a lesson box that was all about safety. He didn’t want any content whatsoever, he just wanted safety. I mean Morgan. I was all excited about mine and I know I talked about a million miles per hour, well I got up there because he was doing so much pressure about the time, you have this many minutes and I

> wanted to show them the color change, so I wanted to do the demonstration. Joni helped me come up with the idea of the red cabbage indicator. Everybody oooh and aaah'd and I felt so glad …He was real harsh on me, it upset me and it hurt my feelings. It addressed safety, but safety was not the only thing that I talked about, so I talked about that when you are dealing with acids and bases and any kind of chemicals you need to wear your splash-proof goggles and things like that. He didn't appreciate the fact that I had, for what he wanted I guess it should have been above and beyond. I don't know, from what else we have seen, as far as many standards that we need to cover and especially if you are in a block scheduling [school] where you only have a semester you kind of need incorporate safety… He said, "I had too much standards that I shouldn't have talked at all about pH in my….red cabbage pH juice indicator that is what it is. I can't help that that is what it is. (Sarah L)

Gaining a perspective of what Sarah experienced sheds light on how other pre-service teachers might have felt in the class that day. Confusion about the focal point of the assignment, the lack of individualized grading for the lesson box, and the concern over content inclusion definitely emerged through these presentations and later conversations.

In our final interview, Morgan discussed the lesson boxes, which were a small component of the larger safety plan, and his concern that some pre-service teachers did not focus on safety or ethics. Rather, he indicated that the pre-service teachers did not spend enough time or come and talk to him about what he expected for the assignment. He viewed the presentation to the class as an opportunity for the pre-service teachers to improve their projects. Morgan shared a concern that many of the pre-service teachers did not take his critique well and did not make the required modifications to their safety plans. Those students who appeared to be less prepared were those who, based on conversation, changed their activities at the last minute in an attempt to preclude him telling them that there was not enough safety. He did share, in a private email, that the most impressive lesson boxes were those integrating ideas relating to environmental and social justice issues, but proffered no response to those which did focus on safety but not in the realm of citizen science. When asked privately to address the concern for showing favoritism in his responses to the pre-service teachers during the lesson box presentation, he responded with the comment that 'it's hard to be fair because you are connected to some students more than others' (Morgan K). When we talked at the end of the semester, Morgan shared his excitement at how much time the pre-service teachers had spent developing their safety plan, noting that 'compared to prior semesters, this group of pre-service teachers created documents which were 40-50 pages in length while previous groups turned in 5 page projects.' Morgan described the details which students included within their safety plan, and commented "it's like they had been thinking about safety all the way along" (Morgan K).

Final reflections: The photo-essay assignment

When presenting the photo-essay assignment to the class for the first time, Morgan talked about its value as a resource during job interviews and recruiting fairs. He suggested that the photo-essay assignment would give the pre-service teachers an opportunity to get out and learn about their community, developing an understanding of what 'real-world' science included. Ultimately, he suggested that the assignment would provide them with an outlet for expressing their newly developed beliefs, with Morgan wanting “the students to recognize at the beginning [that] they are going to have to compile all these photos in a collected activity and kind of place them into an essay and show me what they have learned about the class” (Morgan 1). The assignment was described as a way of allowing pre-service teachers to use digital photography, writing, and illustration to represent their interpretation of the world around them – in turn providing representation of their personal philosophy. “They know that whatever they represent is their philosophy; it’s how they see the world. So …they are going to pick the photos that really embody the experiences that they think really shape their philosophy; then they write about it” (Morgan 1). The photo-essay, as he excitedly shared, allowed him to see what the pre-service teachers were paying attention to throughout the class. In an example shared in our prior to course discussion, Morgan talked about how photos from one ‘student’ in an earlier course described her personal culture and the lived curriculum. “This reflective photo essay is to really show me what they have learned about teaching science” (Morgan 1). He shared his belief that what the pre-service teachers would choose to take pictures of would change over the semester due to their developing philosophy – something which he would be able to see in the final photo-essay product. The syllabus provided the following description of the photo-essay assignment:

> The Reflective Photo-Essay is to show what you have learned about teaching science, classroom management, asking questions, guiding activities, safety, analyzing resources, and citizen science. You are encouraged to take photos of the learning experiences you engage in (I

> will also have some photos to provide you). Provide a rationale (including examples) for how you have developed as a teacher. This essay should be five pages double-spaced with photos and provide detailed artifacts. For example, if what you have learned is "how to put out a fire in case of an emergency," then provide a photo of this experience and write a short description of how this photo provides evidence of what you have learned to do. (Syllabus Fall 2009)

When asked about his expectations for what the students should include in their photo-essay, Morgan indicated a strong belief that ecojustice, citizen science, and community involvement should be primary influences on images portrayed in this project. He anticipated the pre-service teachers, in some form, would represent citizen science, and commented that he wanted "to see that, as a whole, the community has developed an understanding of science education for the community and the environment" (Morgan 11). The assignment was intended to provide Morgan with evidence, by the end of the course, of the pre-service teachers' understanding of citizen science with an emphasis on personal assumptions and cultural expectations which would ideally be depicted in their photo-essays. During the presentation of photo-essays, a time when the students made them available for others to view, Morgan told the group that these 'reflect your philosophies and claims that show me why you should be a teacher'.

Discussion with the pre-service teachers indicated varying levels of value and consideration for the photo-essay project. Paul's discussion of his photo-essay represented the randomness and lack of concern for what it entailed, sharing that it was not thought-provoking for him nor something he 'really cared about' (Paul O). Seeing the photo-essay as somewhat more involved and relevant to her future teaching, Rose shared that she included thoughts about her teaching philosophy, pictures and discussion of what she would do as a classroom science teacher. She also felt it was important to share some of her interests outside of the classroom, since she viewed the project as something she could use when applying for jobs. Rose felt especially strongly that her photo-essay would interest individuals in positions of hiring new teachers. Of significance to her teaching, she indicated the inclusion of photos showing her teamwork skills, her ability to be professional, and the value she placed on safety skills she learned in the class.

Daily classroom activities

Anyone who has taught or been a student realizes that assessment happens on a daily basis. Activities are planned which give some level of comparison between what was intended and what might actually have been learned through discussion and participation. During daily class meetings, Morgan introduced the pre-service teachers to different concepts as a way of encouraging them to challenge their current perceptions and integrate ecojustice philosophy. Considering the focus of the class, it makes sense that Morgan chose activities that exemplify some aspect of ecojustice philosophy or provide the pre-service teachers with exposure to using citizen science pedagogy.

Challenging assumptions

In order to encourage individuals to begin to make sense of citizen science pedagogy, Morgan believed they had to be exposed to ideas which encouraged them to address their currently held assumptions. Presenting opportunities for pre-service teachers to challenge assumptions was a primary component of how Morgan attempted to present ecojustice as a viable philosophy for science teaching. To move pre-service teachers in this direction, they were given activities and experiences which juxtaposed their current beliefs with alternative ideas held by others. Activities which were included required completion of at home projects that were later shared with the class, pursuits such as analyzing websites, completing nature journals, or creating a community map. Morgan used these activities as an opportunity to present controversial ideas and promote discussion that addressed some of the assumptions held by the pre-service teachers. Controversy played a significant role in Morgan's instructional style, and he recommended it as a tool that the pre-service teachers could use to gain the interest of their future students. In Morgan's opinion, the integration of controversial topics was becoming more main-stream in today's science classroom. A specific example he provided was the possibility of discussing religious issues in class, emphasizing that it would be acceptable in that it provided an opportunity for the students to express personal views. Morgan stressed how important it was to get to know your students, discover their interests, and allow them opportunities to express their beliefs. He further emphasized the value in using something familiar as a good way to get students interested in science. In another example of using controversy to incite discussion, Morgan spoke of how science and technology could potentially solve the world's problems by extending life and providing more enjoyment through material possessions. Immediately, the students began to debate but quickly realized he was being intentionally controversial in his comments.

In one classroom Morgan asked them to draw a picture of a scientist. It appeared that males typically drew males and females drew females; a discussion ensued about why the pre-service teachers tended to relate one gender or one appearance to science. The pre-service teachers were encouraged to remain aware of these stereotypes and how personal opinions might influence their teaching. However, Morgan hinted that the pre-service teachers might only attend to ideas they endorse. He encouraged them to consider those who are ‘outside the box’ in their future classrooms. Sarah discussed her interest in having students recreate their view of a scientist as a way to spark discussion on misconceptions, indicating that she found the activity to be valuable and something she wants to use in her own classroom.

A large portion of one class period was spent addressing the pre-service teachers’ concept of culture and identifying aspects they found to be valuable for teaching. Pre-service teachers were instructed to bring in magazines, samples of “popular culture which represents science” (Morgan 2). Highlighting media culture allowed Morgan an opportunity to gain a better understanding of what assumptions the pre-service teachers had, and what they deemed valuable within their lived curriculum. It appeared that this assignment was a way for Morgan to determine the context and background from which the pre-service teachers derived their basic understanding of science education and what they potentially might utilize in their own instruction. Time was allocated in class for the pre-service teachers to discuss the material in small groups. However, the pre-service teachers never discussed the activity as a large group, nor did Morgan provide an explanation as to why this activity was relevant to gaining an understanding of a student’s background knowledge. Immediately following the small group discussion on media culture, the pre-service teachers discussed the community map Morgan asked them to complete. These ‘maps’ showed the varied types of outside encounters the pre-service teachers had experienced. Sharing and discussing these maps accentuated the differences between each pre-service teacher, and promoted an increased awareness for what wasn’t ‘seen’ or found valuable enough to document. Morgan used these maps to introduce questions about where people in a community get their food, how they access transportation, and whether they have safe outdoor spaces; the related discussion appeared to have prompted a greater awareness in many of the pre-service teachers for the diversity which exists in many communities. Morgan described the first tenet of citizen science as ‘becoming informed’. Developing an awareness of one’s surroundings and acknowledging currently held beliefs could be viewed as part of the process of becoming informed. Those were characteristics of the community mapping activity. In talking with Morgan about the community map activity, he shared surprise at how the pre-service teachers responded to the assignment and discussed his realization of the need for having sample works to show them.

Introducing strategies for teaching science

Various strategies which Morgan believed could be especially useful for teaching were incorporated into different class meetings. Classroom management, collaboration, and content introduction strategies were integrated with specific points about their use as they emerged at different times throughout the semester. Morgan introduced collaboration techniques through a handout outlining grouping strategies, and then had the pre-service teachers practice selected techniques. Discussing grouping as a management strategy, Morgan emphasized that it was important to first learn about the students in a class before using this strategy. He emphasized, in particular, that students with low interest in science should not be placed with high interest students because of the potential for increasing levels of frustration for both groups of students. Many of the pre-service teachers found the grouping ideas valuable and considered them as practices that could be utilized in their future teaching. Rose's discussion of her experience with the grouping strategies was positive, describing them as having the potential to alleviate some of the stress felt by students who don't always feel confident in their answers. Bernie was very excited about the idea of grouping students, mentioning that it could be beneficial in helping students learn from each other and fostering motivation. Bernie mentioned that grouping students according to skill level, low level students together with those performing slightly higher, could be an effective way of learning collaboratively and one that he would likely use in his own classroom. He related it to Vygotsky's zone of proximal development, resolving that "you have students a little bit better than each other [working together] so that everybody can grow a little bit" (Bernie D).

Another strategy Morgan discussed was having students act as managers in their classroom, pointing out that this strategy allowed students to have some ownership and 'is a way for you to breathe and have time to do other things'. During this class, Morgan suggested that students be allowed to create lesson plans and act as the responsible party for various components of the class, reporting back to peers in smaller group meetings. Morgan affirmed in our after class discussion that the ideas he presented would most likely be considered controversial because 'there is an assumption that the teacher should do the lesson-planning.' Morgan felt that his teaching style would not work for all of the pre-service teachers, but wanted to "give them as many different resources and arts of teaching" as possible (Morgan 3). It was difficult to gauge the pre-service teachers' willingness to incorporate this strategy in their own classroom, and without further discussion in class it was impossible to determine whether they found it valuable. Morgan did share that he didn't anticipate everyone wanting to use the collaborative strategies that he promoted, but felt it was important to share his own experiences. The discussion of student managers provided alternatives for classroom management without prescribing details, making it potentially somewhat difficult for the pre-service teachers to imagine enacting the strategy on their own. It seemed that time was limited in this instance for the pre-service teachers to ask questions and establish a deeper understanding for how this could unfold in their own classrooms, should they decide to implement Morgan's suggestions for using student managers.

Probe assignment

An additional classroom activity planned for the pre-service teachers included the use of technology for teaching science. The pre-service teachers were given an opportunity to learn how to use various scientific probeware[9] and develop a lesson and presentation to share with the class. During the introduction of this 'assignment', Morgan explained to the pre-service teachers that he wanted them to have complete ownership of the probeware activity so that they would learn the material better. For this assignment, the pre-service teachers divided into groups, based on their interest levels and established relationships with others in the class. They were told that the lesson had to be created and practiced outside of class, and that feedback would come from the two graduate assistants who made themselves and a laboratory available. The purpose of this ungraded 'assignment' was to help familiarize the pre-service teachers with different probes, allow others to see how different probes worked, and provide the pre-service teachers valuable

[9] Common to some science classrooms, probes are types of electronic devices which can be used to conduct various experiments – examples such as continued documentation of temperature or detection of ph changes in aquatic environments. These 'pieces of technology' often provide exciting pieces of lab equipment with which teachers should familiarize themselves.

practice teaching to their peers. Morgan shared that he saw the probeware lesson as a good opportunity for the pre-service teachers to practice lesson planning and use of science equipment and that while he did not ask for lesson plans he expected each group to have one. For the probeware activity, Morgan stressed that he would be impressed if they put together a lesson plan, even though it was not required and would not be graded, but "would be blown away if everyone put together a handout to give peers that uses the probes" (Classroom Observation 6). Morgan emphasized that the probeware activity, and subsequent outside involvement by the pre-service teachers, would provide an indicator of how willing they were to put in the extra effort – something he would consider important when writing 'a better recommendation letter.' As a result of Morgan's unofficial expectation for completing a lesson plan, every group created one. While he did not look at these in class, Joni offered to post these lessons online, allowing the pre-service teachers access to the work of their peers. There was much concern over the emphasis on completing the activity outside of class and on the 'requirement' to do a lesson plan in conjunction with the probe. Sarah shared that many of her peers felt pressured into "doing the lesson plans to go along with the probe, even though they were supposed to be optional (Sarah G)."

Class meetings introducing citizen science as a philosophical enterprise

The following section describes activities that address the different approaches to citizen science, as they were described by Morgan, and how they were introduced to the pre-service teachers. Considering that Morgan characterized citizen science as either a bottom-up or a top-down approach, the inclusion of collaborators allowed him to incorporate activities to this type of variation. Within the activities described here, there is also what he considered a mediated approach, an approach that is neither top-down nor bottom-up. Other classroom activities not specifically included in this ‘section’ might have provided additional opportunities for integrating citizen science and continuing the dialogue about student understanding and acceptance of the philosophy. However, other ‘activities’ were not highlighted by Morgan as particularly significant to illustrating a particular citizen science approach. Therefore, each of the class activities here are discussed in relation to what Morgan presented, how the pre-service teachers participated, and what was evident about citizen science from that instructional approach.

According to Morgan, the larger philosophy of the course was ecojustice – which he admitted re-‘theorizing’ as citizen science. In considering how the pre-service teachers accepted the philosophy of ecojustice as citizen science pedagogy, Morgan described using a back-door approach. By giving the pre-service teachers experiences, he allowed the theory to develop from those experiences. As mentioned earlier in relation to this particular course, citizen science can be either a bottom-up community driven approach, or a scientist-driven top-down approach. Pre-service teachers were exposed to each of these approaches without ever being explicitly told that they should pay special attention to the contrasts between them. The idea of opening avenues of understanding and presenting information and alternatives, while still enabling the pre-service teachers to experience the spectrum of how citizen science was defined, allowed value to be placed where it was meaningful to them. Morgan discussed in our pre-class interview three specific activities designed to expose the pre-service teachers to different forms of citizen science. The first approach was described as a bottom-up, teacher and student driven approach providing the pre-service teachers with an opportunity to collect data and get to know the local community through their involvement in the Garden Earth Naturalist (GEN) program. The bee hunt was the second activity and appeared to be very student-driven, however was described by Morgan as top-down. The bee hunt involved having the pre-service teachers work with a co-educator in an outdoor setting to discover insects, pollination, and use of technology as a scientific recording device. Morgan described the co-educator involved in facilitating the bee hunt as a science-driven citizen scientist and explained his use of the activity to illustrate an example of a top-down approach to citizen science. A third project Morgan described involved the pre-service teachers tagging monarch butterflies with an ecologist who works closely with teachers in both Ecuador and the United States to collect data regarding health and migration patterns. Morgan described this as a mediated approach to citizen science and “less of a scientist-driven approach” (Morgan A).

GEN project as a bottom-up approach

Student involvement in the Garden Earth Naturalist project was the result of collaborative planning between Morgan and Patricia, a staff member at the Piedmont Arboretum. In conjunction with others at the Piedmont Arboretum, Patricia was a key facilitator for the GEN program. Determining the possible roles for the pre-service teachers in the GEN workshop required extensive dialogue between Morgan and Patricia well-before the semester began. Theoretically, the experiences related to the GEN project provided opportunities for the pre-service teachers to have some level of control in making decisions on how to collect scientific data. Through balancing the traditional top-down approach to citizen science, which Morgan assumed the pre-service teachers were more familiar, with a more community-driven approach, the GEN project placed value on how local knowledge was expressed in the community. Morgan indicated that organizing pre-service teacher groups to work on developing the GEN protocols[10] was time-consuming since he was attentive in partnering pre-service teachers who were showing excitement for citizen science with those who did not exhibit the same level of interest. He mentioned placing different content backgrounds together as a way to encourage working across disciplines, with the idea that some students were "internally motivated" and better able to enhance the experience for others (Morgan 4). While encouraging partnerships, Morgan's intent in organizing the groups was to 'help chemistry students see that you can do chemistry outside' and that different parts of GEN were 'interdisciplinary' (Morgan 4).

Introducing GEN to pre-service teachers

On the day of the introductory GEN presentation, it was dark and rainy outside, continuing the week's trend of flooding and muddy classroom activities. To begin the day, the pre-service teachers met in one of the newly remodeled classrooms at Piedmont Arboretum for introductions to Patricia and to learn about what their involvement would entail. Groups which had been pre-determined by Morgan were allotted the task of teaching a concept from the GEN work-book to a group of in-service teachers as part of a professional development workshop. This required conceptualizing the activities around a 'protocol' and making sense of how to incorporate citizen science into their workshop presentation. Protocols were described as a prescribed method of collecting data, with the encouragement to alter these prescriptive strategies so they better fit the intended purpose of whatever project they were studying. Patricia emphasized that the GEN program

[10] 'Protocols' represent a set of instructions that students and teachers follow in collecting data; these instructions were provided in the GEN work-book for the teachers trained during the program.

allowed for parents to have a greater role in doing science with their children, thereby involving the community. She also encouraged the pre-service teachers to think scientifically, as in 'how would you know that degradation was occurring without some form of baseline data?' (Classroom Observation 8) Patricia shared that the program had been used for after school activities and recommended using it in that manner since the activities could be difficult to accomplish with too many children in a classroom. The instructions were brief and the pre-service teachers were told that time working together outside of class would be required to complete the preparations and be ready for the workshop presentation. As Patricia outlined the different activities included within the GEN handbook, she emphasized the lesson creation based on an "Understanding by Design" format. The pre-service teachers were given instructions regarding how they would present their lesson to in-service elementary teachers with Morgan emphasizing that their experience with GEN would be a 'valuable [experience] because it will help you not be complacent or robots' (Classroom Observation 8).

In developing their teaching presentation for GEN, Morgan encouraged the pre-service teachers to break up the information, change the activity around and have fun with the project, but to use good teaching skills to create different methods of citizen science. Morgan described this aspect of GEN as democratizing for the pre-service teachers, allowing them to determine boundaries and the approach they would choose for best addressing the expectations of their 'protocol'. Both Morgan and Patricia emphasized the GEN lesson as an opportunity to 'get elementary teachers excited about science so they can in turn build excitement for their kids…[this] is a chance to influence that before they come to you' (Classroom Observation 8). GEN was put forth as a community and/or teacher-driven approach to collecting data that served as “collateral that teachers use year after year to show they are valuable stake holders in their community, along with their students” (Classroom observation 8). Pre-service teachers were encouraged to design their own protocols for the water monitoring aspect of GEN, allowing for a bottom-up citizen science approach while still promoting accurate collection of data. A primary focus of this class meeting was for the pre-service teachers to gain experience using GEN in the field. The following excerpt portrays the field practice on the day of the pre-service teachers’ orientation to GEN:

> It had been raining heavily since Tuesday, downpours on and off every day and night for four days. The sky was gunmetal grey, with an occasional darker cloud and the constant sound of water falling from the leaves. Everything was wet and dark from excess water, all the participants were in rain gear or with umbrellas. The occasional flip flop, inevitably being ruined, and hiking boot plodded the path to our outdoor classroom. “Meet at the outdoor gazebo, and bring your test bags.” The invasive vine protecting the structure gave little protection from the rain that fell in fat droplets onto our papers, down the back of our necks, and onto the brick pathway. The simulated scavenger hunt required teams to travel along the pathways in search of questions that must be answered by the group. Three or four students quickly oriented themselves to the map and set out with a plan in mind. Minutes into the adventure, the skies opened again. Slowly at first, the rain guided our path, dampening an already moist clipboards and question sheets. Nearing the end of the path,

> the umbrellas were opened although a bit too late for rescue of ourselves or our written work. The rain drops continued to multiply in number and diameter as we moved to phase two of 'outdoor learning'. Passing asphalt streams and manufactured puddles we entered the quieter cove of woods with trails branching in representation of the surrounding trees. Huddled together under the few present umbrellas, the students strained to hear the teacher over the sounds of woods, fallen leaves, and torrential rain. Moving further together and more tightly under the largest umbrellas, few students ventured out to hold the test ropes and perform the actions that could be simulated later in their classes. Morgan walked the perimeter of the student group and often mentioned that he wanted them to think about using this idea, and to imagine how they could see 'this' working in their own classrooms? If responses were made, it was overshadowed by the rain steadily falling on our outdoor classroom. The outdoor instruction ended and we began our trek back to the indoor classroom, umbrellas following wet raincoats and jeans darkened by moisture. Our path upon reaching the building was easily discernible, water drops and puddles along the newly renovated floor heading to a classroom with upholstered chairs that were permanently changed as a result of our return. (sab 9-18)

The field-training for GEN highlighted the potential for citizen science and teaching in a completely different light. Some of the pre-service teachers got past the soggy day enough to experience learning. Questions were raised before going outside - 'can you collect this information and send it to experts?' After being outside for almost an hour, student comments changed to ‘can you actually do this in class?’ And ‘these are methods we used in our science class for collecting data.’ Morgan felt that these pre-service teachers still saw citizen science as a top-down approach and only viable if scientist driven. Going into the project introduction, Morgan felt that the secondary pre-service teachers would think the GEN project “too low level”, since it was geared towards the elementary student. However, as the planning continued he privately shared that the GEN project helped to “mediate some of the tensions” which had been problematic in earlier courses by allowing the pre-service teachers to experience how citizen science could unfold in their classroom. Regardless of grade level, it seemed that GEN provided an opportunity for the pre-service teachers to work together and develop a new understanding of how to use nature for science teaching.

After the water-logged meeting ended, with students exiting the classroom, Morgan and I met for a quick informal discussion. He enthusiastically commented that ‘you got to hear 10k rain drops hitting the ground at one time.’ Excitement was obvious as he discussed the possibility of the day’s events challenging 16 years worth of science and allowing the pre-service teachers a chance to face assumptions about how they defined science. Morgan further described the GEN project as allowing some of the previously held assumptions to be mediated, making it easier for the pre-service teachers to “apply [citizen science] to their middle and high school classrooms” (Morgan 4). He argued that pre-service teachers should have freedom to work with their individual protocols and negotiate what they wanted to do with GEN rather than being given prescribed formats or having restrictions placed on specific teaching ideas. Although he emphasized the value of developing a format that fit with their own expectations, the groups were told to consider Patricia as ‘the school board’ and the person they had to impress. In order to develop their presentations, they had to negotiate with Patricia what they wanted to do. Morgan shared that his assessment would come, not from working with the small groups, but would be based upon what Patricia had documented as the goals for their project presentations.

In observing the presentation and reflecting on past experience, it soon became obvious that similarities in protocols and activities exist between the GEN program and the GLOBE project. The GLOBE program is a collection of environment-based activities in which students, under the supervision of their teacher, work in the outdoors to collect scientific data and submit this data to an internationally accessible web-site shared by students throughout the world who were collecting similar data. GLOBE includes specific instructions on how to collect and input the data, with follow-up on how it can be used in the classroom and encourage international relationships between students and teachers. With the GLOBE program, students are responsible for collecting data following certain criteria and methods, then posting this information to an online data-base which is accessible to students across the world who participate in the program. GEN, on the other hand, is primarily a Georgia-based program with no interaction with other areas of the country. When asked about the similarities between these programs, Morgan admitted being somewhat unfamiliar with GLOBE but stated that he thought it was more of a top-down approach.

What happened during the GEN workshop?

Morgan gave instructions on how he would observe the pre-service teachers. He explained that he would ‘follow the groups around and that they wouldn’t be graded on how the event unfolded, but more on evaluating the process of how they worked, since that was more important and a more accurate indicator'. Morgan made it clear to the pre-service teachers that he expected them to stay until noon, since they would have all of the next week off. He thought he had made it clear early on in the semester that "this would be a day they would have to give up an extra hour." Houston asked about leaving for his 11:15 class that was on campus; he didn't want to be absent. Morgan stated that the group would have to cover for Houston and pick up the slack if they were willing. Morgan emphasized that the pre-service teachers needed to get used to working odd hours as this would be necessary when they started teaching full time, also explaining how they would likely be working all the time during their student teaching the next semester. The following description came from observations on the day of the Garden Earth Naturalist presentations.

> Patricia began the workshop by introducing everyone present; pre-service teachers were standing along the side walls. The in-service teachers were divided into two roughly equal groups that would rotate through each of the stations which were being facilitated by the pre-service teachers; I stayed with one group of teachers until we reached the final activity and all teachers came back together.
>
> Lizzie, Paul, and Joel began the outdoor training by describing the activity they chose as something that would be taught to $4^{th}/5^{th}$ graders. Cameras and sketch books were suggested as tools for collecting and recording data and extending the requirements of GEN, as the process of measuring trees and determining biodiversity were demonstrated to the in-

service teachers. As the teachers began the activity, Bernie gave his arm to Emma and helped her up the hill before joining another group to lay out the quadrant rope and discuss what was within the rope boundary. Paul came from working in the woods to check on the other groups – one was out in the grassy area, one in the woods, and one at a spot ‘in-between’. The in-service teachers were listing the names and types of plants, while the pre-service teachers noticed fungi and detritus. The first group came back with Paul mentioning safety issues that teachers needed to be aware of when working outside. The group had prepared a brochure relating the project to citizen science, but was not allowed to give it to the teachers. Patricia indicated that she would collect the brochures to give to the in-service teachers when they returned to the classroom. Paul explained that the brochure highlighted aspects of food production and activities relating to a feeder watch program that involved birds and ornithology.

Kelsea, Buford, and Beth were next to present with a focus on air protocols. During their presentation, Patricia stepped in often to make comments on what the group presented and give different instructions on how to take part in the activity. Their citizen science project dealt with clean air and monitoring air quality. Patricia made many comments after this group’s presentation, which for the most part did not elaborate on or validate the activities the pre-service teachers had presented.

The next group led an activity that required the participants to lay out a rope quadrant and identify organisms inside the perimeter. The actual activity was very much like the first presentation, yet the group leaders had less voice in sharing directions and expectations with the in-service teachers. When one of the pre-service teacher group leaders instructed the in-service teachers to divide into two groups, Patricia responded that they should divide into three groups. It seemed that Patricia's intervention took the power away from the pre-service teachers and made them appear less capable while hinting at either a lack of supervision during planning or a lack of preparation on the part of the pre-service teachers. The citizen science project used by this group was the goldenrod challenge; sharing the value of digital photography in recording science, they related that pictures in the brochure were taken by the pre-service teachers in the class.

The groups rotated to the creek area for the remaining presentations where Rose's group went first. It appeared that all members of the group shared the leadership role, as each talked about pollinators. As the teachers divided up to count pollinators, Bernie ended up in the group with all female teachers; he tried to sneak up on a butterfly and capture it with his fingers, repeating the handling techniques the pre-service teachers were shown during the monarch lab. Lee closed the small group presentation by talking about citizen science integration. He related the day's activities to real world science and the value in making learning relevant to the community. He questioned the group: 'what is citizen science?' After a few comments from the group, Lee explained that it was a way to enable their students to participate in work that would be meaningful and beneficial to local and scientific communities as a whole. Some of the pre-service teachers were taking pictures along the way to the whole-group activity. Patricia encouraged everyone to move along in an effort to allow the next group to begin their presentation on time.

The next group to present, Alan, Peyton and Leah, discussed water absorption. Alan was very energetic and enthusiastic as he worked with two groups of in-service teachers, helping them link the activity in which they were participating, to other possible learning opportunities in their school. It was apparent that Leah was the group leader as she guided Peyton in remembering the need to talk about water as he ventured off onto the meaning of organic as it related to chemistry. Alan finished the group presentation by discussing the citizen science project their group had chosen; they decided upon a rain garden which Alan tied into the monarch watch using the rationalization that they could plant milkweed in their rain garden to attract butterflies and make a smaller project much larger in scope.

The final group to present included Sarah and Bernie, who directed us closer to the stream to hear an introduction to water quality. After I sat down, Morgan came up behind me and squatted down saying very excitedly, “did you know Beverly’s mother is here? She didn’t know her mother was coming until she said she would be at the botanical gardens for a workshop. Beverly responded, I am teaching something for that

> workshop!" Morgan then wandered off taking pictures as I moved to sit on the rock near the creek and watch the pre-service and in-service teachers collect water quality data. Lee came to collect samples where I was sitting and discussed 'things' that might change water quality data or give skewed information. Lance, in the final group, spoke last about the value of reliable data and gave background information on citizen science. Lance suggested the participants of the workshop 'change their community' with ideas about citizen science projects on water conservation and the 'adopt-a-stream' program. (Classroom Observation 14)

Reflecting upon GEN

The pre-service teachers participating in this study shared differing ideas about their involvement with GEN. When Paul reflected upon his experiences, he shared that it wasn't overly useful since the project was geared more towards elementary students and he would be teaching high school physics. The most important aspect of GEN, for Paul, was the inclusion of safety precautions which had to be considered when working with students outside. He also valued having an opportunity to talk with in-service teachers about their thoughts on working outdoors with middle school students.

Rose shared that her group initially felt they could simply rely on her outdoor expertise to carry them through the activity, yet she quickly let them know that she expected the group project to be a true collaboration. While outdoor instruction was an experience with which Rose was familiar, she indicated that the time spent with the in-service teachers discussing modifications and teaching skills that could enhance outdoor learning was beneficial to her growth as a pre-service teacher. Rose described the GEN project as representative of what she wanted to emulate in her own classroom; she referred to going beyond the scope of just the goals of the GEN project, while using the outdoors as a context for science teaching. Rose discussed the repetition embedded in the activities as extending and elaborating on experiential knowledge and allowing the teachers to learn alternative ways of exploring their local area.

Sarah described a slightly different experience with GEN. She shared concern because her group had to prepare a water purification presentation that would be done in front of all of the in-service teachers, rather than smaller groups as everyone else had experienced. There was an apparent frustration when she talked about the constant ‘teaching’ that happened in the other group presentations and how the in-service teachers “didn’t understand about the scientific process”, and consequently didn’t always grasp the intent of the activities presented by Sarah’s classmates. Sarah shared her level of involvement with the GEN program as:

> We participated, we did it out of respect of our classmates, but because [GEN] was geared toward third, fourth, and fifth graders and their teachers and those age children... Yes you could apply it to some of our stuff if you wanted to, but the materials are not made for our age group of students, so you are doing this for all of these other teachers, which is good to present to your fellow teachers…but you just don’t, I don’t know, we didn’t do a whole lot, we just presented that one time and the rest of time we were walking around and talking. (Sarah G)

Sarah discussed the project as being helpful because it led the in-service teachers to think more about science and how they could in turn influence their students to think differently about science. Sarah considered the project as useful in providing support for the elementary teachers in helping them develop ways to prepare their students to perform better as later preparation for science in high school. She also argued for the GEN project because it showed citizen science at multiple grade levels, through instructional techniques which were not overly complicated.

Bernie felt that having modules and curriculum already prepared removed some opportunity for learning. He shared that the pre-service teachers were not encouraged to create their own citizen science activity, indicating that their job was to suggest ways for improving the prescribed activities they were presenting to the in-service teachers. He described the presentations as innovative in that they encouraged teachers to get out of the classroom to do science. Bernie expressed disappointment in the lack of challenge when they were not allowed to develop their own activities for GEN within the context of their content area. The project further emphasized for him a lack of connection between chemistry and outdoor learning.

Bee hunt as a top-down approach to citizen science

The activity which Morgan described as representative of a top-down approach to citizen science was the ‘Bee Hunt’. Cane, the co-educator who worked with the pre-service teachers for the ‘bee hunt’ was described, by Morgan, as a scientist-driven type of citizen science person. Morgan had worked with Cane in a prior course on the Bee Hunt activity involving several activities involving insect identification and monitoring. Morgan and Cane had worked together with local teachers to develop activities that encourage students to become involved with citizen science, with the Bee Hunt curriculum, which was written by previous students enrolled in Morgan's class, serving as an example. Morgan described a push and pull relationship with Cane "advocate[ing] for enlarging the scope of scientific investigation possible with teachers and I advocate for the enlargement of education" (Morgan 8). It seemed that Cane's approach was described as top-down by Morgan because advocated for standardization in protocol and equipment as a way of encouraging consistency for comparison of data across larger areas of the nation. Given this understanding of regulation, Morgan argued that his method of encouraging manipulation of protocols seemed to be more mediated and somewhat at odds to Cane's approach.

During the bee hunt activity, the pre-service teachers were told they were going to learn about various forms of digital technology that could be utilized in the science classroom to aid in data collection. Morgan introduced a global positioning system, a cell phone, binoculars, and a yearly almanac as tools which could be used in teaching science. Cane arrived after this introduction to talk with the pre-service teachers about using digital cameras for taking pictures of insects pollinating the goldenrod plant. The Bee Hunt was associated with something called the Goldenrod Project. Both projects deal with locating the goldenrod plant and documenting which types of insects serve as pollinators. The pre-service teachers were given instructions on how to calibrate their cameras for taking finely detailed pictures and encouraged to take time to observe various plants and document the variety of organisms that could be found on a small plot of land. Spreading out over two acres, the pre-service teachers came up close and personal with spiders, honeybees, and pollen as they began to make observations about the time of day and yearly influences for data collection utilizing plants. Later discussion with Morgan emphasized his view of the project as a top-down approach, since Cane had given the pre-service teachers a scientist-driven project of documenting insects which pollinate the goldenrod plant. Cane shared that scientists were collecting data on which insects frequented these plants in nature and how teachers and their students could add much needed information to the pool of data.

Monarch tagging as an integrated approach

The final project which was used to illustrate a citizen science approach was the introduction of monarch butterflies, a project which was described as one which was more integrated approach rather than a top-down or bottom-up approach. Bonnie was the university instructor and expert on butterflies who taught the pre-service teachers about the Monarch Watch project. Through allowing authentic experiences with the butterflies, and learning about the science behind the project, pre-service teachers were provided opportunities similar to those experienced by teachers with whom Bonnie worked. Classroom observations from the monarch presentation are included below:

> The presentation on monarch butterflies took place on the main campus in one of the ecology classrooms. Bonnie began her presentation by asking how many of the people in the room were going to teach – they all raised their hands. After giving an overview of the monarch, their migration and gender identification, Bonnie moved onto projects that she described as citizen science based. She discussed the projects in terms of how they provide data for scientists and help predict patterns in monarch behavior; Monarch Watch, Journey North, Monarch Larval Monitoring

Project, Monarch Health were some of the sample projects she described. Morgan asked her how the students could approach this type of project if they were not biology teachers. She suggested looking at size of wing tips and the amount of drag they produced and also emphasized that many butterfly movements were related to weather patterns.

Bonnie asked the class about specific characteristics that were common to monarchs with responses ranging from 'monarchs like milkweed'- to 'they migrate'. She spoke about the characteristically bitter taste that birds associate with monarchs, with one pre-service teacher asking how harmful it would be if the kids decided to eat them. The group discussed how milkweed was required for the butterfly to lay eggs and for larvae to develop with access to a constant food source. The general consensus was that milkweed also required lots of sunlight and water for growth, which could be a factor that might limit monarch location. Discussion of migration pathways indicated that tagged butterflies were found in Mexico and along routes that were eastern, central, or specific to California; a map was shown with a record of butterfly tags reinforcing this pattern of migration. Morgan asked if radio waves, things such as cell phone frequencies influenced their flight path; Bonnie discussed the feelers on the butterfly antennae that contain sensors and help determine locations. Butterfly life spans, which can be two-four weeks or 8-9 months, were also discussed in relation to migration.

The idea of local knowledge and knowing what lives and thrives in your geographic location was emphasized when the pre-service teachers were asked to consider migration. Bonnie mentioned that people in Mexico had no idea where the butterflies went when they left there, but were paid to collect tags and turn them in for five pesos per tag. The butterflies typically end up back in Mexico on or around the day of the dead, and represent for the locals the returning of souls of the dead; this story emphasized the important link between scientific events and local culture. In viewing the migration map as a group, Bonnie questioned why South Georgia had relatively little data. Sarah responded to the question, explaining that she was from that area and that no one took the time or really knew how to record the data.

Bonnie discussed monarch diseases and the role of scientists and citizens in determining health and migratory patterns. Sarah shared that she had read about the research and monarch project on the website, but still had questions as to where the disease came from. After the discussion ended, the pre-service teachers were equally divided for work in the laboratories. The first area visited by the students was a traditional lab with microscopes and black-topped counters, where the monarchs were stored and checked for parasites. Bonnie brought forth a small envelope from the refrigerator, which contained a monarch, and demonstrated the proper techniques for handling the butterfly. The pre-service teachers were directed to hold the monarch and use clear tape to collect samples from the abdomen to determine if parasites were present. They were given the opportunity to see examples of parasites on infected butterflies, examples of butterfly scales, and examples of butterflies not having parasites. The conversation turned to how teachers could collect data to be used for science. With the exception of Alan, who said his fingers were too big, all of the pre-service teachers handled butterflies and used tape to collect scales and then used compound microscopes to view the scales from their specimens. Bonnie shared that many teachers are trained on safe handling techniques and then sent tags for collecting, sampling, and tagging the monarchs.

After about 30 minutes in one lab, we switched to the lab with live specimens flying free in netted enclosures, to talk about handling and feeding requirements for captivity, and how to tag monarchs for release. The lab assistant, Andy, talked about the style of containment and the methods of cleaning equipment to avoid parasite contamination. Andy demonstrated how to prep the sponge with honey water, which is required as a food source in the lab for the butterflies, and discussed how they respond when placed on the sponge and detected food. While in the containment room, Andy passed around a live specimen for everyone to hold. Sarah took tons of pictures of herself holding the butterfly in her hand. Stuwart didn't want to hold the butterfly at all, and ended up next to one of the maintenance pipes reading the instructions on the side of a tank that was making clicking noises. Andy demonstrated how to place identification tags on the monarch wing, while Morgan took pictures of all of the pre-service teachers who held the butterfly. Kelsea ended up with the final butterfly and stood staring intently at it, bringing it up close to her face and turning it in different directions. Alan asked questions about the possibility of scientists going to schools and checking on the health of butterflies, and providing training to the teachers on how to determine the presence of parasites. Alan argued that the training could prevent introduction of diseased butterflies. Andy explained that disease was a common problem because people are raising monarchs, while trying to do a good thing, often released infected specimens. Andy responded that the participating teachers don't want to kill butterflies, so even if it is infected they release it, and increase the prevalence of parasitic diseases. Andy noted that the parasites are found on the milkweed and typically die when the milkweed dies back. He explained however that introduction of tropical milkweed had been a bad thing because it does not completely die back. Without the plant host dying back the parasites are never completely wiped out and increase in numbers every year. Morgan brought the day's activity back to citizen science by stating that all of the questions asked during the day were things that could be investigated with students and might serve as great projects to get them involved in science and monarch monitoring. He asked the pre-service teachers if they could see how the

> monarch project and involving their students in something such as Monarch Watch could be seen as citizen science. (Classroom Observation 13)

After the ‘monarch’ class, I ran into Sarah in the eatery and had lunch with her. She was very excited about the Monarch project because it seemed like something her husband could do at the park where he worked. She felt he could involve more people in butterfly protection as the training would be fairly easy to do. She also mentioned the possible relation to her future chemistry class by focusing on the toxins within the milkweed that make the caterpillars and butterflies bitter for birds.

These projects were presented by Morgan, during our first interview, as examples of approaches designed to expose the pre-service teachers to a variety of ways in which to incorporate citizen science. While it was difficult to determine the approach at times, Morgan anticipated they would cover a top-down, a bottom-up, and mediated approach to using citizen science in the classroom.

Summary

Within this section, activities which were designed to increase the pre-service teachers understanding of citizen science were discussed. These activities included daily events which challenged currently held beliefs and allowed the pre-service teachers opportunities to reflect on the possible differences they would encounter in their future classrooms. Morgan presented the specific events in this section as enabling the pre-service teachers to gain exposure to citizen science on multiple levels and address ecojustice philosophy through processes of democratic learning. He also explained that the activities were meant to challenge assumptions and illustrate the role of mediated learning as provided by the co-educators throughout the semester.

Through the eyes of the researcher: A commentary

Morgan argued that face to face contact could encourage development of relationships with the community, help preserve local knowledge through interaction with others, and might promote appreciation for those with different degrees of experiences and knowledge. As with other experiences in the class, additional opportunities for dialogue about these interactions and the value of different knowledge sources could have potentially enhanced the pre-service teachers' understanding and willingness to access and include other content areas. Challenges in equity, such as Emma's inability to take part due to physical conditions, may have diminished the extent to which the pre-service teachers considered embracing ecojustice as part of their teaching philosophy. Positive experiences did exist and pre-service teachers did take away life lessons and tools that could be used in their own teaching, but possibly not at the level Morgan intended.

One of the most valuable activities involved having the pre-service teachers consider their own assumptions and learn how to be more attuned to what they chose to notice or disregard. The community mapping activity alone would have suggested value in noticing surroundings. The dialogue which occurred as a result of the community mapping activity further validated the need for the pre-service teachers to challenge some of the undisclosed assumptions they held. It is possible that these future teachers will encounter great diversity as they began their teaching career, and will need to accommodate the beliefs of those vastly different than themselves. The opportunities for personal beliefs to be addressed and re-evaluated in terms of peers and instructors in the course may have enhanced their appreciation for exposing their future students to diverse ideas and opportunities to make personal decisions.

Assignment expectations

The pre-service teachers in the methods course were expected to complete all assignments according to standards expressed by Morgan. The pre-service teachers were not always aware of these standards at the onset of some projects. This seemed to cause great anxiety for many of the pre-service teachers. Considering that grades were not strongly emphasized in the class, the reliance on completing assignments according to Morgan's specifications made for contradictions. Setting expectations and encouraging students to perform their best in an attempt to meet them may be described by some as an admirable goal. However, inconsistency in feedback, which at times appeared to favor one belief set, created problems and frustrations for some of the pre-service teachers. This may have influenced the extent to which they were willing to engage in citizen science and consider it as a desirable pedagogy.

In terms of the lesson box presentation, students created a wide variety of projects. Some projects emphasized biology, others focused on chemistry. Some illustrated science content through a lab activity; others were lesson presentations focused solely on safety without any relation to science specific content. From observations, it appeared that Morgan had an apparent preference for certain projects over others. Those lesson box presentations which were completely focused on ecojustice or citizen science ideals were praised even when they appeared to lack a direct link to content standards or safety issues. On the other hand, presentations which focused on safety, as it related to content standards, were treated with much less excitement. Morgan even suggested that they did not meet expectations. The lesson box assignment was one activity in which there appeared to be a huge degree of favoritism towards those who bought into the idea of an ecojustice philosophy. Toward the end of the lesson box presentations, pre-service teachers who normally excelled on their assignments received little or less than stellar feedback with respect to their projects.

Did the special presentations really represent different approaches to citizen science?

In order for students to understand the theory behind citizen science, they must have experiences which introduce them to ideas. Understanding theory cannot come from being told about a concept, pre-service teachers need opportunities to experience what they are learning about. In this light, Morgan included many different ways for the pre-service teachers to experience the course. However, the lack of in-depth reflection and discussion about the meaning of those experiences may have hindered them from internalizing ecojustice philosophy. From Morgan's perspective, the GEN project, the Bee Hunt, and the Monarch tagging were all included because they illustrated how citizen science could be approached in different ways. However, the pre-service teachers were not privy to the same information which I had been given. I knew in the beginning to look for each of these projects and attempt to identify the approach Morgan had described. Yet, classifying these activities as bottom-up, top-down, or mediated was challenging because I didn't see the same things Morgan may have seen. The lack of conversation about what made each activity align with a particular approach made the process of understanding citizen science more difficult to consider, especially in relation to content areas.

In terms of the Garden Earth Naturalist project, there seemed to be an obvious disconnect between expectations and the final product. For GEN, it seemed that the pre-service teachers didn't always facilitate presentations in ways that were acceptable to Patricia. The apparent dissention led me to wonder how Patricia (and Morgan) instructed the pre-service teachers during their individual project meetings, or even if those meetings occurred. Were the pre-service teachers given instructions on specifically what was expected and how things should be conducted? When asked about the project, few of the pre-service teachers mentioned speaking with Patricia in planning how they should design their presentation. Those that did have an opportunity to work with her, felt she was negative and not very supportive of their plans. Overall, the GEN presentation was beneficial to the pre-service teachers as was evidenced through the comments and activities they portrayed as valuable at the semester end.

Actions speak louder than words

Four walls are common for a classroom and learning indoors with paper and lab materials is a familiar experience. By contrast, learning in nature can be both common and uncommon. Non-traditional experiences open a new way of thinking for students. Exposure to nature, encouraging views of the world which may have been foreign are all part of creating opportunities for students to acknowledge the livestock which provides sustenance, the hawk who serves as a predator, and the mystery which exists in nature waiting for discovery. During this class, although not always explicitly stated, the outdoors served as a co-educator throughout the semester, a backdrop for learning as well as a focal point for many activities. It was a constant source of both conversation and action, which for many pre-service teachers may be repeated in their future teaching. The following discussion and examples of learning in the context of the outdoor learning environment provide an outlook on preparing teachers to not only experience science, but to experience it in ways that may contrast with the traditional laboratory-based science education that many of the participants experienced in high school and beyond.

Learning which is based on a context is not new to; however the outdoors as a context for science teacher preparation is unique. Taking walks to observe nearby surroundings or participating in field experiences during inclement weather are experiences which maintain a focus on the natural world and promote learning of science in ways that ARE more attuned to citizen science. From Morgan's perspective, exploring the world around us is part of discovering ecojustice. The questions that were asked of us forced many to consider on a much deeper level what really matters. Consider a very hot summer day, soaring temperatures with a slight breeze. You have access to a really cool creek, but you are bit leery of jumping into the water. You've never been swimming here and what if you can't find the bottom? However, on this hot day you are not alone. You have friends with you, some of whom have floated in these waters. They dive in – swimming and laughing and telling you how cool the water is. Dipping your toes, you realize it feels pretty good. Taking your time, you decide to wade into the water. You've never been here, but the others seem content. Without the others before you, eager to share their experience, you may not have waded in to the water. No one would have reprimand you, but why not at least try it? You have an opportunity to experience something, though no o one is really even talking about whether you need to join in. In the end, we realize that sometimes actions really do speak louder than words. Dive into the water, or simply walk along the shore. Attempt to pay attention to what those in the water are doing, watch and listen and possibly walk away with a new interpretation for what it means to be a student and a teacher. Participation in an event promotes a new way of viewing the world and could, in some small sense, encourage alternative responses to how teaching might occur in the classroom of an individual who was given opportunity to not only learn but to fully experience learning.

Context for learning

> The farm teaches the students, the farm itself. I mean they learn so much from just being there, you know. It is the same with the Arboretum, when we are at the arboretum, the arboretum teaches the students, and the students, they take a role in their learning by paying attention to different things and not others… But they really get the opportunity to stop and look at a beaver dam and think about it and look at a flood plain or we saw a hawk…and one of the students just paused and just stood there and looked at the hawk. It was self reflective…there is a lot of teaching that is going on right at that moment between the hawk and the student, and the student brings what they know to the hawk, and the hawk then mediates that experience. (Morgan A)

As Morgan's reflection suggests, context for him was a much larger idea than just location; it is about the experience of the location and the realization that it is somehow different. One of the factors distinguishing this methods course from others that have typically occurred at the university was the diverse locations in which class meetings were held. Of the 16 class meetings, at least eight were focused on learning outdoors – being outside for class and/or discussing aspects of nature. During a personal conversation early in the semester, Morgan shared his belief that the environment should play an essential role in providing pre-service teachers the opportunity to experience and consider citizen science as a pedagogy. While he argued that citizen science does not have to take place in nature, he indicated that the environment does serve as an influential teacher that could foster learning in different ways. Environment, in Morgan's case, refers to the outdoors – the natural world which surrounds us and is usually overlooked. The Piedmont Arboretum, one of the primary course meeting places, was a valuable 'tool' for instruction that provided an opportunity for pre-service teachers to 'exist in a location' and be influenced by what they saw, felt, smelled, and heard. Observations and conversation with participants indicated that context provided them with an opportunity to experience teaching in the outdoors and experience firsthand how collaborations could be formed between formal[11] and informal[12] educators. Morgan perceived that exposure to different locations during the course would introduce the pre-service learners, as future teachers, to the many possibilities which exist for using the outdoors in science teaching, including optional settings and different people who could serve as learning facilitators. The traditional classroom, as described by Morgan, was a space representing cultural assumptions that are often stereotypical; by contrast 'nature is something which cannot be separated from the individual'. Morgan further described outdoor spaces as a context for enabling teachers to let go of textbooks and other constraints that exist in the classroom and develop a 'curriculum based on the students lived experiences.' Morgan emphasized the notion of creating a very personalized science education curriculum, one suitable for the unique content and interest of a discipline and location.

[11] Formal - teaching and learning which occurs typically in a classroom
[12] Informal – teaching and learning which occurs in settings outside of the typical classroom (i.e. museum, nature center)

Location was also used as a source for the development of scientific content knowledge and fostering the pre-service teachers' abilities to relate content to local practice and information. One example of the importance of location being used as a context for learning can be seen in the initial visit to the arboretum, during which we discussed rock formations and relationships between rocks in other areas and the rock we stood upon. Awareness of location and examples of how to use natural resources to teach science were integral to the class discussion, prompting students to experience and consider learning in the outdoors. In an effort to reassure the students, Morgan encouraged them to think of any space that is outside as a place to teach science, emphasizing that it did not have to be as extensive as the arboretum. Emphasizing the value of having opportunities to experience and become part of the natural surroundings, Morgan pointed out how these experiences might enable them and their future students to make decisions and know if the environment is being degraded or improved. At the conclusion of the discussion, he encouraged the prospective teachers to listen – as he pointed out the bird flying by, to the sounds of nature, and the feeling of wind and cool air.

Using the outdoors as a classroom

In early group discussions of using the outdoors as a classroom, Morgan explained how many teachers find it difficult to manage students outside, are concerned with liability, or don't feel the curriculum allows time for outdoor instruction. Morgan stated that sometimes it is just a place to teach, that outdoor learning does not have to be learning about the outdoors. The continual use of outdoors as a learning site could be described as a form of modeling with the environment being utilized as both a subject of teaching and a location for instruction. By modeling the use of nature as a classroom, having class meetings outside to talk about typical indoor topics, the prospective teachers had an opportunity to observe teaching while outdoors but not necessarily using the outdoors as a context for learning specific content. Morgan later elaborated through personal conversation, his use of the outdoors as a location rather than a focal point of instruction. He explained that his intent was more about having students become aware of their surroundings through implicit learning rather than explicitly telling them what to attend to (Morgan A). Throughout the course, much attention was given to outdoor endeavors, placing the focus of the course primarily on how to teach outside, through both implicit[13] and explicit[14] instruction.

Most teachers who attempt to incorporate diverse learning experiences would likely agree that planning for teaching outdoors requires additional thought and preparation. In an attempt to prepare pre-service teachers for upcoming classes which were to be held outside, constant input was given on how to dress for the outdoor learning environment. Morgan also pointed out special issues the pre-service teachers needed to consider in light of the different locations for class meetings. For example, as preparation for the fire training activity, Morgan suggested to the class that "[they] wear long pants and closed toed shoes…[since] it may be cool early in the morning so a jacket may be needed" (Observation 6). Reminding college students, at every class meeting, how to dress could seem unusual if they were not actually being given an opportunity to be outside. Holding class outdoors, in various weather, prompted the discussion of what would be needed and what 'supplies' might be appropriate for the context in which

[13] Implicit – learning which occurs via exposure, not conversation and direction
[14] Explicit – learning which occurs via directed action and discussion

learning was to occur. In another example, Morgan cautioned the pre-service teachers to dress for the weather explaining that they would still be participating in activities outside at the arboretum even if it rained. The three descriptive observations included below serve as essential components of the outdoor learning which occurred and are used to illustrate the notion of nature as a co-educator.

Fire training

As mentioned in section one, this course was structured around the National Science Teacher Association Standards for Science Teacher Preparation (2003). These standards indicate a general expectation for what should be incorporated into a teacher preparation program, and the expectations for those graduating from such a program. Especially significant for Morgan's representation of these standards was his focus on safety in the science classroom. Standard Nine includes detailed standards which are specific to safety and welfare. A general description of this standard was included in section one; included below are the more descriptive aspects of safety which teachers are expected to demonstrate:

> Teachers of science organize safe and effective learning environments that promote the success of students and the welfare of all living things. They require and promote knowledge and respect for safety, and oversee the welfare of all living things used in the classroom or found in the field. To show that they are prepared, teachers of science must demonstrate that they:

a. Understand the legal and ethical responsibilities of science teachers for the welfare of their students, the proper treatment of animals, and the maintenance and disposal of materials.

b. Know and practice safe and proper techniques for the preparation, storage, dispensing, supervision, and disposal of all materials used in science instruction.

c. Know and follow emergency procedures, maintain safety equipment, and ensure safety procedures appropriate for the activities and the abilities of students.

d. Treat all living organisms used in the classroom or found in the field in a safe, humane, and ethical manner and respect legal restrictions on their collection, keeping, and use. (NSTA, 2003, p. 28)

These standards are inclusive of experiences a secondary (middle or high school) student would have either indoors or outdoors and rely heavily on the teacher's knowledge of handling materials safely. Knowing how to effectively handle hazardous materials, considering safety precautions with equipment and activities, and maintaining a classroom that follows safety regulations seems to be a comprehensive description of these standards and a part of what Morgan strived to instill in the pre-service teachers enrolled in his course.

Morgan shared his attempt to expose the prospective teachers to as many opportunities to 'do' science outdoors as possible. Through planning his course, he adjusted instructional methods so that his students could be outdoors and learn comparable means of maintaining a safe classroom. Since one of his primary goals was to present alternative learning environments, the inclusion of fire training in an outdoor location served to reinforce his goal. Fire training was not a required activity, but was incorporated as an opportunity to expose the pre-service teachers to a different environment and potential fire hazards they would encounter both within and outside the classroom. At the conclusion of this event, pre-service teachers received a certification in fire safety which they could include in their portfolio as documentation of their knowledge of safety.

The environmental complex served as the fire training facility and provides another example of the use of non-traditional settings in the course. Morgan directed pre-service teachers to drive towards the university farming areas, heading out of town to reach the environmental complex. After travelling through several twists and turns in the road, a pre-service teacher could be seen standing alongside the shoulder, near the turn-off, in a brightly colored poncho directing the parking. Through the heavy rain, a small building with a large, tall garage became apparent, a structure which was surrounded by trees with few signs of civilization. Cars lined up in front of the lower building; one of the many off-campus university facilities utilized during the semester, this building held extinguishers and was used for fire-equipment repair. There was a state of the art classroom with presentation equipment and an outdoor area for putting out fires and learning more about extinguishers. The scenario described below comes from observation notes taken the day of fire training:

> Morgan, appearing very much to be a micro-manager, instructed the pre-service teachers to take notes because of the value of information being presented; many of them were already writing in their notebooks.

The pre-service teachers were very engaged, asking questions about different types of fire extinguishers, the use of pressure cookers in the science lab and sharing their experiences with fire. Sarah had questions about home safety and proper equipment, but many questions were related to the science lab as well as personal safety concerns. The pre-service teachers appeared to have some knowledge and experience dealing with fire safety, as was evident through their questions and in the responses to questions posed by their classmates. Morgan asked the pre-service teachers to pay close attention during future visits to schools, remembering the things that were considered fire hazards- especially the idea that only 10% of the walls in a classroom could be covered with instructional materials such as posters.

The second part of fire-training took place in the rain, with the training instructor attempting to let students who were not putting out the fire stay in the garage to watch, where they would not get wet. Morgan told the instructor that 'we will all be out there' and shared with the students that it would be a good experience to undertake training in the rain and learn how to get over similar issues of weather they may face in their own teaching. Morgan further explained how working together in the rain and experiencing fire extinguishers was a good way to build relationships, a sense of community among students. The rain slacked off a bit as each pre-service teacher, and Morgan, braved the soggy ground to put out a fire, using one of the extinguishers that had been described in the sit-down training. (Classroom Observation 7)

Allowing safety activities which might typically happen indoors to occur outdoors provided an exciting opportunity for some of the students to begin to develop an understanding of their own teaching styles and preferences. Rose appreciated the action involved in the fire training, because they were actually 'out doing it, extinguishing a fire'. The interactive nature of the fire training encouraged students to become involved and experience a hands-on learning experience with safety. It also served as another type of modeling strategy for the pre-service teachers to consider using in their own classroom, when providing instruction about safety. In Rose's excitement, she shared how valuable actually being able to use the safety equipment was in increasing her confidence level and helping her be prepared for teaching. Rose emphasized the significance in providing the pre-service teachers an opportunity to *do* safety, to put out fires, as a more valuable experience than simply reading about the action in a book; the act of taking part in performing safety measures 'makes them [the pre-service teacher] more comfortable doing riskier activities in their own future classroom.'

Learning at the arboretum

Located about three miles from the university campus, the Piedmont arboretum took in 300 acres of forested land. With a meandering river providing nourishment for the town and the creatures living in this area, the arboretum was a sanctuary for those who sought the woods, trails, and landscaped gardens. Manicured gardens, indicative of locations both around the world and indigenous to the state, along with several trails maintained to co-exist with the natural world complemented a large conservatory, housing flora from various geographic regions with economic and aesthetic significance.

While the arboretum and other field locations were of critical importance because they provided a different context for learning, they were not the primary focus of the class. Of greater significance and more heavily emphasized by Morgan was the way in which nature could serve as a co-instructor for the course.

> For me, nature is a teacher so when they are out at the arboretum, they are learning a lot of things that I know they will come to know by just being in the environment. It's this idea of letting them roam around, being in the environment, getting to know plants and animals and the sounds of the wind, what it feels like to experience teaching outside. (Morgan 2)

While at the arboretum the pre-service teachers were encouraged to consider aspects of their location for instructional purposes, regardless of whether it was something they deemed to be relevant to their science specialization. During many of the activities in which the students took part, they were not given explicit directions such as what to observe or how to view their surroundings. However, it was apparent that Morgan framed nature as a teaching tool.

Through simple exposure to different experiences outdoors the pre-service teachers were encouraged to develop their own understanding of what it meant to learn in different environments, such as the arboretum, and how those settings could be used as a teaching frame for their own future classroom. Two different activities which took place at the arboretum, described below, served as an introduction for the students in using the outdoors as a context for science teaching. The hike was an experience designed to foster in the pre-service teachers an awareness of their surroundings. The journaling experience was more structured, providing a final product which was discussed among peers.

The Hike

> During one of our early arboretum class meetings, we met at the lowest point in the garden. In order to reach this beautiful green spot, with an Athenian concrete stage and pillars, the pre-service teachers had to descend a fairly steep hill with many steps. Due to the physical condition of Emma, a pre-service teacher with a physical disability that required the use of a cane, one student went ahead to notify Morgan of Emma's physical limitations and suggest meeting further up the hill to accommodate her needs. In response, Morgan pointed Emma towards a path with no steps and explained she would not have to climb any stairs. Emma, together with Sarah who helped her down the climb, arrived at the stage after Morgan had already begun a discussion on citizen science as a precursor to the hike.
>
> As an introduction to the idea of citizen science, Morgan asked the class as a whole to think of what things have rights. The whole-class discussion of citizen science centered around a student project from a previous semester. The project focused on invasive plant species, illustrated the kinds of plants that might be encountered in the arboretum, and served as a 'student-created' example of citizen science in action. While the project was passed around for viewing, students were encouraged to work in groups to discuss the meaning of citizen science

and ‘rights’ on a more personal level. Each pre-service teacher had an opportunity to view the project as it circulated between the groups, although time for observing the project was limited. After about eight -ten minutes, Morgan instructed the group to select one of two trails which began in the lower garden and ended in the upper parking lot. Morgan told the group that each trail would take approximately 15 minutes to complete, and that they should meet in the parking lot for a discussion of what was seen along the trail in ten minutes. He encouraged each group to work together as they hiked and to identify and discuss non-native species along the trail. The student-project which was passed among the class served as representation of what each prospective teacher should attempt to observe.

The pre-service teachers quickly divided into two groups, each selecting a different direction and path to hike. The smallest group consisted of about five people, myself and four pre-service teachers. As we walked down the hill, into the trees, a clearly defined dirt path became evident. The trail paralleled, within 3-4 feet of the slow, brown river. The smell of water, plants and a decaying animal were prominent as the group attempted to locate flora which seemed to represent the invasive species seen in the project. Having stopped at one plant to discuss the name, the instructor joined our group – having been with the others for a brief period of time. Aware of the time constraints, Morgan suggested the group proceed more quickly. From that point forward, the group spent most of

> their time with heads down, walking rapidly in an effort to reach the parking lot by the allocated time. The only glances at plants came when someone saw something unusual; the rapid pace prohibited much observation from actually happening. As a consequence, time appreciating the scenery as well as the physical condition of group members caused many to miss the final discussion in the parking lot. Morgan held the end of class discussion without all members of the class present, a concern for some of the students. (Classroom Observation 4)

The opportunity of being outdoors was worthwhile but could have potentially had even more value with additional time to actually experience the event. The pre-service teachers in my group began the hike very interested in what they were seeing, asking questions and pointing out plants or structures created by nature. However, Morgan's constant reminders to hurry along appeared to impede learning. The time-constraint seemed to play a large role in what learning occurred during class. While it was evident that the hiking experience seemed to be a primary goal of the instructor, time constraints prevented the pre-service teachers from being fully immersed in the setting. While being a great example of how planning for lessons requires consideration of time factors, the overall goal of being outside and seeing the invasive plants was lost in frustration of 'just finishing the trail'. Seeing this happen was a great experience for some of the pre-service teachers because they gained an understanding of how to factor in time constraints when planning for activities. The second experience described was designed to provide the pre-service teachers with opportunities to appreciate the natural surroundings through a more structured activity.

Journaling in the garden

One of the classroom activities which Morgan had the pre-service teachers participate in involved journaling and developing a creative story based upon their surroundings. The description below comes from observation notes during this event:

> The class met on the large granite outcrop, where the sun was shaded by the trees and it was still fairly cold. Morgan suggested a move to the sunshine, which resulted in students sitting huddled together on the benches or ground. Morgan began a discussion by sharing his experiences with grant writing. He made available several different teacher resources for grant writing which he had found helpful in his own teaching. Subsequently, different methods of teaching science were discussed, including the use of journaling, drawing, and story-telling as approaches particularly suitable to the outdoor setting. The pre-service teachers were directed to write a story about the environment, with Morgan suggesting that they ask each other and the area “what happened here”, from the perspective of an organism living in that location. As the pre-service teachers walked around and observed different regions of the garden, Morgan circulated, asking the different groups “What happened here? What caused this?” Paul had wondered off by himself, not with a group. During the interview after class, Morgan shared that Paul had difficulty finding examples of physics in the garden. Morgan, in talking with Paul, brought up the idea of the brick wall and how different parts of the wall

had fallen down. Morgan explained “Once we started talking about that, he got really excited and started looking at it as a possibility for exploring physics” (ART17). Rose and Bernie were in a group that brainstormed the beginnings of an imaginary story in which the brick wall had been formed from the carcasses of insects who tried to save the world from trees and other plants. In an attempt to capture the imaginative story they shared during our interaction at the brick wall, the following excerpt is a representation of how this group of pre-service teachers shared their story with me.

> ‘The three foot wall grows higher, inch by painfully slow inch. Insects migrate here to end their days, donating their exoskeleton to the cause – to the continued and urgent cause of protecting the kingdom. The Kingdom of Vines afforded sanctuary from the world of giants, those towering trees and wild animals of the surrounding forested lands. Lands that encroach upon the safety of the kingdom- lands and organisms which seem to be winning the war between vines and trees, insects and vertebrates.’

Rose, Bernie and Molly debated the specifics of the story that would be shared with their classmates. In their final story, the power of democracy and a more present biology background defeats the chemist in the group; the story is about succession and the mythical world that only exists in the minds of this group of three pre-service teachers. Looking around on this clear, crisp, fall morning, groups of pre-service teachers were observed investigating the gardens and trees comprising this outdoor learning environment as part of their assignment to write a creative description of how science is evident in nature. (Classroom Observation 10)

A few class meetings later, Rose shared her belief that teachers and students could be outdoors and could use nature in teaching. Rose's prior experience as an informal educator provided her with a great love of nature and living things and a strong background in teaching science outdoors. In conversation about teaching and her past experiences she indicated that prior to this course she didn't realize that interactions with plants, animals, and other people were 'acceptable' ways of teaching in a 'formal setting'. Rose shared that as a result of the experiences in the course, her excitement for choosing a career path as a formal science teacher had increased.

The Piedmont arboretum was the primary location for many of the course experiences and provided a wealth of diversity for pre-service teachers to draw on in forming personal ideas for learning outdoors. It could be argued that, when considering the availability, or lack thereof, of resources such as the arboretum in other communities, a course with the intended goal of sharing the outdoors and attempting to help pre-service teachers develop a philosophy for teaching would not be complete if local resources were not included. Given the potential availability of resources in local communities, both landscaped and natural versions of the environment were used to demonstrate what 'experiences' were potentially available for doing citizen science and other outdoor activities. The farm, which served as the final location described, provided a realistic view of what many rural, and even suburban, schools may have accessible to them.

Learning at the Farm

One of the last class meetings was held at a local farm cooperative, a location which some of the students were familiar with due to work in prior courses. Through a set of emails, participants were given directions and input on how to dress in preparation for the visit. The farm, situated about ten minutes away from the university, served as the cool early November morning meeting site for a tour and hands-on experience. After parking in a somewhat muddy field, everyone in attendance walked down the one-lane dirt road to an open area under a grand old water oak. The early morning crowd appreciated the old farm house, talking about experiences having been there or places similar.

> Rick, the 'caretaker' of the farm joined the group with conversation about the types of crops, animals, and farming practices that we could expect to see. He used words like "pedagogy, action preferred and perennial truths" – in relation to education, science, and the farm. The language he used was not simplified; rather it seemed an attempt at true explanation for why things happened as such. While research does take place at the farm, it is a for-profit venture. When Rick asked which pre-service teachers had never been on a farm before – Bernie and Paul both raised their hands.
>
> We were told what we would begin with the baby pigs as our walk started down the dirt road, pine trees mixed in with hardwoods lining the path. Stopping at the electric fence, everyone was cautioned to be careful

so that it would not shock us. Some with great care, others with little concern, climbed over the single strand of wire. The sow[15] having a relatively young set of babies was lying on her side in a big pile of hay under shelter consisting of one solid back wall and posts holding up the roof. Rick told us how old the 'piglets' were, and Sarah whispered that her husband would say Rick is not a real farmer because he called them piglets. Rick walked us up to the sow and told us about the breed, the number of babies she has typically and about how many hogs are finished at the farm for distribution to restaurants. Eli, Alan, and Lizzie had been to the farm before – and Rick asked if they remembered Elroy (the boar[16]). He told them that the boar died because of some type of trauma – they had him autopsied. Rick explained that apparently this breed of hog are judged and prized based upon testicle size; however, when the testicles become too large it can be problematic. Rick explained that they believe the boar died because he sat on something, ruptured his testicles and got an infection, something that could not be seen from the outside. Elroy was less than two years old. Rick said that he learned a lot from Elroy. As we began walking away, the baby pigs began to nurse and one of the girls asked why they butted against the bag so much. I started to tell her as Morgan began to listen and ask me questions. He then told us he had never been around animals much, since he had lived mostly in the city and did not have much experience with farms.

[15] Sow – A female pig that has had babies.
[16] Boar –A male pig of any age.

We moved from the pig pen down the road, around the mud puddles with Houston sharing a story of he and his grandfather castrating pigs – he related how removing the testicles was really gross. We were told that we would meet at the chicken 'tractors', large rectangular frames enclosed in chicken wire with half covered also in plastic tarps. The 'tracks' had handles on either end for easy movement because the boxes are repositioned at least once a day so that the chickens can feed on grubs in the ground and bugs found in the cow waste. At least 25% of their feed comes from eating from the ground (the same for the pigs that were fenced in at the woods). Rick explained this as being able to express their full 'animal' side. Rick further explained how this type of feeding is close to what it would be in nature, but with obvious dietary supplements. As we stood on a hill overlooking much of the farm, listening to and watching the chickens forage, Morgan asked why the chickens on the trucks were white and the others brown or guineas (grey). Rick talked about the many different breeds of chicken that exist. He also told the group that in December they would be processing chickens should anyone want to come back and learn about the process.

As we left the chickens, moving down a hill towards one set of woods, instructions were given to let the truck pass first. We were to meet at a lower electric fence where the truck would be parked. The whole time we were at the farm, work continued to happen – as is necessary on a working farm. There were plans of moving cows to another field, traveling the same path we were on. Neither the instructor nor many students realized they had to get out of the path for the cows to actually be willing to move through. Rick had to instruct the class several times to move down closer to the truck which had been parked near the electric fence surrounding the wooded area. No one really moved. Paul and Morgan were the ones closest to the path and finally had to be told again that the cows would not come through. Once everyone was out of the path, the fence was let down and the cows literally thundered past. They ran at near full speed – less rapid than a sprinter but much larger. The electric fence was closed as they were sectioned off in another quadrant surrounded by electricity containing their foraging. Morgan asked why the cows actually came and moved when you wanted them to. Rick explained how the cows were used to moving constantly and that it meant they would get food – grass, not the bucket Morgan thought had to be offered every time you wanted them to move.

Morgan was standing to the side with a few students and said, “Isn’t this amazing? This is in Athens.” He was talking to Eli and Lee when the rest of the group noticed the pigs. The students lined up along the fence to watch the pigs, several leaning over to pet them. These were several months older and very friendly, mostly white and weighing in between 40-60 pounds. Rick explained that these pigs feed mostly on the roots and items found in the ground under the trees, in the fenced area where they are contained. Morgan stood to the side as students asked various questions about the diet of the pigs and the length of time they were kept before processing (processing was the word used for slaughter and freezing). After everyone had a chance to see the pigs, we moved down to the crop area – greenhouse and open plots of vegetables. Morgan walked with Sarah, talking about the camping trip and what supplies he would need since he planned to bring along his oldest son, Jonathan.

After walking down a small hill towards the tree line to reach the garden plots, Rick had everyone look at what was growing while he talked to one of the workers about moving compost and soil. The students took pictures of peppers and eggplants, inside the greenhouse. Rick came to the group after about five minutes and asked the pre-service teachers about their ideas of why the garden was located where it was. Some prospective teachers suggested that because of water it needed to be at the bottom; others hypothesized that it was because of the nutrients that are found along the creek. He agreed with them about the nutrients but talked about the drought and effect of the flooding on erosion at the farm. We moved to a section of garden that had ‘cover crops’ growing – legumes of various types. Rick asked about the beans and the purpose for having them growing in this area as opposed to leaving the space open, or unplanted. Some said erosion, then suggested they add nutrients to the soil (I told Sarah about the nodules that have nitrogen fixing bacteria in the roots of these plants). She repeated that explanation out loud and Rick began to ask more questions about what that meant in terms of soil health. He went into a detailed conversation about nitrogen fixing bacteria, the roots/nodules of plants and scientific names for the bean family. The discussion was very rich in details and content on why and how things work the way they do. Morgan was not giving a lot of input during any of this discussion; he quietly stood to the side and listened.

Rather than dividing into groups as was originally planned, Rick had the entire class move up near the truck to break apart the garlic. Through questioning the class about garlic, Rick explained about the direction that garlic grows and background about the purpose of Allium – even asking for other examples in the same family. Lee was curious about whether or not garlic ended up being a clone of itself. Rick talked a bit about his not knowing the answer, but noting that it was a good question. He explained, 'Garlic is a great pest control plant and way of adding nutrients to the soil – it is very cleansing'. Everyone had gathered around the farm truck with boxes of garlic bulbs to divide into cloves, laughing and talking with each other about recipes and how they used garlic. After breaking up two boxes worth, we realized that we were supposed to break it and separate according to size. Since we had no idea what constituted 'small'- we just put the garlic all in one bucket and ended up with five buckets at the end. Rick's instructions on how to plant the garlic consisted of asking students about how deep it should be planted and in what direction. After directions, we were sent down the row in different sections to begin planting. Planting tasks were divided among groups.

> Some worked in groups of 3-4 to make holes in the ground, plant and cover the garlic in an assembly line pattern. Others worked alone in their own world of dirt, cold air, and garlic. The five buckets were divided up and self-assigned managers kept track of who needed more garlic and where we were in planting the two thirty-feet rows. Emma sat on a bucket that someone brought over, taking pictures and giving encouragement. Looking down the row was very entertaining, butts were sticking up in the air and heads close to the ground – fingers poking holes in the wet, clumpy clay. Some of the students were very organized in their planting methods – Buford poked holes and stuffed in the garlic and only covered them after he finished an entire section of about three feet. He was very organized, with Rose working across from him using the same process. It was a really great bonding experience, everyone got dirty planting, laughing and taking pictures. I looked up towards the end of planting to see Bernie over to the side, wiping his hands in the grass. I asked what he was doing, and he said "cleaning my hands". I laughed and said, that is what you use your jeans for. He got all serious and said "not these jeans". We laughed at him because he also had on a white sweatshirt with no dirt on it after planting in the red clay. (Classroom Observation 15)

Pre-service teachers held different understandings of the value in visiting Luna farm, and in what they were expected to learn from the experience. When asked what he thought the instructor wanted him to learn, Paul indicated "probably something about using resources in the community" (Paul J). Paul was not experienced with farm animals, and had a very limited view of what use something such as the farm could provide for his physics classroom. Sarah thought it was a good experience for those unfamiliar with farming, relating it to the current organic movement and suggesting that it could foster a better understanding of food production. Aside from the content she observed at the farm, Sarah was excited that Bernie got to see the baby pigs, 'he was like a kid at Christmas' (Sarah G). While she admitted to the value which could exist in the farm visit, it was something with which she was already familiar, and shared that the idea of expecting the pre-service teachers to think 'outside of the box didn't really fit for her because she grew up outside the box, so it was nothing new.' Bernie, who had an obviously limited experience in nature – most especially with farming, talked about the farm visit and attempted to find meaning in why it was included as part of the class.

> I haven't spent that much time on farms in my life, so it was neat in that regard. I mean there has to be a connection between the fact that Morgan took us over there and what he wants from us as teachers. Does he want us to take our kids to a farm too? Maybe. There is a lot you can learn in the context of a farm, like everything there, you have science happening in many levels. I mean I'm not sure what planting garlic had to do very much, but it was fun and I enjoyed it, but I'm not sure how that will….it's kind of like, I'm not sure how that relates to being a science educator honestly. I mean it is kind of like a field trip kind of thing. Maybe once a school year, take the kids to a farm. I remember in middle school we went to six flags and we had these like physics questions that we were suppose to answer while we were at six flags. So maybe it is the same kind of thing

> that you can have. You take students to the farm and you like have them answer questions that were relating to your field. How do you think the sun? How do the crops look in relation…I don't know what kind of questions you could have. I mean….I like the idea of getting kids outside and seeing the relevance…and the farms are great place to do that. I'm not sure what planting garlic had to do with anything. But I enjoyed it. (Bernie I)

The farm was beautiful and there was a lot of information shared with the students during their visit. In terms of science content and creating relevance, this outdoor experience provided that more than any of the others. Yet, based on earlier class meetings and conversation with Morgan, science content was never a focal point of the course. In one discussion with the class, he indicated that science content was one of the National Science Teacher Association Standards for Science Teacher Preparation that each prospective teacher should have already mastered prior to enrolling in the course. Any content mentioned in the course interactions were extra, but content knowledge was something frequently discussed by the pre-service teachers as will be seen in section five of this chapter. The experiences of the class and conversation make it evident that the course was about having pre-service teachers participate in something local and learn more about what resources are available for teaching.

Challenges to the outdoor classroom

Although many of the pre-service teachers felt that having class outside during inclement weather was a bad idea, Rose shared her passion for outdoor learning and supported Morgan's decision to have class outside regardless of weather. One of the benefits Rose found in the course and an aspect of her support of the course framework came from the fact that the class required pre-service teachers to be active and consider different perspectives for teaching. Morgan acknowledged the concerns about inclement weather and discomfort that may have been felt by some students. After our class meeting in the rain, Morgan shared his nervousness about the rain continuing to fall heavier and his hope that the students would simply acknowledge the location and possible problems with teaching outdoors. 'Part of being outside means that there may be moments of discomfort, and that is something teachers must recognize (Morgan).' Morgan indicated that the cold temperatures, the discomfort of sitting on the hard ground, the rain falling constantly, and the extremely warm temperatures served as lessons which needed to be learned when planning for the use of outdoors as a setting for instruction.

In reference to the use of the outdoors as a classroom, Bernie indicated a need for an established management style and emphasized that outdoor learning must have "an appropriate context" (Bernie D). Bernie argued for a historical approach to learning by sharing that we moved indoors for a reason, believing that there were advantages and disadvantages to both locations. He discussed implicit benefits to being outside, breathing air, not being oppressed by lights, and the idea that holding class outdoors sends a message that science doesn't have to be an indoor activity. However, when considering nature as a classroom he declared that "I don't see its function if it is not directed to some end" (Bernie I). Continuing with the idea of having a purpose when outside, Sarah discussed the possible connections which are lost when students don't have a reason for doing a particular activity. While she felt that at times new ideas emerge when students are given open reign, she emphasized that, "if you are not given something to focus on then you will miss the connection" (Sarah G). According to Sarah, there needs to be a pre-determined, discussed reason for taking part in something and if additional learning opportunities present themselves that is an added benefit. Yet, she was emphatic that a purpose must exist or the context is irrelevant.

In conversation with the pre-service teachers, it was evident that holding class outdoors was a vastly different experience than that which they were accustomed. While modeling the use of learning outdoors in diverse weather conditions was valuable, many agreed that it only provided a sampling of what might occur in the secondary classroom. Arguments put forth by some of the pre-service teachers indicated a need for instruction that was more varied, including a wider array of indoor activities which were representative of a secondary science classroom. Rose emphasized the expectation she had for the course being a methods course, and that she had anticipated gaining more experience with different types of methods for teaching that did not involve outdoor learning. While she felt that outdoor learning was valuable, she expressed concern that she and the other pre-service teachers also needed experience in working with diverse strategies for instruction both indoors and out.

Considering students with physical disabilities

Context, in the case of outdoor settings, may have unique considerations that need to be taken into account. One concern with outdoor learning has already been mentioned in terms of weather conditions, but another issue is the potential for students with physical limitations to take part in all of the learning activities. By holding class at an outside location, where mobility can be an issue, some students may not have the same learning opportunities as others. Emma, a student with physical limitations due to a permanent illness, had to rely on a cane for walking. Health limitations seriously hindered her ability to walk long distances, climb stairs, or participate in very physical class activities. Provided is a short discussion of how Emma responded to the course, what concessions were made for her learning and what the other pre-service teachers discovered in the process.

During the introductory Garden Earth Naturalist presentation discussed previously, the pre-service teachers were required to complete a scavenger hunt. For the scavenger hunt, groups were directed to walk along a trail and locate place cards with questions for them to discuss and answer. Emma was in a group that considered her needs and decided to follow a trail that required them to walk downhill only. At the end of this scavenger hunt, the teaching assistant brought her car to pick Emma up so she could then drive her to participate in the remaining activities. I walked with Emma to the road where she would be picked up. To some degree I didn't want her to be alone should something happen, but partially I just wanted to talk about how the class was going for her. Emma has an illness that prevents her from walking long distances, climbing things, or over-taxing her body; she tires easily and is relatively weak compared to others. I asked about how she was responding to the class; below is a brief synopsis of our conversation.

> She gets frustrated because she can't do what everyone else is doing and thinks that sometimes Morgan doesn't understand her limitations –he may think she just doesn't want to actually do the work. It bothers her that he could possibly feel this way, and she doesn't want it to influence how she is graded in the course. When she signed up for the course, she didn't realize it was outside most of the time and different from the traditional

> format. The organization of class is interesting and she feels like she is learning things, but she isn't sure that Morgan truly understands her issues. (Observation 8)

While Morgan stated, in an after class discussion, that he appreciated how we took care of Emma, it was not apparent that he made any consistent considerations for her disability. In discussion about an upcoming optional trip for the pre-service teachers, Morgan indicated the presence of different trails for Emma to use which would not be as difficult as those being taken by the remainder of the class. Yet, taking different trails meant she would not be having the same experiences as her peers and therefore discussion would also be limited.

The outside nature of the class promoted a certain type of learning, but did not provoke extensive discussion about how all students could best be accommodated in such a setting. Rose mentioned that one of the things she had learned over the semester was the idea of modifying activities for students with special needs. She indicated that rather than avoiding doing outside activities as a whole, she would work to create opportunities for all of her students to participate fully in learning. When asked about what accommodations she saw, Rose had difficulty naming specific accommodations, commenting: "He didn't do any of that, he just said how to – little tips on how to get everyone to be quiet. I don't know if he was required to do that because we didn't see things like that" (Rose M). Rose was a group member with Emma the day we had a scavenger hunt, and was therefore completely aware of her limitations for physical activity. Rose explained that she did recognize the need to adjust instruction for students with disabilities- something which she admitted became evident without explicit discussion.

Citizen science becomes an outdoor only concept

Since the course experiences occurred more often in outside locations, pre-service teachers began to develop specific ideas of what it meant to do citizen science. Many students assumed that outdoor components must exist for an action to be considered as citizen science. Morgan addressed this concern about citizen science being an outdoor only endeavor, through sharing what he had learned from earlier classes.

> I used to assume that citizen science had to happen in the environment… I no longer think that, I think my chemistry students taught me. They were having tensions with citizen science- the way they were taught is to put things together in a lab. They are not really taught to do, you know application. That's not how chemistry is even taught in high school really. So they were having tensions with the outdoor thing they could only find chemistry in taking the ph of water or you know soils, whatever. Whereas, being able to work in a kitchen, to look at what assumptions do we have about the kitchen. (Morgan 4)

Based on descriptions provided through conversation with Morgan, citizen science can happen in any place with location being secondary to the act of becoming involved in the basic tenets of the pedagogy and overarching ecojustice philosophy. In considering value in learning while outdoors, Bernie shared that "Morgan's whole emphasis is getting kids outside… experiencing nature…first hand" (Bernie I). While

Bernie may not have always agreed with the use of outdoors as a learning location, he considered citizen science an impressive perspective on science teaching and learning.

Summary

The idea of context as a key component to Morgan's mission of using citizen science as a framework for helping prospective teachers develop an individual teaching philosophy was discussed in this section. Activities which could have been completed in a traditional classroom were modified to accommodate his secondary goal of using nature as an instructor. In spite of difficulties such as purpose of instruction, physical limitations of pre-service teachers, time appropriated for discussion and reflection, and the risk of citizen science being viewed only as an outdoor endeavor existed, a clear student interest was obvious. On some level, learning did occur – as was evident in the responses of the instructor and pre-service teachers.

While ecojustice is comprised of many valuable ideas, this section primarily addressed context of learning, particularly in terms of location. Further discussion of ecojustice philosophy and the possible purpose for many of the activities chosen by Morgan are included in sections one and two, as they relate to experiences in the class. Discussion of ecojustice philosophy and Morgan's attempt at creating experiences for the pre-service teachers to gain exposure to the pedagogy of citizen science and adjust their current philosophy is presented in greater detail in chapter five. Location was obviously a large influence on how Morgan perceived the students learning about and experiencing citizen science. Through visits to a university facility to learn how to put out fires, the arboretum to complete assignments while exploring the outdoors, and working on a local farm, the pre-service teachers gained exposure to the value and emphasis which was integral to Morgan's definition of citizen science. Through these experiences, he attempted to foster an understanding for ecojustice philosophy by challenging the pre-service teachers to think of science learning as something which could happen outside of a traditional laboratory or science classroom. Challenges occurred in attempting to have learning take place in alternative locations, and these were discussed in terms of physical limitations of students and the understanding of the pre-service teachers that citizen science should be defined primarily as an outdoor pedagogy. As was mentioned at the beginning of this section, context is larger than just a location. Context can also mean the frame in which a discussion is structured. In this case, context can go beyond location to include the use of citizen science as a course framework. The next section of this chapter will discuss how students came to make meaning of learning and teaching within a citizen science context.

Through the eyes of the researcher: A commentary

Experiencing citizen science

Citizen science was considered as a context for science teacher preparation with outdoor spaces being used to draw in the pre-service teachers and have them recognize value in both ecojustice philosophy and location. If the purpose of the course was to focus on citizen science and learning outdoors, which seemed to be apparent in the examples discussed, the farm visit was a perfect culminating activity. Spending three hours outside, learning about animals and natural farming methods, taking the time to plant garlic and discuss the ideas of organically grown vegetables and meats made the ideas of citizen science local. If we consider that citizen science is about learning in the community and about the issues which exist, participating in actions to protect or serve what you have learned about, and then taking the information with you to forever change your life experience, then the farm did that. The naysayer would consider the need to make learning relevant for all science disciplines, and the lack of discussion on topics other than the life sciences may make it very challenging to convince everyone that citizen science matters to their content. However, it is possible to gain perspective when referring back to a comment by Morgan – ‘if you only reach a few teachers, then they reach a few more, and in the end it’s bigger than you and I.’ Given this consideration, the course was not planned to connect with every teacher. Rather, it was designed to provide a background for those who would buy into the philosophy of citizen science and an introduction to alternative pedagogies for those unwilling to change. The outdoor events were designed to paint a picture of what science teaching and learning could be, if they were to embrace ecojustice philosophy. “Buying into” the philosophy of ecojustice is how Morgan discussed the acceptance or negation of citizen science.

It is important to remember that the pre-service teachers came to the class with science content, and with experiences in education and teaching. If the argument of Morgan prevails, his job was not to teach them “methods” of teaching. His job was to help challenge the pre-service teachers to develop a philosophy of teaching which could be taken with them and adjusted according to what they learn in the future. As a teacher and researcher, I initially made the assumption that a methods course should address the needs of all students; this assumption was based on my prior experience and feedback from students over the years. However, after considering the structure of the course and the main intent of the instructor it became more obvious why certain actions were selected over others. Pre-service secondary science teachers come to the class with safety experiences in the science laboratory. They have worn goggles and aprons and have participated in indoor, prescribed laboratory experiments. Yet, outdoor learning was a focus of <u>this</u> course – an ideal goal of <u>this</u> instructor. Taking them outside may not have been necessary for fire training, but it provided an experience which was atypical while consistently following the goal of outdoors as a context for learning science. It became evident that safety instruction can happen in any location and can be embedded in any content. Outdoor training for fire safety was not even about citizen science in this case, it was about having students consider alternatives to current instructional experiences. Being outside was the focus of the course –at every opportunity students heard about citizen science, but they were cognizant of their surroundings often times more than what was being said.

Why did it feel like something was missing?

In considering the responses of the pre-service teachers, it seemed like something was still missing. Without explicit discussion, much of what the instructor stated as his intended learning goal was left open for personal interpretation. The connection to whatever goal Morgan intended was not necessarily made for the majority of the primary participants, leading one to ask what was missing. Was it an aspect of reflection? Or was it simply a lack of discussion? If one considers the background of the pre-service teachers and the lack of connection made by the 'farm' girl, it was apparent that some additional level of instruction needed to take place for the Morgan's goals to be achieved.

The role of direct instruction, explicit rather than implicit, in helping students learn was debated in many personal conversations with Morgan. He indicated through our conversations that he didn't discuss certain aspects of class because he wanted the pre-service teacher to make their own meanings. At times, discussion might have benefitted the prospective teachers, encouraging analysis and deeper understanding of how the actions they viewed could unfold in their own classrooms. It could be argued that dialogue, in addition to either implicit or explicit instruction, would have enabled the students to further reflect upon their experience. Morgan had many opportunities to discuss the interactions and reflect upon his own classroom praxis. Similar considerations might have been beneficial for the pre-service teachers. It was apparent that the pre-service teachers wanted so badly to find meaning in the outdoor context, but required an additional level of guidance so that could happen. The time spent on discussing the value found in outdoor learning was not sufficient. This is not to say that conversations did not occur individually, but generalized class discussions did not always take place in ways that helped the pre-service teachers make sense of what was intended through the use of a citizen science pedagogy. On a philosophical route, it could be argued that they made sense of what they were given, of what they could internalize, that it was enough and that was all they should take away. From a more practical perspective, the level of attention and possibilities for inclusion might have been enhanced with a little more talk.

Through observation and conversation with Morgan, it appeared that he assumed that students were aware of different contexts for instruction and how location could serve as an educator. While Morgan hoped that the pre-service teachers would develop an awareness and understanding of nature as a teacher, the prospective teachers made no indication that location was seen as anything more than location. Without explicit conversation, the pre-service teachers in this study did not always realize how Morgan viewed the location as an instructor.

Behavior management and many other issues are dependent upon the location and must be discussed with pre-service teachers so they feel comfortable and are more likely to utilize the outdoor classrooms. Additional adult supervision may be necessary for outdoor learning in the high school classroom to occur, a need which must be considered by the pre-service teacher. Management of middle and high school students was not discussed in depth and was something which seemed highly relevant in these alternative settings, lying outside the four walls of the 'traditional' classroom. While the prospective teachers gained exposure to the outdoors as a context for teaching, it did not necessarily mean they were fully prepared for using the outdoors as a meeting location, study site, or focal point of instruction.

Pre-service teacher perspectives

My attempt to understand the experiences of individuals by questioning what they remember and consider relevant could shed light on their potential actions as future teachers. What does this mean? When trying to figure out how someone is going to teach, maybe looking at their past experiences as a student matters. In an attempt to make sense of how the pre-service teachers were internalizing citizen science and building on their previous experiences as students, this section focuses on the student perspective. While all of chapter four has included the pre-service teacher, there has yet to be a focus on what the actions of the class meant to them. They haven't really had a chance to say what works about citizen science, what they have real concerns about, how they foresee its relationship to their classroom teaching, or how interactions with their peers might have influenced them on a personal level. More than any other, this section allows the pre-service teachers ideas about teaching and learning science to be heard.

How do pre-service teachers describe the secondary science classroom?

As a way of understanding the prior learning experiences of pre-service teachers, each participant was asked to share their vision of what teaching might look like in their content area and what they anticipated for their own classrooms. The descriptions they gave provide a more accurate understanding of their experiences in science classrooms, both during high school and college, and illuminate possible beliefs which they hold about science teaching.

Sarah described her experiences in chemistry courses through high school and college as consistently lecture-based, suggesting that this was likely due to the safety concerns of using chemicals in the laboratory. She continued by explaining that she tended to dislike lecture classes because there was “not a whole lot of interaction”, generalizing that students sometimes had trouble understanding the concepts since there was no opportunity for application (Sarah B). Consequently she described her role as a chemistry teacher as one of making the subject more accessible to the community and helping future students understand its applications while becoming more scientifically literate. Sarah elaborated by arguing for a style of teaching that expands upon chemistry by relating it to community issues and prior beliefs as a way of helping students see the science in their lives. One of the most significant things Sarah believed she had learned was that beginning science teachers want to ‘make a difference, have their students love the subject and see the wonder and fascination they [beginning science teachers] see themselves’ (Sarah G). Bernie expressed a desire for an active learning environment, based on standards and considerate of both the role of the teacher and the student. His description resembled a more democratic classroom – “there are standards that have to be met … but then kind of like on a lighter more flexible area toward the end of the unit or something in the middle, students could have a say in what route we should go (Bernie I).” Bernie’s conception of a good science teacher was one who communicated with his or her students, attempted to make science relevant to their lives, and was supportive and encouraging. Like Bernie, Paul also wanted to have ‘students be more active if that is something they were interested in doing’ (Paul O). Similar to the other pre-service teachers, Rose suggested that a class should have some kind of meaning, a structure that could work for an entire semester (or year) and would encourage students to get more involved in learning science. According to Rose, a successful classroom would include a teacher who cares about helping students learn things that are relevant to the world that is around them. Rose emphasized the need to let students question things and for the teacher to respond to questions in ways that made sense and simultaneously would encourage students to ask more questions. She particularly noted that a desire to learn was essential to student success. An additional argument for hearing the voice of the students and placing value on what they can teach was emphasized by Sarah. In considering the use of citizen science in her own classroom, Sarah mentioned the need for teachers to provide students with background science knowledge prior to exposing them to opportunities in which they are required to apply the knowledge. Many different descriptions of ‘teachers’ arose throughout the semester, from the perspective of both instructor and pre-service teachers’ and are embedded in the remainder of this chapter.

How were pre-service teachers encouraged to engage with citizen science?

Different levels of pre-service teacher engagement with citizen science were evident throughout the methods course. One example of pre-service teachers attempting to make sense of citizen science involved questioning by Alan during the introductory Garden Earth Naturalist meeting. Alan wanted to know 'how federal organizations view the data [collected through citizen science efforts] and if it would be accepted even though students were collecting the data.' He was curious about whether or not scientists would value the data collected by citizens and if in turn that would make citizen science a viable teaching tool for his future classroom. While never completely answering his question, Morgan called citizen science "innovative, cutting-edge, [involving] local experts", further outlining the need for citizen science in the classroom as a learning guide. Morgan argued that "youth are excluded from decision-making. YOU can help increase their access. This is to help them participate more fully. Do you see how powerful that is as a science teacher" (Observation 8)? Alan appeared to be very interested in the use of citizen science, but also indicated a level of concern as to the value it would have for 'real' science. Many of the pre-service teachers remained quiet during this time of questioning about the role of citizen science in influencing local decisions and the subsequent need for teachers to participate in larger projects with researchers. The need for student participation, in both the community and scientific learning, was highlighted during this discussion with particular emphasis on the importance of teachers helping students become more aware and active in how their world functions. While Alan never explicitly said he would use citizen science in his teaching, he did have many questions related to how it 'could really function' in the schools.

While this section focuses primarily on how the pre-service teachers made sense of using citizen science it is important to share a conversation that occurred with Morgan.

In our after class discussion immediately following Alan's questioning about the use of citizen science in the classroom, Morgan questioned personally whether collecting data and sending it off to scientists "takes away some of the responsibility, the awareness, or the understanding we are trying to develop with our students" (Morgan 4). Morgan went further to argue that by involving students in learning in the community they become more knowledgeable and able to participate in local decisions as stakeholders, explaining how this would enable students to "develop expertise in place (Morgan 4)." Since Morgan described the inclusion of citizen science tenets as having the potential for cultivating advocates for the community, it appeared that his approach was more community-driven, with the teacher playing the role of mediator in student learning.

In furthering the discussion of how students could engage in citizen science, Paul introduced his perspective, emphasizing the potential it could have for a community:

> A lot of things that we consider environmental causes that [they] could maybe get a better understanding of that. Some ability to discuss meaningfully, rationally, and similarly, just how much we can actually do about any of it. You know…how much we should do because we can't satisfy everyone on that, and sometimes you think two sides and the dialogue is generally down-rated by the extremes on either side just because they are interesting and get viewers. Hopefully some understanding of what can be done, should be done, whether it should be done [could be discussed]. (Paul E)

Though a wordy explanation, Paul appeared to exhibit a belief that problems exist in the public understanding of science and that citizen science could help the community gain knowledge in this regard. While it appeared that Paul was not altogether accepting of citizen science as a way of teaching in the physical sciences, he did acknowledge that the general public becoming more knowledgeable about their community and acting to incite dialogue could be potential benefits of using this approach. Paul mentioned a need for the public to learn about what was going on in their community and develop the ability to know how to deal with things on a larger scale. He noted specifically the need for the public to maintain a conversation that would enable them to decipher the actual needs of the community. Though this example does not specify a type of action, Paul did discuss the possibility of advocating for something after learning about the issue and deciding what course of action would be possible. While it may be a stretch to believe that Paul would consider citizen science as valuable, the idea that there are degrees of knowledge and action was evident in his comments.

Whether intended as a derogatory statement, encouragement, or simply another way of sparking controversy, Morgan often mentioned that he considered good teachers to be ones who use citizen science as a pedagogical approach. Several times throughout the semester, the pre-service teachers were told about fantastic teachers being those who use citizen science. As a way of promoting discussion or forcing the pre-service teachers to address perceptions about the practicality of citizen science, they heard the same statement and may have internally questioned their level of agreement. In response to this statement made by Morgan about teacher value based on the use of citizen science, Bernie shared what he thought this statement meant. ‘It is not that he expects us to be outside all the time, but he wants to see it [citizen science] taking place because it is more conducive to better learning’ (Bernie I). Bernie felt that Morgan simply wanted them all to be good teachers and exhibited motivation to have the pre-service teacher develop a philosophy similar to his own. The continued discussion of these ideas prompted the prospective teachers to think more deeply, with Bernie sharing the difficulties he anticipated in developing a foundation in ecojustice. Bernie felt that his lack of a 'concrete' situation/classroom of his own, or context that might promote an actual understanding of what he would do, prevented his full acceptance of the philosophy.

Pre-service teacher's understanding of citizen science

Sarah comes from a rural community, where rain is essential to survival. According to her description, science can be, and usually is, present in most activities without a direct connection being recognized by most people. She portrayed citizen science as providing opportunities to involve the community in acknowledging what they already do as science; indicating a seemingly bottom-up approach. However, Sarah's ideas of how citizen science could be incorporated in the classroom reflected a very top-down approach characterized by students assisting researchers in collecting data. Sarah argued that making people comfortable with the experience of science and having them acknowledge the presence of science in most aspects of life as something more valuable than creating a baseline of data. It would seem that she was asking for the same level of participation that was described by Morgan in his private discussion of citizen science tenets in section one. Sarah noted that advocacy in the community in which she lived was second nature because knowledge of and interaction with nature is how rural communities survive.

> It's not something you have to be in the labs to do, it is something that they have to get comfortable with and showing them things that they are

> already comfortable with. Like in South Georgia, you know, one of the first things you do every morning or every afternoon after you come home, usually in the morning because somebody is going to ask you that day. You go out and you check the rain gauge. Because somebody is going to ask you. Did you get any of that rain last night? You have to be able to tell them how many tenths that you got at your house last night. That the amount of rain and the measurement and looking and being able to tell how much, that's science and people just don't realize stuff like that. Looking at the outside thermometer, that's science. Looking at the wind vane on top of your house, that is science you know…know what side of the fire to stand on so the smoke doesn't blow on you, that's science and that is the thing that people…you know…people want to put science as being abstract, so part of citizen science is just kind of getting them comfortable and then letting them help. Researchers, that either have a lot to do and you know…they want to do this…but you know….they have a lot of grants or big projects for where ever they work and they want to do something on the side, I think that is just a way to help people become more comfortable with science. (Sarah B)

Sarah's brief glimpse into the lifestyle in a rural community clearly outlined the role of science that was often left unmentioned, but actively engaged in on a daily basis. Her description of citizen science served as an excellent synopsis of what it meant for science to be embedded in the life worlds of students and other community members. According to Sarah, the first step in utilizing citizen science as a tool for instruction was developing an understanding of the students' backgrounds and what they valued as important.

Bernie's understanding of citizen science also appeared to focus on a top-down, scientist driven approach. He admitted difficulty in relating citizen science to what he feels he already knows about teaching, yet he indicated an awareness of issues which could be beneficial for both the community and students to become involved with. Water purification and sanitation issues were ideas he suggested, sharing that he knew of these projects only because of an article he had just read for another class. Individualized projects relating to the local environment are not driven by the needs of the community but, in Bernie's view of citizen science, are more about "getting involved in such a way that it is actually helpful for real research that is going on by scientists" (Bernie D). While it appeared that Bernie wanted to believe in the importance of making a positive impact on the community, he struggled with the idea that he as a teacher or his students as part of a community could have enough knowledge or influence to embark on something not clearly defined by a scientist. Paul, who had a physics background, described value in having students see that science can be applied to life outside of class through "projects that someone else has put together" (Paul E). While Paul described a top-down approach to learning through the use of citizen science, he did feel there was value in the students being able to apply their knowledge of science in the field. The need for making science relevant seemed to be a consistent theme felt by all pre-service participants, despite their background or perceived acceptance of citizen science as a potential pedagogy for their classroom. Group dialogue around ways citizen science could be used in the classroom emphasized the top-down, scientist driven approach as a more familiar and preferred strategy for use of the pedagogy in their work as future teachers.

What examples did pre-service teachers provide for using citizen science in the secondary classroom?

Participants were asked in individual interviews how they saw citizen science unfolding in their future classrooms, with additional examples being evidenced through one-on-one class conversations. Regardless of what activities the pre-service teachers thought of in terms of bringing citizen science into their future classroom; a common theme was involving the students in community relevant science. Bernie valued "getting students aware that the concept that they are learning in the class has real value in their individual lives and the lives of the community" (Bernie D).

Possibly as a result of Rose's background growing up in a small, rural community, one of the teaching associations she made with citizen science was the idea of encouraging potential involvement in community health and gardening. Rose shared a concern for helping families understand how their decisions about consumerism (the quality and quantity of something) might influence their livelihood and community; she wanted to involve parents and children in gardening projects. Rose implied that knowledge of where food comes from, and the direct relationship with its supply, might help students make better decisions which could affect the community at large. Another project that she mentioned illustrated her passion for ornithology, she suggested that she would have her future students identify birds and present the information to scientists who are collecting data about their habitats and migration. Using birding as an example, Rose explained how these projects had the potential to help students understand different interactions that occur in the ecosystem and why we need to do better at preserving certain species. Rose emphasized involving students and participation in the community through “getting out there and doing community service, like helping elderly people, or them going out….just like a trail walk, to learn more about those things” (Rose C).

Sarah, another rural native, considered citizen science as interdisciplinary and useful for students in rural communities who encounter science in their daily lives, often unconsciously. Unique life experiences, which were emphasized in chapter three, may have prompted her awareness for students needing to fit somewhere, to have a purpose larger than self. This connection to something beyond the regular curriculum indicated a possible understanding of the need for making science relevant. Below are examples Sarah shared of how she envisioned using citizen science in her own teaching:

> They could also do rain barrels and like compare the quality of the water, like a rainwater runoff, compare to quality, compared to tap water. Measuring…we could have somebody come show us like when you send your soil off, we could have the extension service come show us how they test that soil, and then we could help the map/soil composition where ever they lived. All they would have to do is bring in a bag from their area and that would help them…the conservationist or soil researchers map out the different fertility or richness or un-richness of the soil in those areas of the county… So I really like to soil idea, I just came up with it, it is not something that I thought about before. I think that we could do rubber, like if we have…I mean most of the rural schools are like going to have an automotive kind of lab and so we could do something with the oil or some

> of the stuff from them. Like used oil…comparing the contents of used burnt motor oil to fresh new motor oil. Elbert County has a granite lab, so that would be. …like we could use it and apply to why the different granites are colored different colors. Why gems are colored different colors and how to tell by looking at something what possible chemical elements could be in it simply by looking at the color. just the application….because so much of [Chemistry] is just pencil and paper and math, but you could use this to show them that we are going to do this even though you may not tell them that we are going to do math. You tell them that we are going to see how we get this…this piece of dirt…see what makes this piece of dirt up, even if it is not that specific piece of dirt you can use the reaction that makes the composition because I have one at the house that is for clay that's really like a chemistry/art crossover but it goes into the different chemicals, the different things used in glazes for pottery, and so that is what comes to mind, just the application. (Sarah B)

Sarah's understanding of citizen science included a greater focus on acquiring scientific knowledge and less on social/environmental action. Throughout her interview she emphasized the need to teach science in ways that would make it more applicable to students' daily environment, and she presented citizen science as a way to help facilitate this type of learning. Likely, over time and with practice of her citizen science ideas, the "relevant" science could become inclusive of advocacy, which was one of the desirable tenets of citizen science, according to Morgan. It was evident that Sarah considered citizen science an idea that could be used for framing lessons, but the degree to which she consciously accepted the underlying assumptions of ecojustice and specific tenets of citizen science was unclear.

Bernie suggested using one large citizen science project as the basis of instruction across different science disciplines. He recommended 'starting off in middle school and having students participate on different aspects of the problem, using tools from all branches of science and building on their knowledge.' Bernie went further to describe how such a project could get parents involved in learning science and in the lives of their children with the addition of allowing students to appreciate "tangible outcomes" (Bernie D). A specific example he described involved students testing sewer drainage over time, making observations on changes and reporting these to the city. While his initial focus was on a top-down only approach, he quickly moved to discuss how students could get involved and become advocates. Yet it remained unclear whether Bernie truly valued advocacy or was more interested in stressing knowledge and participation in science. Although he often mentioned not understanding how citizen science could fit into his curriculum, when asked Bernie could give solid examples of what he might do to embrace this pedagogy as a future science teacher. The project-based method envisioned by Bernie would incorporate different areas of science and encourage students to make connections through various courses over multiple years.

When Paul was asked about what he could teach that allowed physical science to be taught using a citizen science context, he mentioned gravity, efficiency, and thermo-dynamics as possible connections. However, he indicated that the time required for preparing students with the knowledge to actually apply these concepts far outweighed the inclusion of citizen science in his class:

> Some of the content can be related to things that we are talking about [citizen science], like cars and the efficiency of what that actually means. You can actually teach some of that but as for actually doing anything directly with [citizen science], that would require more training and knowledge than you can put into two weeks or the course or whatever. (Paul E)

Paul's concern that students would need more time to learn the information was addressed in his comment "it's not time, it's really just that. You do need some of that knowledge on a lot of things. They just don't have it, and at the level that you are teaching it. There is just not much [citizen science] you can do with what they are doing in high school" (Paul E). He conceptualized ways of using citizen science in physics, but his concern for content standards and his knowledge of how difficult these are for students to comprehend influenced his ideas about the practicality of its use. While noting that there was value in student participation in citizen science projects, relating their involvement to the potential for seeing how physical science works and recognizing that science does exist outside of the four walls of the classroom, Paul was still adamant that he would not be using citizen science for his own teaching of physical science. Paul was not silent in his concerns for using citizen science, and while not always the loudest to disagree his position was clear. Morgan was aware of the disparities felt by Paul with respect to the inclusion of citizen science 'concepts' in the physics curriculum and made efforts to allow Paul to experience connections and form his own opinion.

Citizen science involved the community

Every participant in this study described citizen science as having some important connections to notions of community. The most comprehensive description of the role of self within the larger community, in relation to citizen science projects, came from Rose. She exhibited an understanding which indicated an already present interest in environmental and social justice, the basis for citizen science. An explanation of what Rose was learning in class hinted at her preliminary attempt to make sense of citizen science in action:

> From what I have been learning and thinking, it is just basically getting along with the students, getting them outside and involved in activities, like nature. Like the younger you learn, and you like it, you will keep on doing it throughout life and I think it is one of those. It is like you learn to roller skate when you are young and you are going to keep roller skating throughout life you know. Get involved, get down to see what they can like. Give them extra projects to try to open their minds on other things besides like video games and things like that. I don't know, just trying to help them to better society in a way, so it starts basically by looking at themselves and what they can do…being where you live, it's what you can bring to the community…(Rose C)

A belief that knowledge of issues and participation in events can influence the lives of everyone in the local community was a large part of Sarah's expressed value in the use of citizen science. While it was apparent that Sarah didn't completely accept the idea of advocacy, she did exhibit an awareness for the importance of knowing about where you teach and understanding how current actions could influence the health of people. This awareness was furthered in her argument for students having knowledge of measures already in place for protecting the environment and making decisions about the value of these actions. Her argument indicated an underlying belief in the value of community and the potential impact that knowledge acquisition could have on the understanding of environmental and social issues, and the benefit this could have in the community. Sarah discussed how learning about the community was contextual and the value she placed on helping people gain knowledge:

> …it just depends on what is a big part of the community … I think that will be one of the hardest things, especially if we move around… learning the community… learning what they like… If more of the community, I mean everyday people, you know...not just the environmental people, not just this mom and not just that, but like it could help bring people together if they will. It can help change people's use of science and make them more open to studying it, understanding what is going on. Realize why they can't bulldoze this place over here to put in a shopping mall, because a lot of times people don't care. Some of the people don't understand what different like EPD reports, EPA reports are, why they are important and so you kind of just need help some of them become scientifically literate to use a big term there. (Sarah B)

In a later interview Sarah continued to discuss the idea of community. She explained her belief that involving students with science in the community could provide a connection that would promote a greater understanding of science in the real world. The idea of community was furthered by Rose as she shared the value of knowing about your surroundings and how her belief for success seemed closely associated with Morgan's view of increased understanding and value in community-based activities. Morgan emphasized the value of knowing the environment of the area in which one teaches and figuring out how to draw on this knowledge to create examples relevant to the lives of students. The idea of getting to know the community was emphasized as beneficial since it would provide some context for learning.

Collaboration with peers is a component of 'building' a community of learners

Throughout the semester, pre-service teachers were encouraged to work together to build relationships and foster a sense of community within the class. Community building, in this sense, seemed to allow the pre-service teachers access to a wealth of diverse knowledge through their peers. One aspect of course structuring which Morgan considered to be a strength was the interaction that happened between the students. He shared the following in describing the relationship that he anticipated developing between the pre-service teachers:

> …the connection, their sharing of themselves with each other- becoming an ecological oneness. Just that they are all breathing, living life outside and inside of class but that comes together in one breath, I breathe out, you breathe in and we share the air. That becomes us, our community of learning. (Morgan K)

Morgan emphasized the importance of enhancing interpersonal relationships between pre-service teachers, noting that it further promotes a reliance on community and awareness of the knowledge held by others. Morgan maintained that a greater understanding of personal philosophy could be fostered through the creation of a community of learners.

Encouraging the development of a "community of teachers" may have helped to foster the pre-service teachers' understanding of the value which could exist in external community involvement. By external community involvement, Morgan pointed to the value that elders have or the knowledge which is held by a family who has lived in the area for decades. He repeatedly emphasized that involving the community can be a positive way of making science a 'take-home' relevant idea that could influence decision-making and future action. Community was an idea embraced by all of the participants and will likely be incorporated into their future teaching. Often pre-service teachers were asked to work in groups to discuss or collaborate outside of class on assignments with a goal of promoting a view of science as being connected across the disciplines. The idea of chemistry pre-service teachers working alongside biology pre-service teachers was one way Morgan attempted to challenge the assumptions that each discipline should be taught separately. He also indicated that through groups working cohesively, there was potential for gaining a better understanding of how different science disciplines could function together. However, it was not evident through observations or in participant interviews that the pre-service teacher acknowledged the diversity Morgan hoped to provide.

Another component of community building included the development of relationships among the pre-service teachers and co-educators. Morgan maintained that this encouragement for collaboration may eventually lead to the pre-service teachers' increased involvement in the larger context of community to include schools and traditional learning cultures. According to Morgan, community life is an extension and continuation of how he has defined science education. One component of encouraging community involvement, specifically related to fostering a community of peer learners in this course, was the interaction evident between the pre-service teachers outside of class. "A dark and chilly night" highlights one of these events that allowed the pre-service teachers to become involved in activities outside of the regularly scheduled class meetings.

It was a dark and chilly night…

One of the pre-service teachers, married to a park ranger in a nearby state park, arranged a camping trip for anyone associated with the methods course. After talking it over with Morgan, she organized a camp site, facilitated equipment, directions, and pre-service teacher participation, and ultimately cooked for the event. Morgan lobbied for the camping trip to take place on Friday the 13th, suggesting that the group could tell scary stories while bonding over a campfire. He felt that interacting outside of the classroom would have a positive impact on the developing relationships among the attendees. Having an opportunity to enjoy time outside of class, taking leisurely hikes with pre-service teacher experts, was a wonderful bonding opportunity for those who attended. The description provided below, based on my own personal experience, indicates the type of activities, camaraderie, and sense of community that was fostered through sharing of knowledge in conversation and interaction:

> Six pre-service teachers drove the almost two hours to the local state park where Sarah's husband works. Upon arriving at the camp site, situated high on the hill at the end of the dirt road, we were greeted with several tents set up around the large campground. One located under a building with a roof and floor, others nestled near each other on the path to the bathroom which would be shared among all the campers on the hill.

Sarah, her husband John, and young son Chris prepared a cozy area for us to gather and enjoy a Friday night. Firewood was arranged within the circle of rocks, chairs neatly circling the area for the 'teacher' campers to visit and eat. Everyone brought some form of food – marsh-mellows, chocolate, drinks, chips, all of the last-minute munchies one would expect of a college student. Lee arrived after dark, when we began to feast on the large pot of stew Sarah and her mother had prepared. Parking his motorcycle between the cars, he immediately went to the fire and started re-arranging logs.

The group divided between the fire-pit to eat in chairs around the circular brick wall and the picnic table holding the bowls and food. Most everyone migrated to the fire after eating dinner. We sat around and talked, some about teaching, some about dating (Rose, Sarah, Molly and me). Alan brought his sleeping bag to the fire and lay down on the ground. Lee was the fire man, he stoked and stacked and fed the fire to perfection at the evasion of most other things including dinner. Morgan stood for a long time and talked to Lee, tasting everything that was being cooked. Rose talked about her upcoming trip to Mexico for the holidays as we huddled. Sarah chased Tyler until John took him back to their house and her mother – who had come up for the weekend to help cook and take care of Tyler. John came back with a mattress to put in their tent. I had the most awful early beginnings of a migraine and Molly worked on my neck and shoulders before I went to bed early. It was super, super cold once we

> left the fire. I was the second to hit the tent, after Alan, and was there a bit after 9. Even the extra wool socks, long johns, heavy duty sleeping bag and extra quilts didn't stifle the chill which most everyone felt once we made it to our tents. I didn't get to sleep until many hours later, from the cold temperatures and giggles of people wondering through the woods. Linda and Morgan, the kids, Lee and I don't know who else went looking for 'glowing' lichens. (Observation 17)

The pre-service teachers who participated in the camping activity indicated that they had forged a closer relationship because of the experience. Rose noted that spending time with her classmates outside of the traditional academic setting was helpful because they discussed views and ideas related to teaching. Rose felt that the extra time spent out of class allowed for conversations to develop which helped her think about what she believed in relation to her peers. The experience outside of class were very beneficial because it appeared to give everyone an opportunity to 'get to know' one another on a much different level. We managed lunch a few times as a group, after the arboretum visits, and were all invited to a Halloween party hosted by Emma and her husband. Relationships were formed which continued to be evident after the course ended.

Citizen science may increase science literacy

Scientific literacy, an important aspect of citizen science, was an issue discussed in class and defined much the same way across the pre-service teachers. One of the first activities which Morgan had the group complete in class was to research citizen science outside of class. Groups were put together with the intent of discussing components of citizen science and what it actually meant , when they returned to class for the next meeting. Morgan asked the pre-service teachers to explain the relationship they believed existed between citizen science and scientific literacy and create a diagram of this relationship. The written products which Morgan asked the groups to turn in as an ungraded activity, were analyzed as Artifact 1 and represented an overall understanding that use of citizen science could potentially increase scientific literacy. Artifact 1, identified as the "class activity in which students define citizen science", suggested an understanding of scientific literacy in which student learning of science is influenced by both teachers and the actions involved with doing citizen science. One group was assigned the name Group Green, referring to three pre-service teachers who worked together in creating the diagram seen in Figure 3. Artifact 1_Group Green. By placing scientific literacy at the center of their argument, this group identified teachers as essential in helping students understand, apply, and make more informed decisions about science. Figure 3. Artifact 1_Group Green indicated an apparent role they anticipated for citizen science centered around creating a platform which would have the potential to allow students to become involved in their community. It was apparent they also anticipated that students would potentially move between experiences that could foster the construction of knowledge through inquiry, data collection, and developing conclusions.

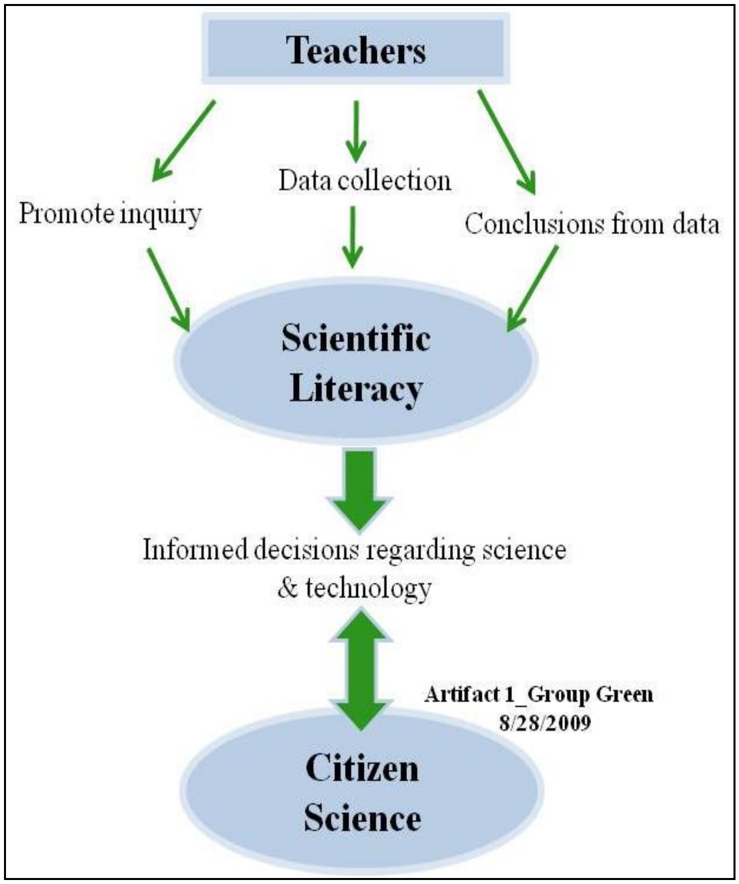

Figure 3. Artifact 1_Group Green

Another group of three pre-service teachers, Group Blue, built on the same concept presented above, by explaining scientific literacy as the ability to consider a situation, incorporate a specific skill set, make decisions about action and then be able to evaluate, through observations and other measures, the issues and effectiveness of those actions. They characterized scientific literacy in relation to citizen science, describing it as real-world opportunities that enable the use of skills that are obtained in learning science. Group Blue explained that while these actions are often directed by scientists, they still provide opportunities for individuals to learn and make decisions in their own lives. Lee, who was in Group Purple, further validated Group Green’s diagram with the comment that the “goal [of science education] is to make students literate and we can do that through citizen science" (observation 3). It appeared that many groups were in agreement that citizen science could provide the basis by which the general population could potentially gain experience with the application of scientific principles. The key to all aspects of citizen science, as described by these participants, was the real-world application of scientific knowledge. Sarah discussed the value of students being able to learn science through application, expressing a personal understanding that in her experience, chemistry was not taught in isolation and that students should leave her class with an understanding of how to apply what they learned. She also addressed the perceived relationship between standards-based instruction and students' opportunity to apply what they learn,

> …if it is a standard, then we are going to go over it, we are going to learn how to do it, but I want them to remember it, not because they are going to have an end of course test, or because they are going to have their graduation test, but because they can apply it. (Sarah B)

Sarah expressed the belief that an ability to *apply* knowledge was more important than simply holding knowledge. She emphasized the idea that knowing why AND how things work matters, and may make students more in tune with their world.

Summary

Within this section, different approaches to science education (as experienced by the pre-service teachers) were discussed with ideas of how citizen could be incorporated into classroom instruction. Pre-service teacher interactions with and interpretations of citizen science were evidenced in how they defined, engaged in, and envisioned the use of citizen science in their future classrooms. The notion of community was discussed both in terms of the pre-service teachers building a peer community and in relation to how citizen science could benefit the community at large. This section also highlighted the pre-service teachers' belief in the value of citizen science for increasing scientific literacy within the community.

Through the eyes of the researcher: A commentary

How do they want to teach?

Most participants agreed that their formal science education experiences did not reflect an ideal way of teaching or the structure which they would likely use in their future classroom. The rigid, lecture-based science class was common to their experience and could arguably be what many of these pre-service teachers would return to, if not given an opportunity to form an alternative vision. They expressed dislike at the lack of student involvement which characterized their traditional classroom experiences, acknowledging citizen science as involving students and presenting a different type of learning opportunity. The general consensus was that students need to be encouraged by teachers, and should know they are cared for and have a voice in their own education. The pre-service teachers quite ably described how citizen science could be incorporated into science teaching, although it didn't appear that many planned to use the pedagogy as it was presented through the course. They expressed value in having participated in science learning while outdoors, in the opportunities for building relationships with their peers, and in learning about strategies which they could use as teachers in planning for outdoor learning. Aspects of ecojustice philosophy may have been integrated into their personal philosophies of education, but the degree to which this occurred was difficult to determine.

Encouraging students to engage with ecojustice philosophy

Some of the pre-service teachers grew up in rural environments, with experiences that encouraged them to value local knowledge and recognize the presence of science in everything around them. Sarah and Rose were obvious examples of rural students, with different science disciplines, and somewhat different ideas about the use of citizen science in their future classroom. There was an initial assumption that pre-service teachers from a rural background would find it easier to understand citizen science and embrace its possibilities for teaching. However, pre-service teachers' science discipline mattered more in their ability to find value in citizen science as an instructional pedagogy than did geographic experiences. For the most part, the pre-service teachers' understanding of citizen science and how they might use the pedagogy in the future reflected a top-down approach where students could be involved in projects that were already in existence. Through the course, the pre-service teachers were able to see various examples of citizen science, and they gained an understanding of what it could potentially look like in the secondary science classroom. Yet, the pre-service teachers' emphasis on making science more relevant – an idea which was mentioned often over the course of the semester- seems to suggest that this will be the most likely rationale for incorporating citizen science in their future teaching. Their emphasis on making science relevant went hand-in-hand with the value they placed on the inclusion of standards in the curriculum, and their description of citizen science as a tool for increasing scientific literacy. Morgan emphasized that citizen science had a greater purpose than simply increasing scientific literacy; his intention was to develop advocates for the local community. While these two ideas do not have to be mutually exclusive, the pre-service teachers tended to weight the value of scientific literacy higher than participation and advocacy.

Addressing community

For most participants, community meant assorted living populations coexisting with necessary non-living components of a habitat. The pre-service teachers were cognizant of the value in knowing the local area in which they (and their students) would reside and interact. They recognized the need for awareness of locality, events (both natural and human-induced) and the relationship these have on a successfully, healthy functioning system. Morgan's emphasis on community encouraged the developing idea of continued interaction with surroundings, awareness of and appreciation for diversity, and the value that can exist when these are included within the science curriculum.

A big idea that pre-service teachers left the course understanding was that community has value in science teaching and learning. Fostering relationships between parents, teachers, and students was viewed as a positive way of encouraging participation in decision-making opportunities and in strengthening the learning environment. The pre-service teachers had opportunities to see the value that different individuals have in structuring learning and impacting a student's ability to interact with science. They may not have bought into the idea of citizen science as the most effective pedagogy for teaching their students, but they did take away a deeper understanding of ecojustice philosophy and the opportunities which exist in unique communities to learn and become more involved in the local 'world'.

Considering citizen science as a pedagogical organizer for secondary science

When confronted with something unfamiliar, dissention is common. Attempting to make sense of what it means to participate in a new experience is challenging, especially when it appears to contradict most everything deemed acceptable. Yet, the only way to overcome an obstacle is to work through it while attempting to integrate some of what is familiar. While new ideas are introduced to teachers on a regular basis, they often have a background experiences from which to decide on the relevance or practicality of using the newer idea. This section addresses some of the limitations felt by the pre-service teachers, expressing how they attempted to make sense of contradictions and overcome tradition to accept and internalize a new idea.

Challenging prior assumptions

When considering how we view the world, it could be argued that most people hold particular assumptions about many topics. Yet, many individuals are not cognizant of how their beliefs may differ from others, or on what those assumptions are based. As teachers, the assumptions we hold make their way into our classrooms and have the potential to alter our teaching and interactions with our students. Morgan specifically mentioned designing this course so that it would encourage a developing awareness for the differences which exist in cultural assumptions and how those existing beliefs might be addressed in a classroom. One of the primary goals Morgan had for the course was to "counter all of [the prior assumptions] that" were accepted by the pre-service teachers through introduction of a philosophy of teaching that was different than what many were accustomed to experiencing (Morgan 2). Morgan considered the most important thing that the pre-service teachers could take from the class was a change in their teaching philosophy, a change that might more closely resemble ecojustice philosophy. Morgan staunchly supported the idea that the pre-service teachers could be influenced to act differently in their future teaching if they were given the opportunity to become more aware of their current assumptions and encouraged to challenge deeply held beliefs. By encouraging the pre-service teachers to understand their current assumptions Morgan may have promoted the viewing of ecojustice as a potential philosophy. Understanding that all pre-service teachers come to his class with prior knowledge and beliefs, some developed as counter-arguments to their own classroom experiences, Morgan discussed the idea that many would buy into the ecojustice 'style' of teaching. However, according to Morgan, the pre-service teachers would often view citizen science as something extra and "[if] that's not going to help with the test …it's not going to frame the way that they teach" (Morgan 2). The focal point on standards and teaching for state tests was an issue that many were aware of and acknowledged would be a part of the expectations they would have to meet as future teachers. Classroom activities and discussion provided the platform Morgan utilized to present alternative viewpoints and at times play the devil's advocate in an effort to encourage the pre-service teachers to think outside the box. The course was built upon the idea that there are things we can all agree upon, and that our perspective is often determined by others. The diverse activities which took place in the course were obviously intended as opportunities for the pre-service teachers to analyze their own beliefs and make decisions about their personal ethics.

Context, as discussed in section three, involved situated learning so that a purpose became evident, whether that was learning outdoors, experiencing collaboration, or increasing observation skills. Creating a context in which the pre-service teachers would seriously consider the idea of teaching for citizen science was challenging. According to Morgan, prior assumptions and decades of education lend themselves to an academic system that is "all about teaching for success in a capitalist society….being able to buy the latest fads and trends equate with happiness" (Morgan 2). Evident through conversation, Morgan emphasized the value of citizen science in positioning science as relevant to all students and helping to prepare them for a more diverse future that includes more than gaining entrance into higher education. In our final interview, Morgan discussed his belief that the pre-service teachers might interpret his class and some of the ideas presented as "irrational or not concrete enough or that the investigations are not science enough" (Morgan K). However, through Morgan's challenging the pre-service teachers to think about how they would teach, using citizen science, he shared what it looks like to be passionate about your content and your profession. Context was used a way of challenging assumptions in that most secondary students spend the majority of class time within a structured system, not outside in inclement weather; if teaching occurs outside, typically the focus of instruction is something about the outdoor setting.

Morgan often challenged the pre-service teachers' to consider their personal assumptions by incorporating controversy, either as part of a discussion or personal actions. A specific example of presenting controversy came up during the technology introduction and explanation of the probeware assignment. The assignment was to develop a lesson based upon scientific probeware and use technology to teach science;

the day this assignment was presented to the class, the pre-service teachers expressed perceived value in advanced technology. By contrast, Morgan presented technology as something negative indicating that communication becomes electronic, diminishing personal encounters such that relationships with the community become weakened. The probes were shared as something exciting, a possible way of using technology to supplement learning, something that the pre-service teachers would be expected to understand, but not necessarily as something positive. In small-group discussion that day, Lee vocally worried over the contradiction of Morgan introducing the positive inclusion of technology and in the next moment his devaluing of its use. Lee continued explaining that it was difficult to understand where Morgan actually 'stood with things' when he first said 'we need to learn how to use technology because it is valuable and then that there is too much significance placed on technology, resulting in children being placed on medication'. When Morgan was asked about the contrast in value he placed on technology, he emphasized the need for a balance so that technology is not over-used. Mentioned earlier was the role of the teacher as a mediator for learning; this was an opportunity for the pre-service teachers' to be guided into thinking differently about a widely accepted concept. Morgan justified his action of provoking controversy in his position of serving as mediator in the discussion of technology; he maintained that he helped the pre-service teachers address their assumptions about what constituted good science and valuable technology. He felt that his presentation of contrasting views encouraged the pre-service teachers to think about what they believed, the possible stance they would take on technology, and what assumptions they held.

Wait…isn't this a methods course?

A second assumption the pre-service teachers were forced to address was their consideration of the course as "Methods of Teaching Science". Presenting the course as a philosophy class was potentially "illogical", yet this furthered Morgan's goal of challenging assumptions (Morgan 1).While Morgan shared his intent, with me, that the course was being designed as a philosophy course, the pre-service teachers did not get the same qualifier, and anticipated learning 'methods' for science teaching. Implicated as an aspect of philosophy, citizen science was portrayed as a method of preparing pre-service science teachers in ways which would make them more aware of what is happening in their world and the actions that may be needed to protect it. For Morgan, part of the draw for citizen science was that it functioned to "help [students] understand [that] this is your environment, this is your community"; he shared potential in citizen science for deepening connections to the surroundings and possibly encouraging action in protecting resources (Morgan 2). The theme Morgan repeated throughout the course, the purpose of citizen science, was to 'position students so they participate more fully in their community.' Rose shared her difficulties in the class, explaining her concern over the lack of traditional methods of teaching science – "I feel like I am lacking other methods of teaching, besides just always being outdoors" (Rose H). Rose was one of the biggest champions for outdoor learning, but expressed concern that the primary person she learned teaching methods from was one of the co-educators rather than Morgan. She shared her familiarity with techniques for outdoor instruction but expressed concern for the other pre-service teachers who hadn't had similar experiences because she felt they had not learned how to incorporate outdoor learning effectively into a future classroom.

While the purported focus of the class for Morgan was to help students understand citizen science and develop a teaching philosophy, the anticipated goal for many students was to learn methods of teaching science. The greater focus placed on the outdoors, rather than the "traditional" classroom was a tension for many students. Rose, the informal educator in the group, addressed the outdoor component in the following statement:

> And I know it is a very different course, and I know most people don't agree. And I do see things that I wish he would do more methods, teaching methods. Cuz he does spend 99% of it on just being outdoors. I like it, but I wish he could just give other methods in case we can't do that. What to do, that's one thing I feel is lacking. But for me, he is trying to show us a balance on that, I guess – I am seeing it that way, of how what you can bring in and what you can bring outdoors. (Rose H)

While being very supportive of Morgan's strategy for teaching, Rose was still considerate of those students who didn't agree with his way of instruction, clarifying that there were pre-service teachers who needed something more from the class. Rose felt that Morgan communicated, through personal conversation with her, effective methods of integrating the outdoors even when instruction couldn't happen outside. Rose shared that Morgan was very encouraging and informative when it came to individual discussion of the realities of what would be expected of a teacher. Rose shared her belief that 'it isn't necessary to be outside all of the time to do citizen science; it can be about bringing an animal in the classroom to handle and protect.' Following this comment, Rose discussed the value of including live animals in her classroom, so that her future students would have opportunities to learn about organisms that are often considered scary. Modeling, discussed in section one as representation of preferred behaviors or actions which individuals can copy and make their own, was a major component of the class. The use of the outdoor learning environment as a classroom was ‘modeled’ eight out of 16 class meetings. While Morgan did not explicitly state that all science classes should be held outdoors, it could be implied that he emphasized the importance of location through modeling. While Morgan had concrete beliefs regarding his use of nature as a classroom, some of the pre-service teachers felt at odds with the focus on outdoors since it went against most of their previous educational experiences. In a personal conversation with Emma, she explained how the informal nature of the course, with many outdoor experiences, was an unexpected and stark contrast to the more ‘formal’ classroom which serves as the typical learning environment (informal conversation with Emma during Classroom Observation 8).

In sharing conversation with other pre-service teachers, their ideas about citizen science and the use of outdoors as a learning space seemed to be a constant source of concern. Bernie was very diplomatic when elucidating his ideas related to citizen science and always attempted to find something positive in his classroom experience, especially in relation to the outdoor focus of class. When conversation turned to citizen science, the result was an apparent search for something positive to say as he explained how he didn’t see the fit for his own classroom teaching. The excerpt below starts with Bernie discussing another course he was taking in conjunction with the methods class; in the other course he was analyzing classroom situations and learning about what effective and ineffective teachers looked like.

> Those have been helpful for me in developing my ideas about my future teaching and less kind of general impressions that this idea of going to visit botanical gardens. I feel like more [of] those types of direction would perhaps be more helpful for me personally than visiting the botanical gardens. Like when we have gone out there, we haven't had many examples given, like here are some things that you can do outside. Other than like the GEN projects, these are examples, [but] these are from elementary kids. I mean, I still have a hard time imagining what it looks like when someone has….say they did their chemistry class entirely outside all year, what would that look like. What kind of things would they be doing? That would be more helpful for me than just kind of expressing the general idea that it is a good thing to have class outside. (Bernie I)

All participants in the study had some degree of concern over the emphasis on the outdoors and de-emphasis on what they considered "traditional" classroom settings. For Paul there was value with an environmental focus in class, as long as it included a specific context. Yet he did note that, at times, it would not be worth the effort required in content preparation to attempt connections to the outdoors. To some extent, Paul was a special case and required additional considerations, seemingly as a result of his blatant lack of excitement or more obvious physics background and inherent unwillingness to make intentional connections. For the Garden Earth Naturalist project, Morgan shared that he had grouped Paul with people who could potentially alter his ideas about the value of citizen science; he was really excited about the possibility of Paul changing his mind to think more positively about citizen science. Paul openly discussed with other students that he didn't feel the course was useful in his preparation as a teacher. Earlier conversations with Emma highlighting her concern over the course focus, in conjunction with Paul's mixed feelings of the use of citizen science in his teaching, served as evidence that some of the pre-service teachers may have had difficulty accepting the ideas represented in the class.

Is citizen science interdisciplinary?

Interdisciplinary is a term that has been used as a way of justifying activities or attempting to form connections between content areas; obvious from the name is the relationship across different disciplines. Science can be taught in conjunction with other content areas, in addition to the different scientific disciplines. Using citizen science as a focal point could potentially allow for these cross-content relationships to be fostered. Citizen science includes a wealth of community components and requires knowledge about other content areas; the association of community with content knowledge requirements could serve as threads for connecting different disciplines. Morgan often validated the potential of using citizen science to promote connections between teaching differing areas of science as well as other subject areas. Morgan explained that "many of the students go through science classes and see them all as disconnected, but [science] can really be done across disciplines – biology not being separate from physics or earth science" (Morgan 4).

There was some degree of disconnect with Morgan's anticipated use of citizen science for teaching different science content and his inclusion of multiple 'sciences' within his instruction. While Morgan suggested the value of citizen science for teaching multiple disciplines, the class was focused more on biology and learning outdoors with limited connections to other science disciplines. The possibility of incorporating citizen science across disciplines was often mentioned in conversations between pre-service teachers; also mentioned was the lack of focus beyond life science being addressed in class. Sarah expressed an understanding of how citizen science could be integrated with chemistry by involving students in something larger than just 'pencil and paper and math.' She suggested that by demonstrating or encouraging the application of knowledge, students could potentially gain a greater understanding for real-world science connections. Sarah explained that real world applications of chemistry, such as identifying glazes for pottery or composition of soil, could enable her to incorporate something she considered to be representative of citizen science. Our individual discussion resulted in creative ways to incorporate chemistry with citizen science in everyday life. However, Sarah argued that 'the projects he has presented have been pretty fantastic, but I have a hard time seeing where it fits in with the standards of chemistry.' We discussed aspects of the world around her which could be used to teach chemistry, things like light or the paint on the walls. Within the scope of learning science, Sarah stressed the need for students to have some background knowledge which could facilitate understanding of local issues. Time constraints were another component which was emphasized when discussing her ability for teaching with a focus on citizen science. The notion of interdisciplinary science teaching was suggested throughout the course, but practical applications were often limited. In our final interview, Morgan shared that he "failed to recognize the interdisciplinary nature of what motivates citizen science" (Morgan K). This comment was immediately following a question about what changes

Morgan foresaw making in future classes that would better address the needs of the physics, chemistry, geology, and earth science majors in relation to citizen science. Morgan's comment suggests potential concern and the possibility for changes in future instruction.

Focus on life science

The reliance on nature as a classroom was evident in the percentage of class meetings held outside. As a biology teacher, the connections to content standards seem obvious to me, and could possibly be even easier to address in "alternative" environments. However, the use of citizen science as a framework for other science disciplines was at times a source of tension for the pre-service teachers. Chemistry and physics pre-service teachers appeared to have the most difficulty relating learning outdoors and community-based activities to the content they would be required to cover for their discipline. For those students majoring in disciplines other than life science, the application of concepts in chemistry and physics was felt to be even more challenging due to the lack of direct examples. They felt that the vast majority of class was directed at life sciences. The pre-service teachers were given some outdoor opportunities to do science in their discipline, but with very limited parameters and little discussion. While opportunities may have existed that would have allowed the extension of required material to address content standards, the limited discussion may have prevented acceptance of citizen science as a profitable framework for teaching. Considering that Morgan had used citizen science as a framework for previous methods courses, he was innately aware of the tensions felt by the non-life science majors. In private dialogue, Morgan acknowledged the challenge he faced in working with non-life science majors with respect to the application of knowledge and the emphasis on learning about the community. The challenge of meeting the needs of pre-service teachers with different content backgrounds is one likely experienced by many teacher educators who instruct multi-content student populations, especially those with content areas different than their own.

Without an obvious or openly and thoroughly discussed avenue for connecting citizen science with chemistry, physics, and physical science, these pre-service teachers expressed frustration. They attempted to validate the notion that their content areas were very difficult and could not accommodate anything other than ‘traditional’ instructional formats, regardless of other possibilities they deemed valuable. Sarah shared her pre-established ideas about the course and what she had expected in terms of application to chemistry. The comment below is repeated from a conversation she had with a chemistry teacher friend who had taken the course in a prior semester.

> …she had already told me that Dr. Morgan is a very biology/ecology based kind of person and he does not get excited or stressed for...he goes over it because he has to for chemistry groups but not because he is excited about what they have to say. I have really put that in the back of my mind when this class started and…I haven’t seen so far that anything that he has told us would directly be related to chemistry. It all seems like it is more biology stressed or bioscience stressed, not just biology, but you know…like worldly stressed, like physical, here it is touch it kind of stuff. I think that like the general concepts I will know, but I don’t think I will be shown how to apply those to a chemistry classroom. (Sarah B)

Describing the community-based nature of citizen science, Paul indicated that there was little connection for him with physics or physical science. He felt that chemistry included more topics that could be used to address both citizen science and the content standards. For Paul, most of the ideas using citizen science covered content only at a superficial level. Discussing the need for concepts to build on prior knowledge he emphasized his belief that citizen science didn't necessarily enable the building of requisite content. Paul also shared a concern that it would be difficult to delve into content that is required for physics when working in the field or on environmentally-based projects. While depth of coverage was an obvious concern, Paul never said that he could not teach outside- he just felt that it would require more effort than he would be willing to put forth. Teaching science outdoors was disconcerting for the non-biology majors. Additionally, the lack of a context to which they could relate what they were learning proved difficult. Bernie furthered this idea by discussing how citizen science seemed to fit biology well, but was increasingly difficult to plan for without a community in mind. "[It] could get progressively harder with chemistry and physics…and it is hard to talk about when you don't have a specific community or problem in mind" (Bernie D). The idea of relating citizen science to disciplines beyond biology may have likely been less difficult had Bernie been presented with a context with requisite dialogue on how to make necessary connections. In continued discussion with Bernie, he noted the obvious relationship between citizen science and biology – and admitted that the task of using citizen science for teaching chemistry or physics was more difficult. He described the concept of citizen science as 'great with real tangible outcomes', but 'it could get progressively harder with chemistry and physics" (Bernie D). Bernie shared an interest in investigating nature, but he felt that doing that in chemistry would be more difficult and he had yet to 'see' how that could happen in his classroom. Without concrete examples, it was difficult for non-life science teachers to consider using citizen science. Relevance for the subject was difficult to create when many of the pre-service teachers didn't understand the logistics of what actually made citizen science, citizen science. In reflecting upon things learned over the years of teaching this course using citizen science as an organizer, Morgan shared that his knowledge of chemistry had increased and he felt that he was better able to talk about how chemistry existed in application to the environment. The increase in chemistry knowledge may have enhanced Morgan's understanding in relation to citizen science, but the absence of discussion prevented this connection for the pre-service teachers.

Sarah mentioned that being outside in different learning environments helped her understand the need for a correlation between different areas of science or depth of knowledge. However, she also indicated that the activities 'were all biology' centered with little emphasis on other science disciplines. The excerpt below shares some level of the concern Sarah felt at the end of the course, something she related directly to her background in chemistry.

> We [the chemistry students] feel like we have been excluded and been picked on the whole darn semester, but the chemistry students noticed that it was the chemistry students that were getting the most negative criticism. A biology person can go walk around in the woods or somewhere on the school ground and notice things and be able to talk about it and make it kind of be equal with safety. But a chemistry person, you are just not going to put on your safety goggles for no reason…it is a little bit more serious for us because of the obligations that we all feel like we have

> because it is chemicals. People have been in nature a long time, they pretty much know how to deal with stuff like that… (Sarah L)

The issue of bias emerged when in class discussions Morgan was more outwardly receptive to projects which were based on environmental issues. Another example of this bias occurred earlier in the semester when Morgan introduced the idea of "hooks". The students worked together in small groups to develop a hook for teaching science concepts based upon their science discipline. After time for collaboration, they then shared with the class what topic they would teach based on the hook. The largest group of biology pre-service teachers decided on the idea of using a bird song as a hook for introducing populations and mating. The presentation of their hook involved lots of content discussion and hinted at an outdoor component of allowing their future students to be outside attempting to identify birds. Morgan was very supportive and asked no questions about what the students would learn from this activity; they were not told they were attempting to cover too much information. The second and third groups, who did not discuss environmental issues, were treated somewhat differently – treatment that didn't appear to be as positive. Morgan asked multiple questions about why a particular idea needed to be taught and what the students would actually learn, seeming to be very confrontational. The physics pre-service teacher had worked with an earth science partner, and together they came up with a very detailed way of teaching a specific concept. The concept they wanted to cover was something in physics, seemed abstract, and was somewhat more difficult to understand. However they gave a brief explanation of the hook which would be used and provided a more detailed explanation of what the students would learn. Morgan suggested to Paul that he remember the acronym KISS (keep it simple stupid), and take care not to overload the students with too much information. The final life science group decided upon using sea urchins to discuss cell division, sharing that it was such an obviously rapid process. They discussed how the hook would be introduced and went into further detail of how the classroom activity would then unfold. They received minimal but positive feedback. From an observer's perspective, there were obvious differentiations which could have seemed quite negative to the participants. Prospective teachers in life science rarely heard negative feedback, whether this was a result of content knowledge or apparent focus on citizen science connections can't be determined. However, Morgan did mention in private conversation that he was intentionally biasing the course presentation for citizen science being the 'best' approach.

The pre-service teachers sometimes had difficulty understanding Morgan's responses to activities and class discussion, particularly in relation to ideas which appeared to lie outside of the biological sciences. In Sarah's discussion about the lesson box and safety plan, she expressed dismay at Morgan's apparent lack of chemistry understanding. My own lack of chemistry knowledge limited my understanding of any potential problems that existed in Bernie's presentation of safety and his lesson box. However, conversation with Sarah, a pre-service teacher with a strong chemistry background, revealed concerns she had with Bernie's project and the safety of his future students:

> [Bernie] wants to use 18 molar sulfuric acid in the classroom full of high school students, 18 molar. So now Emma and I have asked some other labs, like some real labs, doing research everyday …you rarely even find

> 18 molar of sulfuric acid in their labs, and he wants to use it as something to play with to melt a cow's eyeball. To me … that's not safe, and these kids don't need to think that you can just do stuff like that with it. I mean he did mention that he would get the cow's eyeball from the butcher, but these kids see an 18 molar on a cow's eyeball [and] they are going to wonder what it will do to something else. You can do almost the same thing; you can melt a shell off of an egg with vinegar. It takes days, it's not instant, but that is okay. Because they don't really, the quicker that stuff happens the less safe it is. That's not safe. I mean, professional laboratories do not use. (Sarah L)

Sarah shared an expectation that Morgan should be knowledgeable about chemistry content if he planned to give feedback about safety. Sarah argued that Morgan's positive response to Bernie's activity showed either a complete lack of consideration for student safety or a lack chemistry knowledge. She went further to state that "I don't think he … has enough of a chemistry background to comprehend and understand what the molarity means" (Sarah L). It is possible that Morgan was accepting and showed encouragement for Bernie's activity because it included cow eyes. Other than the possible community aspect of using a local butcher, which is doubtful considering safety regulations, the reason for praise is unknown. The conversation with Sarah, about the appropriateness of Bernie's activity, did not arise until after the final interview with Morgan took place-the timing of Sarah's comment prevented opening discussion with Morgan about her concern.

Does citizen science allow me to cover the standards?

Due to the test-based assessments that are mandated in most states, teachers have to show consideration for standards. While often somewhat individualized per state, all typically have the same structure of addressing the national science education standards. As mentioned previously, teacher preparation programs also have standards for which they are held accountable. Hence, the national science education standards have components for all age ranges, Grades K-16 for general science expectations. Within the state for which most of the pre-service teachers plan to teach, standards are more specific and include a wide array of content specialties for which preparation is necessary; especially relevant for this discussion are the standards for the secondary grades which these pre-service teachers are being prepared. Within an early pre-course discussion, Morgan argued that the state standards are contrary to the National Science Education Standards (NSES) in that the State Performance Standards (SPS) are more “reductionist”. He indicated that the NSES does not encourage high stakes testing and therefore emphasized the need for “multiple methods of curriculum, [with] no single method of teaching… [so] there shouldn’t be a single method of testing” (Morgan 2). By suggesting that there should be multiple ways of determining knowledge acquisition and comprehension, Morgan essentially argued for the inclusion of assessments that were more performance-based. Given the recognition that state-mandated testing is probably inevitable, Morgan presented citizen science as promoting a different type of learning. While admittedly an opponent to high stakes testing, Morgan presented the argument that students who participate in activities such as citizen science will have increased test scores. Indicating that he could prove this claim, the conversation continued without specific details of studies in which learning was assessed when citizen science was the primary framework for instruction.

In early discussion regarding specific components of the course, Morgan described activities such as nature drawings and writing that could be included as ways of addressing the standards. He explained in private conversation how, in these types of activities, students are encouraged to observe examples, “ask questions or to design an investigation” (Morgan 1). Elaborating on why these actions supported the National Science Education Standards, with its emphasis on multiple assessments rather than high stakes testing, Morgan further attempted to justify his use of citizen science. He continued by arguing that citizen science would be ideal for smaller school districts that struggle to perform well in science and where the teachers may actually have more freedom with their curriculum. Morgan noted that citizen science based instruction “will improve test scores in schools that have low test scores right now” (Morgan A), though this was more of a contention than a statement which he validated in any way. The concern of many pre-service teachers was that citizen science would not allow them to address their content standards as required by the district.

Most high school science courses require some form of standards-based instruction, resulting in a standardized test. Many of the pre-service teachers felt that citizen science, as presented in the course, didn’t enable a greater understanding of how to address these content standards. Although science standards address more than just content, the pre-service teachers never mentioned any standard beyond content specific standards. Morgan addressed the concern that had been brought up in previous courses, that “if you are innovative you can still [accomplish what you need to] as far as the standards [go], but you can do it in a way that also lends to participation, more fully in policy making and then there is that last component of advocacy" (Morgan A). Without specifying how these standards could be met, or presenting opportunities for dialogue in class, many opportunities to help pre-service teachers understand how citizen science could be used to address standards were perhaps missed.

Given that pre-service teachers entered Morgan's classroom already possessing the requisite content knowledge, his methods would not, theoretically, have to include a structure which would allow for examples of teaching specific content. As argued in earlier sections, Morgan anticipated a course designed for addressing philosophy rather than methods. However, pre-service teachers had much different expectations for what they would encounter in the "Methods of Science Teaching" course. It appeared they expected some level of deeper instruction on how to 'teach' their particular content area. Sarah noted that there are 'more than enough standards without you inventing other things for the kids to do', explaining that the idea of being outside and doing citizen science was good but not something she plans to do in her own classroom. She also noted that she "hasn't been shown a method to manage my content to get those things balanced out so I have enough time to make sure that I have given the kids all of the content information that they needed before [showing] them how [citizen science] would apply to chemistry" (Sarah G). Morgan responded to this concern by telling the pre-service teachers to focus on a theme and not be overly concerned with time because they would get everything covered. Rose learned that you can follow the standards in your own way, "you can be a very alternative teacher as long as you are following the standards" (Rose H). State standards were never discussed explicitly by Morgan during any of the class meetings. For some students, the lack of connection to content standards within their discipline may have made citizen science appear to be a frivolous addition that did not truly cover any content. This could be a challenging concern for new teachers who are not overly familiar with the standards and understand that positive student performance is conditional for their continued employment.

Summary

The primary concepts evidenced throughout this section included the idea of challenging prior knowledge in ways that would help pre-service teachers think outside of the box, the pre-service teachers' concern for focusing on outdoor learning and life science rather than addressing all discipline needs, and the potential of citizen science for covering the standards. As evidenced in this section, some pre-service teachers felt marginalized because they didn't share the same content background as the instructor. In addition, they felt the class context prevented them from learning necessary information associated with their discipline.

Through the eyes of the researcher: A commentary

Throughout this chapter, it seemed evident that pre-service teachers had to value the tenets of citizen science, as presented by Morgan in personal conversation, to create a vision of using it in their own teaching. Many pre-service teachers in this study will hopefully take aspects of ecojustice philosophy and citizen science and merge it with their own philosophy. However, that won't be seen for many years and at that point may only be a glimmer of what Morgan intended. The biggest tension, from my perspective, was the lack of inclusion, reflection, and discussion of what happened in the class. It appeared that many of the pre-service teachers felt isolated and did not embrace the philosophy of ecojustice because Morgan appeared to not make an effort to include them. And why would they willingly include a philosophy that had no room for them?

Why does it seem that citizen science only accommodates learning biology?

One argument that seemed consistent throughout the course was the lack of discussion on how the pre-service teachers could apply citizen science pedagogy to chemistry or physics. While the biology students may not have accepted the methods of citizen science, they could find ways in which it would be relevant to their content area; the discussions in class centered primarily on the life sciences. The underlying tenets of ecojustice are a viable tool for teaching science methods, but without reflection and direct discussion these ideals may be swept under the rug for lack of understanding or willingness to put in the extra work. Without an obvious or openly and thoroughly discussed avenue for connecting citizen science with chemistry, physics, and physical science, these pre-service teachers expressed frustration. They seemed validated in the notion that their content area was too difficult and could not accommodate anything other than a ‘traditional’ instructional format.

A related concern was Sarah’s perception of inequitable treatment. Morgan admittedly biased citizen science as the right way to teach, but in doing so may have alienated those who were never given clear ideas on how citizen science could work for chemistry or physics. In most examples throughout this chapter, issues of ‘injustice’ towards the pre-service teacher involved a non-life science major. It was a valid argument that those who didn’t appear to buy into citizen science were treated differently. Whether this was intended or not, it must be assumed that Morgan had a purpose. By distancing students based upon their acceptance or disagreement with citizen science pedagogy, the possible connections that could have been established were further eliminated; yet one of Morgan's personal arguments was that the course was never intended to 'convince' all of the pre-service teachers to accept the philosophy, and that maybe it does only matter if you just reach a few. If the argument Morgan intended was addressing the needs of the majority rather than the minority, a stance that was against the "No Child Left Behind" mentality and the standards movement, then addressing the needs of only the life science teachers was what he intended to accomplish. However, my argument would be that are we really telling our pre-service teachers if you don't align yourself with the majority, your ideas don't matter? Do you really have to be in the majority to be valued in education- doesn't ecojustice philosophy encourage the success of all? Or is success and reward available only to those who accept your ideas, or pretend acquiescence. It would seem, to me, that the intentional bias that appeared to exist for life science students and against 'the others' was in direct contention with ecojustice as was defined by Morgan. However, this is only my interpretation and may have been intended as Morgan's method of emphasizing the value he found in utilizing citizen science pedagogy; his intent may have been to make others feel inadequate so they would take up the banner of ecojustice philosophy, if only to please the instructor.

Levels of involvement and understanding may only be evident in the future teaching of these pre-service teachers. Within this course, pre-service teachers' beliefs about citizen science ranged from acceptance to rejection, to feigned acceptance in an effort to garner Morgan's approval. Presenting oneself as being compliant to the greater goal of the instructor didn't promote a challenging of ideas; it promoted consistency in the current system of "getting by". While Morgan would arguably never ask for the pre-service teachers to pretend acceptance, they often presented a belief that temporarily aligned with what Morgan portrayed as ecojustice; yet, I would argue that these beliefs may have only been short-lived.

Discussions throughout this chapter reveal that context was viewed as essential for learning. Simply exposing pre-service teachers to techniques for outdoor education didn't mean they would have the ability to transfer these strategies to a new location and use the knowledge they learned. As was evident in much of the discussion, the focus on outdoor learning led the pre-service teachers to assume citizen science focused only on life science. While, arguably this is not the case, a lack of conversation promoted this misconception.

Challenging their current assumptions

Another key tension was the challenge to assumptions deeply embedded in the beliefs each pre-service teacher brought with them to the class. Diverse experiences that influence the ability to teach and a student's willingness to learn are essential for addressing assumptions that have long been present in society. Understanding how learning can best be accomplished requires the teacher to account for these established attitudes; therefore, presenting the pre-service teacher with alternative assumptions may help them learn how to handle this in their own classrooms. One of the challenges for pre-service teachers in using citizen science to frame instruction was that it sometimes prohibited other underlying assumptions about education from being addressed. The largest assumption, arguably, was the idea that each science discipline was separate and had no obvious connection to the other sciences. This assumption, according to many of these pre-service teachers, was validated in that never did conversation arise on how they could design or plan for a science curriculum that unified multiple content areas. Possibly, the belief in standards-based instruction was too ingrained for these future teachers to accept a pedagogy that apparently had no concern with standards or mandated assessments. While the introduction to new ideas can be valuable, integration with personal teaching philosophies may never happen since, in this course, the challenge was left as just a gauntlet for change with no attempt to help the pre-service teacher begin accommodating a new idea. In theory, the pre-service teachers experienced a similar challenge. However, the pre-service teachers didn't know how to progress past acknowledging the differences and transition into making citizen science pedagogy a reality in their own classroom. Never providing a directed opportunity for discussing how to relate citizen science with specific content areas may have led to the idea being discarded in favor of maintaining the familiar.

In considering the course as a philosophy course rather than a science teaching methods course, we have to reconsider Morgan defining citizen science as an advanced technique for teaching. On one level, the portrayal of citizen science as an advanced technique makes sense; Morgan placed less emphasis on becoming informed and more on participation and advocacy. However, it was difficult for the pre-service teachers in this course to move past the premise of a basic foundation knowledge towards one of advocacy; the challenge was in being able to participate and fight for something without having been taught how to determine whether or not action was necessary, and in turn what those actions might look like.

Addressing the standards

In theory, citizen science could be used to teach standards-based science; however, it would require a degree of involvement that many new teachers may not be prepared to handle. While the pre-service teachers expressed concern for using citizen science pedagogy in the context of a standards-based curriculum, they might have been more amenable to the idea had they been presented with explicit examples in the course. Through conversation and modeling of a standards-based, citizen science approach, Morgan might have convinced more pre-service teachers to buy into the teaching philosophy he advocated. Following the same line of argument, Morgan argued that students who were exposed to citizen science learning practices would perform better on standardized tests. While this claim was not validated through any type of conversation, it could have potentially been accepted by the pre-service teachers as fact. With increased conversation, proof of claims, and inclusion of other content areas it would likely be easier for the prospective teachers to more carefully consider using citizen science.

The data from chapter four was more deeply analyzed with the emergent themes used to generate larger tensions. These larger ideas are related to current literature in science education and serve as a more comprehensive representation of significant findings from the research data. Chapter five includes a discussion of these tensions, and the relationship they have to science education. Tippins and Nichols (2006) use 'tension' as a way to collectively represent themes from their research for promoting deeper analysis and discussion of the data. 'Tension' is used neither as a negative or a positive term, rather as an act of suggesting questions and the need for further dialogue. It is used in this study to represent a larger theoretical positioning for the many themes present in the data and serves to extend discussion around the topic of using citizen science as a framework for science teacher preparation. Within the context of these tensions, literature was reviewed for enhanced understanding of how this study related to the larger existing body of science education research. Contrary to a traditional literature review, relevant literature is woven into the discussion of the data, with a detailed description of how particular strands of literature were selected (see Appendix X). An overview of literature relating to citizen science, ecojustice, and science teacher preparation, which served as the broad context for the course, was discussed in chapter one. Additional information may be referred to in this chapter in relation to previously mentioned content, as it pertains to enhancing theoretical understanding. Here, discussion focuses on what proved significant in making sense of the tensions which arose from the data and how those tensions are significant to science education. The literature addressed is used to expand the argument and broaden theoretical understanding.

CHAPTER FIVE

Discussion of Tensions and Research Implications

Deeper analysis of the data presented in chapter four was conducted in order to identify and highlight themes unique to the experiences of both the instructor and the pre-service teachers in the context of this innovative course format. Emerging themes included: the use of nature as an instructor, the role of co-educators in promoting learning and furthering the goal of citizen science, positioning of a teacher preparation course as a philosophical endeavor rather than a course on teaching of methods, and the value in making science learning contextual. Not all themes identified in the data are included within the above description and not all are elaborated here as larger theoretical ‘tensions’. The larger tensions discussed in this chapter include:

- Practice to theory or theory to practice: Grounding science in context rather than content
- Embodied learning: Becoming what you are and will be
- Building communities: Encouraging intellectual discourse

An examination of these tensions, together with relevant science education literature, provides a clearer interpretation of how the research data has the potential to influence and promote controversy and decision-making within science teacher education.

How do these tensions work together in answering the research questions?

The discussion of these tensions highlights a broader context for structuring pre-service secondary science teacher education courses. The overarching tensions outlined above work together in answering the initial research questions of:

- What can be learned when citizen science is used as a framework for teaching and learning in a secondary science teacher preparation course?
- How do participants make sense of learning to teach in a secondary science teacher preparation course designed around the organizing framework of citizen science?

Question one, specifically emphasizing what can be learned from use of the citizen science framework is addressed through each of the aforementioned tensions. The idea of practice-theory and theory-practice represents how both Morgan and the pre-service teachers experienced the course, with embodied learning further highlighting the nature of what learning appeared to entail. Question one, which promotes an understanding of the varied roles each individual took within the class and how various collaborators were involved in the construction of knowledge, is also supported by the discussion related to the building of communities. Question two, focusing on how participants made sense of teaching, is evidenced specifically in tensions of practice-theory/theory-practice and embodied learning; aspects of how teaching was understood also appear in the building of a community of learners. Hence, both of these questions have aspects which are addressed over the broad spectrum of the three tensions which are detailed below in relation to the research data and current literature in the field.

Practice to theory and theory to practice: Grounding science in context rather than content

The first tension of ‘practice to theory’/ ‘theory to practice’ focuses the discussion of data around what science teaching actually meant for the participants in this study. Evidenced throughout the semester, conflicts existed between the practicing of teaching skills or learning theories for later teaching practice, for both pre-service learners and the instructor. Expectations about what individuals want to learn, how they think they should be taught, and the personal restrictions which instructors place on themselves tend to influence the struggle for making sense of learning to teaching.

Many science teacher educators would agree that teaching to encourage transferable understandings of what ‘practice’ entails is challenging. They might also agree that at times, practice is represented without the benefit of understanding theories of learning which directly relate to that ‘practice’. Korthagen, Loughran, and Russell (2006) share the need for teacher preparation programs to change their status quo which considers theory as something transferable through lecture directed towards future teachers. They suggest modifying current expectations for teacher preparation to allow prospective teachers an opportunity to apply theories before they actually begin the practice of teaching. Martin (2009) shares her experiences and understanding of teaching practice and theory while using the work of Roth and Tobin to argue for context as an essential component necessary for aiding pre-service teachers’ ability to make sense of learning to teach. Her work indicates that more developed knowledge of teaching practice and theory could promote a major “epistemological shift in understanding how teaching and learning occurs” (Martin, 2009, p. 574). Martin furthers this explanation by emphasizing the potential value in having pre-service teachers consider how they will teach science, in addition to how their students will learn. ‘Theory to practice’ and ‘practice to theory’ are approaches to teaching (and learning) that involve processes of understanding which relate to pre-service and in-service teachers, as well as educational researchers. In order for this argument to be comprehensible, there must first be an explanation of what these two approaches entail and how literature delineates between them.

‘Theory to practice’, as described by Martin (2009), considers an approach to teaching and learning that is very de-contextualized, focusing more on strategies for instruction that may not be transferable to another location or another aspect of society. One concern with the use of a de-contextualized approach is that learning environments may differ vastly and, without training and dialogue, the pre-service teachers are ill-equipped to negotiate teaching and learning in different settings. One way to consider a ‘theory to practice’ approach is exemplified in classroom management where the teacher stands in front of a class of students and turns off the lights, in an effort to gain the attention of the class. The teacher educator would ‘perform’ this action and discuss it as a way of managing behavior, but the ‘act’ of turning out the light does not encourage the pre-service teachers to consider or reflect on the possibility that not all populations of students will respond to this ‘practice’ in the same way. The ‘strategy’ described by Martin (2009) may seem familiar to many, however, most educators would agree, from experience, that not all theories of education can be generalized enough to work in every situation.

In contrast, Martin (2009) shares ‘practice to theory’ as being contextualized, where learning and teaching occur within parameters that prove more relevant to the prospective teachers. The ‘practice to theory’ approach situates learning and teaching within a socio-cultural context, one in which experiences are embedded within a familiar set of circumstances. ‘Practice to theory’ tends to represent a more applied approach that enables prospective teachers to learn teaching practices which are transferable and inclusive of multiple perspectives that could aid in more effective teaching and learning (Martin, 2009). In understanding ‘practice to theory’, it is important to recognize that theory is still a major part of the practice; however, there is not the assumption that one action will work in all situations. In science education, learners are encouraged to discuss and consider the potential factors which could promote or hinder a certain ‘practice’. These opportunities for dialogue may likely encourage greater reception in their later application. The following table draws on various bodies of literature to provide an overview comparing and contrasting these two approaches to teaching and learning.

Table 11. Contrasting and comparing 'theory to practice' and 'practice to theory'[17]

Theory-Practice	Practice-Theory
De-contextualized	Situated/embedded
Includes ‘strategies’ that may not be ‘transferable’	Encourages making sense of theory by taking part in an experience within a socio-cultural context
New teachers struggle in knowing when to apply certain ideas	Involves learning process rather than recipe
Instruction is geared more towards examples rather on application	Includes aspects of reflection and dialogue

Additional literature discussing the ‘theory to practice’/’practice to theory’ debate positions learning in different ways while suggesting that both are part of a process which

[17] Korthagen et al. (2006); Martin (2009)

all educators transition between in much of their praxis. In this study, challenges were obviously felt by both the instructor and pre-service teachers in determining the most appropriate way in which to conceptualize instruction. The tension that exists between ‘theory to practice’ and ‘practice to theory’ provided opportunities for both Morgan and the pre-service teachers to make predictions about the ‘stance’ they wanted to take for their future instruction. The question in science teacher education becomes one of teaching and learning and whether the focus should be on ‘theory to practice’, ‘practice to theory’, or a combination of both; alternatively, it may be that the two approaches to teaching and learning science are incommensurable.

Consider the following statement by Stetsenko (2008) describing the ‘practice to theory’ or ‘theory to practice’ debate which exists in most educational arguments.

> …knowledge embodies past practices, at a given point in history and in a given socio-cultural context, to only momentarily reflect these past practices through the lenses of future goals in what essentially are continuously expanding and unbroken cycles of ‘practice-theory-practice’. In this sense, thought and knowledge (including theory and concepts) entail action from which they spring and for which sake they exist. Thought and knowledge therefore appear as practical acts in the world because they always come out of active transformative practices and always return into them, serving as but a step in carrying out these practices and having their grounding, their mode of existence, and their ultimate relevance within these broader transformative practices. (Stetsenko, 2008, p. 531)

Stetsenko further elaborates 'practice to theory'/ 'theory to practice' through this statement by indicating that knowledge is gained through contextualized action with theoretical understanding becoming intertwined with the process of practice. While not seemingly specific to the idea of teacher education, this argument suggests the need for pre-service teachers to gain exposure to multiple realities and 'learning contexts' in an effort to encourage thinking and action in their future teaching. Now, given this idea of understanding and implementation of knowledge, theory, and action, it becomes more evident that dialogue must take place for individuals to actively become engaged in the dialectical process of practice-theory-practice which Stetsenko describes.

Korthagen (2001) provides an extensive review of theory-practice literature as it relates to science education. One of the key points he mentions in his review is the challenge which prospective teachers face once they have left course work about teaching and are finally in the field. He describes how new teachers (even student teachers) become overwhelmed with the contextual concerns they face on a daily basis, often dismissing what they have learned in favor of survival. In Korthagen's (2001) review, he suggests that pre-service teachers should respond to the whole of their prior experiences, creating a portrait of what they think teaching should include. Essentially, he argues that many pre-service teachers expect a recipe for how they should teach their future students – a recipe that they can fall back on for their instruction, even as they emphasize the lack of value it had for them as students. Rose, Bernie, and Sarah repeatedly expressed concern over what they perceived as a lack of 'methods' in the course. Conversation with this group of pre-service teachers indicated a yearning for learning 'methods', since that is what they understood and had previously experienced as 'learners'. In their image of what teaching should be, ‘methods’ was something they anticipated; accordingly they expressed discomfort in not having more exposure to specific teaching strategies. In essence, the pre-service teacher participants anticipated a constant barrage of ‘theory to practice’ design for their teaching preparation and were somewhat unsettled when this approach was not consistently used. What connection to their prior learning promoted a belief in a situated, highly relevant and student-centered science yet, at the same time, influenced them to seek out ‘strategies’ for keeping track of behavior and teaching content knowledge? This example illustrates the challenge for science teacher educators in helping prospective teachers discover the connections between theory and practice.

According to the descriptions of ‘Theory to Practice’ and ‘Practice to Theory’ described by Martin (2009), these pre-service teachers were more closely associating their needs for successful preparation for teaching with a ‘Theory to Practice’ framework. Conversations with the pre-service teachers indicated a quest for instructional ‘techniques’ which they could use for future teaching. The prospective teachers’ preferences for learning teaching ‘strategies’ suggested a belief in traditional methods of instruction. Yet, while they wanted to learn the ‘how it was done’ these prescriptive methods did not necessarily represent how they discussed their teaching visions and intentions. The prospective teachers were somewhat contradictory in their opinion of what type of classroom learning environment they wanted to develop (discussed in chapter four) and the expectations for being taught ‘methods’ to shape their instruction. From my observations, it appeared that they wanted to gain both perspectives without realizing that the democratic classroom environment they wanted was also representative of what Morgan wanted to establish in his teacher preparation classroom. For Morgan, personal challenges of following the popular and accepted path of teacher education or developing viability for teacher preparation within an ecojustice philosophy were evident. The dichotomy in his multiple approaches to instruction and disconnect between how learning was intended and received by the pre-service teachers further emphasized the difference between 'theory to practice' and 'practice to theory'. The constant transitioning between 'practice to theory' and 'theory to practice' created confusion and extended, in some part, to how the pre-service teachers understood and accepted citizen science as a relevant pedagogy. An example of this transitioning can be found in how Morgan pointed out specific strategies for teaching that Joni was using, while encouraging the pre-service teachers to take in their surroundings and vocalizing his expectation that they learn from nature. During the class meeting at the large granite outcrop at the arboretum (detailed in chapter four), Morgan's calling attention to specific strategies being used by Joni would represent a more 'theory to practice' approach. In this same class, it seemed that Morgan anticipated that the pre-service teachers' positioning of learning while outdoors would enable a more 'practice to theory' perspective, since he called their attention to the hummingbird, the hawk, and other features unique to the arboretum. Encouraging the prospective teachers to become more aware of all types of instruction does bode well for considering theory-practice-theory which was described by Martin, yet explicit discussion may be necessary for awareness, understanding, and integration. For science teacher education, this dichotomy between 'theory to practice' or 'practice to theory' is especially important as we often attempt to instill a belief in alternative types of instruction that research and experience have proven to be effective. Transitioning between each of these approaches is not reprehensible, yet it is confusing when one approach tends to focus more on abstract philosophical ideas while the other isolates specific techniques. Representation of one perspective is often undermined in an attempt to make the larger population more willing to accept frameworks which seem vastly different on the surface, though underneath represent a more familiar and relevant approach to learning. In Morgan's case, the dichotomy could have been his response to the pressures of conforming to what he deemed a more 'theory to practice' educational structure. As a result of the expectations held by the pre-service teachers in his methods course, it may have been possible for Morgan to have furthered his philosophical intent had he openly discussed the dilemma between teaching theory and teaching practice.

While there were many outdoor experiences in the course, Morgan's actions while outdoors were not so distant from his performance in a more traditional setting. The indoor teaching often involved Morgan giving samples of classroom management strategies, particularly lessons he had learned as a teacher that he 'wanted to share' with the prospective teachers. He even went so far as to direct the pre-service teachers to 'write this down'; there was continued practicing of 'teaching' techniques with the pre-service teachers, with dialogue from Morgan about what the technique represented and when he would use it. While inside the traditional classroom setting, Morgan tended to emphasize learning knowledge and skills that the pre-service teachers assumed could be utilized in multiple settings. The general behavioral management practices he demonstrated, for example, counting backwards or giving wait time, are more representative of a 'theory to practice' approach and directly contradict his espoused intention of promoting a developing teaching philosophy. The idea of 'theory to practice' was represented in the many occasions when pre-service teachers were told about behavior management tools or ways of organizing their classroom for more effective instruction. These strategies were presented within the context of a teacher preparation classroom and lacked a directed theoretical connection to future teaching situations which these teachers may encounter. For the pre-service teachers, Morgan's message was very inconsistent with his presentation. At times, it appeared he wanted the pre-service teachers to experience things and develop philosophy (arboretum and farm visits); at other times he 'gave' them prescriptive strategies which they might assume could be used in all contexts (grouping, classroom management). Morgan appeared to have conflicting beliefs throughout the course as to whether he should teach 'strategies' for the pre-service teachers to use in their future classrooms or adhere to helping them to develop a deeper philosophical understanding of teaching and learning. This is not an uncommon challenge for teacher educators, but it is often a point of contention and an opening for future discussion with the prospective teachers as to how they can modify their own teaching to more seamlessly integrate multiple techniques without an apparent dissention that took place in Morgan's class. Attempting to demonstrate behavioral management strategies while presenting opportunities for them to gain an understanding of philosophy presented far too many challenges for many pre-service teachers to overcome and fully embrace ecojustice philosophy and citizen science pedagogy as a vision for their own teaching. The data suggest that the pre-service teachers particularly struggled with negotiating and imagining what actions they should take in their future classrooms to enact citizen science as a viable pedagogy. As a way of furthering his cause, Morgan's actions in class could have included transferability of ideas relating to citizen science that better prepared the different content areas for using a pedagogy that was often accepted as unappealing. The appeal for many was in the required ‘action’, but it was often difficult for the prospective teachers to make sense of what ‘actions’ they could perform in a specific community or in a specific science discipline.

Another dilemma of ‘theory to practice’ which seemed to challenge Morgan’s intent for the course was the reliance on grading, which was counter-productive to his espoused belief that grades were ineffectual and not appropriate for determining learning. A large portion of the semester was spent on creating opportunities for assessment, many which represented alternatives to the standard pencil and paper approach to testing. The presence of grades and the emphasis Morgan placed on success completion (to his satisfaction) of projects stood in stark contrast to his beliefs about assessment. Morgan regularly expressed preference for contextualized learning experiences, where, in his opinion, graded assessments were of little value. Yet, his words were often at direct odds to the requisite graded assignments pre-service teachers completed. These apparent contradictions seemed to stem from Morgan’s attempts to conform to the departmental expectations of using assessment data for accreditation purposes. These contradictions lead me, as a future university science teacher educator, to question how much autonomy an instructor has in developing a course and fostering a philosophical foundation in his or her students. Observing these contradictions led me to further reflect on how a ‘practice to theory’ idealism could become represented within the traditional ‘theory to practice’ mindset of a university classroom.

Kang (2008) discusses the idea of relational epistemology as having a sociocultural perspective that enables the “teacher” to construct meaning within the established relationship between the knower and the known. She argues that these personal epistemologies are especially relevant to teaching. She further explains how personal epistemologies related to science teaching change over time on the basis of an individual's science learning experiences; this consideration, she maintains, encourages the idea of challenging assumptions as a way of altering current beliefs. Within her study of 24 pre-service science teachers, Kang (2008) noted that the majority (17) considered knowing as a process of being given knowledge rather than as an act of "constructing meaning or seeking one's own answers" (p. 485). The description provided by these pre-service teachers situates learning science as systematic and lacking the context which Morgan attempted to simulate in many of his teaching activities. Science is described by the pre-service teachers in Kang's (2008) study, as a disembodied experience with little relevance or meaning to pre-service teachers' lives and representative of passive rather than active learning. While some of her participants considered learning of science to be a construction of meaning, they still represented themselves as users rather than producers of science content as a body of knowledge. The very nature of citizen science, at least described by literature, represents an active process of making science relevant and authentic to the learner who identifies an issue and gains knowledge by socially constructing meaning with others. Of related concern was the inference Kang (2008) made that her pre-service teacher participants sought to inform their future students about science content, rather than helping them develop the ability to think and 'do' science. These beliefs, attributed to pre-service teachers' personal epistemologies and indicative of how they might negotiate the 'practice' of teaching, were not significantly altered over the semester. In considering Kang's (2008) study, and a methods course that was not designed specifically for challenging current epistemologies, much could be inferred about Morgan's course and the prospective teacher participants' learning. Morgan explicitly intended to promote philosophical development and planned course activities which he believed had the potential for integration of new beliefs; an impetus which was not emphasized as a goal of Kang (2008). However, since epistemology was not a focal point in the research involving Morgan's fall 2009 Methods course, challenges can only be mentioned in terms of their potential for changing the beliefs of the pre-service teachers who participated in the class. While Kang's (2008) study evidenced experiences of learning and teaching and how these influenced the pre-service teachers' ability to interpret practice from theory or theory from practice, similar results were not apparent in the pre-service science teachers in Morgan's class.

The 'practice to theory' approach also tends to suggest that learning to teach is more effective when candidates are embedded within opportunities to gain varied experience. While different than the idea of embodied learning which will be described in a later section, the idea of learning that is situated (or embedded) within a context suggests a degree of internalization that might enable prospective teachers to apply their knowledge in more productive ways. Specific to this research was the Garden Earth Naturalist project which encouraged pre-service teacher involvement in providing instruction to in-service elementary teachers. The project was positioned at a time and location that could have encouraged translation of 'practice to theory', in ways which could foster a deeper understanding of the theoretical basis for citizen science pedagogy. However, this was not highlighted in the class and may have been overlooked. Korthagen et al. (2006) argues for situating teachers within experiences that allow them to define what needs to be learned and in turn become teachers who are enacting their own understanding of theory. Considering this delineation of situated experiences, the Garden Earth Naturalist project was ideally positioned for allowing development of a teacher persona and understanding of practice. However, key components of transitioning into a ‘practice to theory’ approach required constant dialogue among the learners and the co-educators responsible for the event. Lacking these critical moments of discourse and praxis, the activity became something that just had to be done with little influence or relevance to their future teaching. The pre-service teachers were positioned as both learners and teachers in this process, leading to their personal dilemma of what they were supposed to gain from the experience.

In a study conducted by DeWitt and Osborne (2007) which focused specifically on the use of informal learning settings such as museums or zoos, a connection was suggested between context and pedagogy. These researchers argue that changing the setting of instruction requires the teacher to alter his or her pedagogy to accommodate the informal learning environment, and the challenges which exist. Considering the distinction these researchers and in-service teachers placed on the impact changing location had on learning, it could be argued that, for Morgan, a different context would require him to use a different pedagogy. The argument could even be taken so far as to include pre-service teachers requiring a different type of instruction while in the outdoors. Emphasizing location as an impetus to learning might suggest a pedagogical framework more closely aligned with ‘practice to theory’ rather than ‘theory to practice’. The emphasis on citizen science as a pedagogical framework indicated a possible belief that instruction should be contextualized with direct relevance to the livelihood of the community. Learning took place that may have encouraged the pre-service teachers to consider why teaching and learning must take place inside the confines of the four walls of the classroom. Yet, it led me to question why traditional practice is so readily accepted when it is not always the best ‘practice’? What prompts a teacher educator to seek change in personal praxis for the greater good, while being challenged by those who don’t accept the change as positive?

Approaching learning and teaching through situated events promotes introspection about theory and its potential influence on personal educational praxis. An aspect of philosophical understanding expressed in ecojustice was the idea of challenging existing assumptions which are deeply held by individuals, as a way of having them explore alternatives (Bowers, 2001). In the earliest discussion of the course, Morgan argued for the course design as a philosophy class. One way he chose to encourage philosophical interpretations was through his focus on nature as a location in which he chose to hold class, regardless of the specific content which was being discussed on any given day. Placing an emphasis on the comfort level of the students and extending the boundaries of class to include the natural world and the many challenges it presents could potentially encourage a different way of thinking. Expression of thoughts regarding the value of nature, consideration as to why traditional classes were not held outdoors, and discussion of personal discomfort were common. By far, the biggest challenge for the pre-service teachers was in not understanding what existed in Morgan’s choice of nature as a classroom; he personally talked about the value, but it was typically not utilized as a ‘content’ or actually discussed in terms of why class was being held outdoors. Expressing a lack of understanding as to why they were outdoors when location was not perceived as focal point of the day's lesson, the pre-service teachers were challenged to overcome their assumptions that location must be important for situating what they would experience in the day's activity. They were forced to discover familiar components of learning that were allowed to unfold in a non-traditional setting, even without obvious discussion as to why nature was being used only as a setting rather than focus for content-driven learning experiences. The use of nature as a classroom traditionally meant, for the participants, that some component of learning would involve the location. The presentation of an alternative setting raised questions and forced the participants to attempt to 'make sense' of why the location mattered for Morgan. In one sense, the use of a unique context promoted introspection with the potential to extend the development of a more diverse philosophical understanding of what it means to teach and learn science. Another possibility is that the pre-service teachers simply enjoyed the location without any larger transference of understanding as it would relate to their future classroom. It's impossible to know how much of the philosophy they truly integrated and will include in their future teaching.

Within the scope of this type of instruction, Morgan's focus on utilization of nature as a teacher appeared to represent and embrace a 'practice to theory' model of instruction. Expressing his goal of helping pre-service teachers develop a teaching philosophy, Morgan's approach of using citizen science in ways that situated them within contexts that helped to develop awareness for alternative instruction proved viable, if challenging. Through positioning prospective teachers as both learners and leaders, he encouraged a relationship with context which could in turn be integrated within their own framework of understanding what it means to teach. Regardless of the transitioning between theory to practice and practice to theory, pre-service teachers gained exposure to diverse representations of science teaching.

How do we create practice-theory-practice as a cycle rather than maintaining a dichotomy between theory and practice? Practice to theory and theory to practice, as described, are often intertwined through teacher education in ways that make transitions to actual teaching more fluid. Prospective teachers respond well to thinking theoretically, but express a desire to have practical experience that better enables them to handle classroom situations. From this study, it is evident that both approaches are used, expected, and valued. The concern is in how we as teacher educators help pre-service teachers make sense of what an actual classroom looks like and assist them in being prepared for using the knowledge they gain to be more effective teachers. Creating opportunities for explicit dialogue about the processes which are being used go far in helping prospective teachers understand and internalize ideas presented in teacher preparation courses.

Embodied learning

A second tension identified through closer examination of the themes within the study is the idea of embodied learning. Barton (2009) shares her belief that learning is about “deciding who you are, what you want to be, and actively engaging to become part of the relevant community” (p. 415). She also indicates that “knowing” is about connections between socio-cultural, material, and natural world “that give form to being” (Barton, 2009, p. 415). Learning in this way is a process of becoming something, a transition that may entail qualities of what you are but also allows for integration of new things, as a result being and wholly taking part in the experience. While written as feminist epistemology, Barton's (2009) discussion of embodied learning is especially relevant to the course focus around ecojustice philosophy. Positioning nature as both a context and a co-educator allowed the pre-service teachers opportunities to develop emotional, intellectual, and physical connections to what may otherwise have been taken for granted. The conditions of being in nature both encouraged evaluation of future teaching practices while also placing the learners within learning, through their current interactions. Though pre-service teachers were situated within embodied experiences, it was not at the level described by Barton (2009). Embodied learning ideally sparks a need for action or varying levels of advocacy. The experiences included in Morgan's course could promote a greater likelihood of integration of similar practices in the pre-service teachers' future classrooms and the possibility of them 'getting involved' in the communities they eventually will teach. While many of these experiences were far-removed from what the pre-service teachers anticipated or had encountered before, the exposure to citizen science pedagogy may have been positive in allowing the pre-service teachers to gain understanding of what embodied learning entails and how this type of instruction could be utilized in their future teaching. The unfamiliarity with the experience was evident in the way the pre-service teachers responded to some of these learning opportunities. A specific example was in how Rose responded to the complaints of her peers when the group was 'forced' to be outside during a rainstorm, sharing that 'it won't kill them'. This type of experience was something she valued because it allowed her to see the true expressions of nature, be within an experience, and be encouraged to view that experience as both an insider and an outsider. For her, learning in nature truly was an embodied experience since she took in the sounds, smells, complaints, and content which was present and made attempts to determine how she could incorporate similar ideas in her future teaching.

Barab, Zuiker, Warren, Hickey, Goble, and Kwon (2007) conducted research using gaming technology for science instruction within an elementary classroom. They situate game-based learning as representative of an embodied experience, explaining the process in which student-learners enter the realm of technology and progress through the game by individualized decision-making. Through their presentation of context, positioning learning within a framework and allowing the learner control, they encourage students to be ‘within’ a learning situation. However they share concern over how to combine both content and context in ways that allow the individual to remain in the embodied experience (Barab, et al., 2007). Primarily, the concern is how to address the necessary content without removing the learner from the context that is, ideally, encouraging learning on a deeper level. A similar concern, evident in the methods course, was how to allow learning experiences to remain embodied while attempting to facilitate the ‘teacher’ content that was expected by the pre-service teachers. The idea of transitioning from expected content to a focus primarily on context was another potential difficulty for encouraging the learner to remain ‘engaged in’ the experience. Barab et al. (2007) discuss the difficulties in developing contextually rich learning opportunities that increase awareness in the potential relevance to similar situations which may exist. Encouraging awareness for inter-connectedness is a troublesome, if not focal, point to developing learning as an embodied experience (Barab et al., 2007).

The value in utilizing physical location as a context for student learning was emphasized throughout the methods course and as part of the tension of embodied learning, appears to hint at the understanding which the students exhibited in this course. While ‘place’ was never the focal point, the intent of citizen science is to help individuals become more aware of their community, the needs of others, and act as advocates. In order to do that, place has to be an embodied component within the community. In this science teacher education course, place was allowed to serve as an educator that encouraged the pre-service teacher participants to take part in the learning environment. Participation ‘within’ the environment and the subsequent framework of citizen science pedagogy provided space and an example from which to decide for themselves whether they would utilize this structure in their future teaching. Arguably, preparing the pre-service teachers in this way promotes a personal understanding of the world regardless of whether this transfers to their own classroom. There are inherent benefits to this type of teaching. Even without transference to future students, the pre-service teachers have gained experience in observing their world and making decisions about what they deem relevant and valuable for the teaching and learning of science.

Barton (2009) also emphasized something called *counter knowledge* as that which is held by individuals who are considered marginalized, arguing that an awareness of these differences actually represents embodied knowledge. Embodied experiences position an individual for becoming a stakeholder and defending a location, a people, or an idea. The argument could be made that without first-hand knowledge and experience there is no true understanding. One of the significant challenges in embodied learning is that it focuses on a social context and entrance into that world and this is often counter to an individual’s existing knowledge if he or she doesn’t reside within that community. Barton (2009) argues for counter knowledge as integral to embodied experiences through her description of a seemingly ecojustice-based project. The example she provides involved a geologist who uncovered evidence of environmental toxins within a low income community. The knowledge this geologist revealed was presented to the community who then took action and became experts and decision-makers, influencing their own lives and local environment. Not all of the description Barton shares rings true to citizen science- specifically the idea that a scientist is one that ‘enables a disempowered community’. Citizen science, as it was presented during this course and understood by the participants, provides opportunities for individuals to learn at the ground level, construct knowledge and acquire a skill set that promotes learning from the ‘ground up’ while sparking individuals to take action.

A critical component of citizen science which was described by the pre-service teachers in this study was the value it could have for increasing scientific literacy. Barton and Hamilton (1998) argue for considering literacy as something broader than simply the contents of what is included within the traditional institutions of learning. They suggest looking at “informal learning strategies and resources people draw on in their lives” (Barton & Hamilton, 1998, p. 21). In a study conducted by Roth and Lee (2004), the argument is proposed for scientific literacy to be considered as a process of interaction and learning from others – a process embedded within a community from which knowledge is present and influences daily life. They further express the understanding that not all individuals learn science in the same way, hinting that there should be degrees of democratic freedom in the activities and roles students take while learning. Roth and Lee’s (2004) argument of “rethinking scientific literacy” is situated within a middle school where a local stream/watershed serves as the context for learning science.

Emphasizing the use of alternative learning opportunities that allow individuals to become part of what they are studying and make decisions regarding how they will collect information and what form of understanding will emerge, the students are guided by people in the community who allow them freedom to express interests that are unique to what they need to learn (Roth & Lee, 2004).

Within the discussion of their findings, it could be inferred that a lived curriculum actually represents an embodied learning approach which considers the multiple content areas that could potentially be addressed through the use of citizen science as framework for teaching. The overall description of the project reveals one which encourages community involvement, allows stakeholders to make decisions about what they want to learn, interact with the larger population to share what they have found and potentially develop solutions to environmental problems that were uncovered (Roth & Lee, 2004). A key factor in their study was the involvement of different generations in the construction of knowledge and identification of a 'problem' to study. Additional components of their study involved consulting an elder as to the ancestral health of a stream, having a parent work with the students in the collection of data during the 'field experiences', and allowing the students to be responsible for developing ways of representing their findings to the community. Roth and Lee (2004) suggest that the interactions of the students, who served as knowledge experts, with the community, evidenced a degree of scientific literacy that might not otherwise have been recognized. Community-involved projects such as the one they describe place the power in the hands of all because the data which are collected and represented indicate knowledge gained by everyone involved, and not just something held by the 'scientists' in an abstract way.

Ownership of knowledge, in the case of Roth and Lee (2004), seemed to promote an understanding of embodied learning that allows for "engagement in" rather than "preparation for" science. The work of Roth and Lee (2004) connects to the methods course two-fold. On a basic level, the style of teaching which encourages student ownership for meaning making while experiencing embodied learning represents the intended action of Morgan in designing a course that would allow the pre-service teachers an opportunity to engage in the construction of knowledge about teaching, rather than telling them about it. The second way in which this study is particularly relevant is that it highlights citizen science in action, within a middle school; it further evidences the ability for middle school students to learn in alternative settings, as well as the ownership and responsibility they were given as a part of their larger community.

Several opportunities for embodied learning were presented in the methods course, with specific examples including the fire training, the Garden Earth Naturalist workshop, and the farm visit. Opportunities for learning about lab safety in the science classroom typically include discussion and observation, but rarely practice in real-life situations. Within this course, the pre-service teachers' were able to be outdoors facing a real fire, holding a fire extinguisher in their hands and actually 'putting out' a fire. After learning about safety through a lecture and experiencing years of science laboratory procedures over their lifetime, they were handed over the responsibility of 'engaging in' rather than 'preparing for' learning. Aside from the obvious action involved with this highly personalized experience, Rose mentioned that having an opportunity to actually put out a fire gave her confidence in herself to handle safety emergencies in her future classroom. Arguably, her confidence came from actually experiencing learning rather than being told what it looks like. The second event representing embodied learning was the Garden Earth Naturalist project, which also served as an excellent representation of citizen science. The Garden Earth Naturalist project was an excellent example of the potential in embodied learning, from the initial project introduction to working with a group and finally presenting what was learned to others who were already viewed as experts. This project allowed the pre-service teachers to take on a role that was unfamiliar to them and become actively 'engaged in' something that encouraged them to recognize themselves as teachers. Taking on the role of teaching the elementary in-service teachers who were involved with the Garden Earth Naturalist program provided a way for the pre-service teachers to connect learning with the process of teaching. The tenets of citizen science which were described by Morgan highlight the potential for embodied experiences as representative of advocacy, which were apparent in the activities selected by the pre-service teachers. In discussion of their Garden Earth Naturalist program protocols, each group generated a brochure outlining a citizen science project that would allow the in-service teachers and their students to become involved in some environmental issue at a level of advocacy. Encouraging the pre-service teachers to collaborate and decide upon what specific citizen science projects they wanted to introduce as part of their Garden Earth Naturalist protocol presentations allowed them to view options which could be utilized in their future classrooms and afforded them a chance to discover more about citizen science.

An interesting point of Barton's (2009) initial argument about embodied learning was her suggestion that conversation on and around scientific literacy should shift to encompass more than content and attempt to include deeper levels of embodied understanding. Considering the place pre-service teachers gave citizen science in defining scientific literacy, Barton's argument is logical. There were many examples of the pre-service teachers relating scientific literacy to their current understanding of citizen science, examples which came from their prior experiences and developing awareness for what being literate in science actually meant. Integration of daily events and encounters were used to help individuals make sense of the role of science and become better able to recognize the effects science may have in their world, and the influence they might have on their world using science. For example, the pre-service teachers talked about being at the arboretum and realizing they were doing science which was like their 'hard core science' classes, with excitement that their future students could do similar activities that were based on science. The outdoor introduction to the Garden Earth Naturalist project helped the pre-service teachers realize that science (such as that which they considered themselves doing both in prior classes and in the rain) could be replicated in their classrooms – and positioned the goal of scientific literacy as something easier to comprehend. Another aspect of the course which could be considered as representing scientific literacy as part of an embodied learning experience was evidenced when pre-service teachers were able to make connections between the granite outcrop at the arboretum to other areas of the world, while interacting with it and learning science. Truly representative of embodied learning was the field trip to the organic farm, and the experiences the students had in learning about farming practices, followed by an opportunity to work as a team. The time spent taking apart the garlic cloves allowed the pre-service teachers to ask questions about its ecological and health promotion purposes. The actions involved with placing garlic in the ground, being on hands and knees in the dirt, provided a way of gaining knowledge on how to grow a particular ‘plant’ and the potential impact which that plant has on the environment. All of this happened through the pre-service teachers actively ‘engaging in’ learning.

Another particularly compelling aspect of this study was the influence of collaborators in fostering understanding. The collaborators, or co-educators, encouraged each pre-service teacher to make sense of what was being given and how the information related to their personal livelihood and interest in potentially teaching that content. Nature as an instructor can be particularly challenging for those individuals without an interest in the outdoors or an understanding of how the context could influence their teaching of science. In particular, the non-life science majors could not always attend to the possibility of teaching outdoors because they had no connection to what that looked like within their discipline. The use of collaborators placed value on all individuals and their role in the learning process and emphasized the ideal situation in which everyone has a voice and every voice can teach you something. While this ideal did not always appear to be upheld, it was a mentioned goal Morgan had for the course. Inherent in the notion of co-educators is the value placed on non-human components of our educational system. By non-human components, the methods course was structured so that nature could serve a role as a co-educator. Different than the people who worked in collaboration with Morgan and the pre-service teachers, the role of nature was one of a silent teacher. Having a presence in many of the classroom activities, serving as a backdrop, and promoting different learning environments were some of the varied roles that nature played in its instructional role.

True to the tenets of citizen science are the ideas of participation and the existence of multiple knowledge holders, which were represented in these collaborations. Roth and Lee (2004) highlight the role of collaborators in their study and discuss the idea of embodied learning, acknowledging the legitimacy of stakeholders in the community and emphasizing the value found in living what is studied. It might be argued that for true collaboration to occur, knowledge construction must include conversational opportunities. Such conversations should reflect equity in terms of asking questions and generating responses that serve to encourage greater learning and internalization of what is being learned.

Throughout the semester, pre-service teachers were engaged in learning experiences that often allowed them to understand a larger purpose for science education. In order for changes in science teacher preparation to occur, as Morgan's intent, opportunities are required that create spaces which encourage time for embodied learning experiences that are more inclusive of community and diverse populations. Pre-service teachers expressed value in learning at a deeper level, with the inclusion of specific ideas being added for enhancing this type of learning. Some of these suggestions are included in the following tension.

Building community: Encouraging intellectual discourse

Throughout discussion with participants in this study, and observations of encounters, it was apparent that some form of community may have developed. However, functional learning communities that encourage intelligent discourse require effort and time which was not evident in this course. This tension addresses why communities need to be developed that provide pre-service teachers with space and time to communicate about what they have learned, how it is valuable to education, and what it means to the larger group of individuals with whom they associate. As will be highlighted in this section, much of the literature suggests appropriating energy within teacher preparation for fostering a community of learners that enable discussion of useful teaching ideas and promote a support system for new teachers.

According to McMillan and Chavis (as cited in Handa, 2008), individuals tend to feel a sense of community when they are accepted, and thereby feel a sense of belonging to a group. This acceptance encourages communication and intimacy within the group, making the bonds of acceptance that much stronger. Handa (2008) furthers the idea that community 'involvement' must include "membership, influence, integration and fulfillment of needs, and a shared emotional connection" (p. 140). A key part of Handa's (2008) description includes members with similar interests sharing experiences and dialogue which may have the potential to transform thought and action. Understanding community in this light would suggest that the very nature of a teacher preparation course would establish a relationship between the participants which would be representative of a 'community'. That is not a point of argument. What is suggested is that the 'community' could be enhanced by greater guidance from the instructor and co-educators who served a pivotal role in the course. Greater involvement by those individuals with teaching experience may help the pre-service teachers develop into a more 'thought/action' oriented group who work together in more productive ways to- discuss learning to teach, make sense of what others believe, and internalize these ideas to make the process of learning and teaching more meaningful.

Bell (1998) describes a social constructivist perspective as knowledge being a product of interaction with others, making it both social and personal, with considerations for the context and the role of interactions with others in reconstructing knowledge. Interaction and the establishment of specific communication were encouraged in the methods course, but to a lesser degree than one might deem necessary for constructing knowledge or understanding. The idea of building a community of learners forces the question of what constitutes a community and how does it become functional within the teacher preparation context? Extending the notion of a community of learners to include a community of discourse could promote much needed interaction on an intellectual level. Meaningful learning interactions likely require personal reflection, introspection, and group dialogue with others having similar experiences. The possibility for this type of discourse was rich in this research study, yet productive moments of discourse were deemed lacking by many of the pre-service teacher participants.

Yore and Treagust (2006) further maintain the need for discussion, suggesting the presence of multiple forms of discourse for advancing scientific literacy and enhancing student abilities for future encounters with science. Dialogical discourse is described by Costa, Baker and Shalit (2008) as a form of collaboration in which "connections to other ideas and issues" are considered from many different points of view (p. 142). Dialogue, as described here, can occur within oneself or among many as a constant flow of 'meaning'. Dialogue, sharing ideas as a way of negotiating meaning is a critical aspect of building a culture (Costa et al., 2008). Within the context of Morgan's course, this type of dialogue would likely be critical to building and developing an intellectual discourse community. Intellectual discourse, considered as interaction with self and others, furthers understanding or involvement with a particular idea and could prompt reflection and internalization of the philosophical context which was intended. Adjusting or positioning discourse within a philosophical context includes the notion of embodied learning but the idea extends to focus more on how personal beliefs are impacted as a result of experience. Without extended conversation, the pre-service teachers may not become aware of the experience as truly embodied – allowing it to remain simply situated within a context but not incorporated into their personal philosophy as an alternative to their current beliefs about teaching and learning. Allowing the opportunity for pre-service teachers to 'be' the experts encourages them to view one another as co-constructors of knowledge and indicates willingness by the instructor to give up power that often seems one-sided in more traditional classrooms.

Zembylas and Barker (2002) conducted a study with pre-service elementary teachers enrolled in a science methods course to attempt greater understanding of their beliefs and attitudes related to science. There were over sixty students, divided into two sections of elementary science methods – with one course taught by Zembylas and one taught by Barker. The professors arranged, prior to the beginning of the semester, to follow the same syllabus and use similar assessments and activities in the two courses which served as the context for their research (Zembylas & Barker, 2002). Through their research, they propose that teacher education programs should allow for pre-service teachers' beliefs to be challenged. These challenges are suggested as a way of transforming the prospective teachers' understandings of science through the teacher preparation they receive in the methods course. They specifically designed the two elementary methods courses, which served as the research setting, to allow for space in which the pre-service teachers could reflect upon how the learning experiences they took part in might influence their future teaching. Samples of these learning experiences included reading assignments, opportunities to explore science through various materials which were made available, and through completion of assignments which encouraged the pre-service teachers to gain a deeper understanding regarding their attitudes about science. In their study, Zembylas and Barker (2002), conceptualized spaces for reflection to "include material, intellectual, and emotional elements", which serve as safe areas for interactions and opportunity for the researchers to understand how aspects of teaching and learning might be "enacted" within the confines of the pre-service teachers' future classrooms (p. 332). For the purpose of their course, the spaces encouraged the development of a community of discourse that allowed for "collaborative conversations…spaces for teachers to become aware of and name what is learned and how it is learned. These conversations [provide] spaces for pre-service teachers to reflect on their journey to become teachers with a deeper understanding of science" (Zembylas & Barker, 2002, p. 332). These researchers support the notion of conversation rather than dialogue as a means of encouraging teacher growth. Zembylas and Barker (2002) note that dialogue describes something recorded by one individual, typically the author, and not representative of interactions occurring between participants. They further argue that questioning, sharing, and refining ideas through group discussion helps the pre-service teachers learn how various concepts are 'understood' by others in the same circumstances. Conversation allows for the development of meaning for all parties involved in the construction of thoughts and presentation of understanding (Zembylas & Barker, 2002). That space for conversation and interaction, according to Zembylas and

Barker (2002), allowed for an “evolution” in views and attitudes about science teaching (p. 346). Their emphasis on communication implies a direct connection between personal beliefs and the potential for change/growth through interactions with others.

In relation to the methods course in this study, the ideas of discourse, dialogue, and conversation are pertinent. Each serves to delineate a different way of vocalizing and internalizing the ideas which the pre-service teachers wrestled with over the semester. In thinking more specifically about the interactions, it could be argued that dialogue was what occurred within each participant as they attempted to make sense of citizen science and the theoretical structure of teaching science. Evidence that this dialogue continued over as a form of discourse with their peers in outside of class interactions was apparent in the luncheons I took part in, the emails between participants, and the communications I had with them. Dialogue about the course was also likely in other courses which were shared between the pre-service teachers – the cohort took at least two other classes together, and car-pooled to the practicum with their peers. Conversation, as described by Zembylas and Barker (2002), would be the idealized way of establishing a community of learners as a means of furthering the understanding and re-structuring of beliefs and prior knowledge about teaching and learning. Argued throughout the data, Morgan emphasized the importance of philosophy and his attempt to alter the mind-set of the participants in his class. Zembylas and Barker (2002) further maintain that to truly change the face of teacher preparation, conversation spaces must be created which foster a developing community of teachers and learners. A stronger emphasis on including the co-educators in the class conversation might have enhanced the "safe spaces" and promoted an additional level of understanding from the perspective of a scientist rather than educator. The introduction of an alternative framework, such as the ecojustice philosophy of the course, almost necessitates the opportunity for conversation spaces to be created since, as argued by Zembylas and Barker (2002) "learning how to teach science is a deeply emotional activity in which the individual concerned has to deal with his or her prior emotions and attitudes in the light of the past and present experiences" (p. 346).

Positioning science education as a philosophical endeavor and encouraging participants to partake in the ideology of citizen science as pedagogy requires opportunity for dialogue. It could be argued that citizen science represents, as was described earlier, a 'practice to theory' approach for learning. An approach to learning that requires the individual being situated within a socio-cultural context; with this approach discourse opportunities MUST exist for the participants to fully grasp the concepts of citizen science and the idea of a 'practice to theory' approach. Why does this matter? It has been argued throughout this paper that citizen science promotes a degree of learning that encourages involvement in the natural world, producing individuals with deeper connections to both society and environment. These connections may prompt pre-service teachers to act within the framework of their understanding as advocates for a greater good - be that teaching and learning, or something else. At the risk of sounding unrealistic, it has the potential to make the world a better place. As was seen in the description of ecojustice, the combination of environmental and social concerns, the meeting of two ideals encourages thought about how decisions made today impact what tomorrow looks like. While this task of teaching science education in the broader context of 'saving the world' is daunting, is it not worthwhile given the possible result? It could be suggested that encouraging communication and interactions with others helps position empathy and develop a passion for making a difference.

Kaartinen (2009) conducted a study with pre-service chemistry teachers enrolled in a "compulsory course on chemistry teaching" (p. 604); the focus of her study was to gain an understanding of how these pr-service learners made sense of learning to teach chemistry. Through collaborative strategies that required them working together, talking about what they were understanding and how sense was being made, she discovered a more positive attitude about teaching chemistry that entailed confidence in personal abilities which may have resulted from "joint" construction of knowledge. Teaching is a 'negotiated and re-negotiated' process of introspection, conversation, and implementation, actions which Kaartinen (2009) suggest as necessary for learning to teach. The focus of Kaartinen's (2009) study was in determining learning practices of student-teachers enrolled in a "socioculturally oriented teacher education course" (p. 603). A component of data analysis was to "investigate the nature of discourse processes and collaborative activity" (Kaartinen, 2009, p. 605). The teacher educator in Kaartinen's (2009) study took on a role of facilitator, as the student-teachers participated in a reflective and collaborative experience which influenced their ideas about teaching and learning as the course progressed. In discussing the findings of the study, Kaartinen (2009) indicated that student-teachers worked collectively to create understanding, and in turn became "members of communities of practice of science teachers" (Kaartinen, 2009, p. 614). This study is significant to the tension of building communities of intellectual discourse in that it suggests evidence that pre-service teachers benefit from experiences of communicating and working collaboratively with their peers. Kaartinen (2009) suggests that collaboration promoted discourse which in turn likely altered the pre-service teachers' understanding and appreciation for chemistry, serving as an excellent example of the potential for Morgan's class to develop similar outcomes.

The methods course in this study was characterized by diversity in experiences and educators. However, opportunities for true reflections and peer dialogue were not fully promoted within the class activities. In the beginning, pre-service teachers were encouraged to construct meaning as a group (recall the defining of citizen science in relation to scientific literacy) but those opportunities were not as evident during later class meetings. This is not to say that dialogue outside of class did not occur. Lunch meetings included overheard conversations about teaching; interviews indicated a continued dialogue between the pre-service teachers about teaching and learning. Given the goal of Morgan's design of the course as a philosophical endeavor- debate, dialogue, personal sense-making, and questioning needed to be encouraged in settings where he could take part in 'forwarding' the conversation. The pre-service teachers may have discussed specific questions outside of the classroom context, but researcher access to such conversations was limited to second-hand comments from the participants or experiences previously described. In addition, outside conversations may not have been as beneficial as constructed conversational spaces in class, since not all learning and teaching partners were present to guide the questions and attempts at making sense of how others experienced the events of the course.

While Morgan's course presented varied locations and opportunities for dialogue that could encourage development of a teacher community, the absence of true collaborative opportunities may have impeded collective learning and understanding of teaching. Within many of the interviews, pre-service teachers indicated a 'need' to talk about what they were learning. Liang, Ebenezer, and Yost (2010) conducted a study with pre-service teachers who were enrolled in an elementary science methods course, using an online forum allowing for interaction and collaboration, to determine what processes of science took place in their group discussions. Three specific components were identified in their study as being significant in how the pre-service teachers functioned in online groups. Of significance to this study is the apparent emphasis which the pre-service teachers in their study placed on collaborative discourse. Within the researchers' description of the data from collaborative discourse, they included categories such as "inquiry, persuasion, negotiation, and information seeking/feedback solicitation" (Liang et al., 2010, p. 74). These interactions indicated the most prevalent type of discourse to be negotiation – as it related to establishing a group understanding of some scientific concept or process. This research study indicates that providing a platform for pre-service teachers to interact and produce discourse helps to further the ideas and content which is required for learning and teaching science. It is recommended by Liang et al. (2010) that discursive communities which include pre-service teacher education students should maintain some level of "structure for more evaluative conversation" (p. 78). This suggestion comes from their evidence that many times ideas were reconciled before all members of the group held a comprehensive understanding, and that further discourse may have enabled deeper levels of learning. The study conducted by Liang et al. (2010) is especially important as it exemplifies the potential which exists for including opportunities for intellectual discourse. Within Morgan's class, the pre-service teachers sought opportunities to make sense of what they were being taught, but it was rarely apparent that solutions were allowed to be uncovered as a community of learners. Morgan often suggested that the pre-service teachers meet outside of class, to continue the conversation about what they were learning, possibly in an effort to have them process information and gain a better understanding of how others were making sense of course experiences. However, regardless of Morgan's suggestions for outside interaction, the lack of time appropriated in class for relevant conversation was minimal. The lack of time appeared to represent unwillingness, on Morgan's part, to give up some of his control even though it may have allowed the pre-service teachers to make more sense of what they were learning. An argument which I would make as an observer is that while the intent was citizen science understanding and a willingness to consider ecojustice philosophy these ideas were not discussed in class or in course projects and assignments. At no point during any of the interviews did the pre-service teachers speak about the idea of ecojustice. In fact, there appeared to be confusion about why citizen science was a framework for the course– with some assuming it was only a way of learning science in an outdoor environment. The inclusion of directed conversation and additional opportunities for the pre-service teachers to share ideas, ask questions, and learn from one another could have proven influential in their grasp of the purpose and their ability to view the use of citizen science as a pedagogy. It was apparent from the interviews and other data that, many of the participants gained a better understanding of what science teaching oriented towards citizen science looked like, but it could be argued that these were isolated events and not as fully developed as they could have been. Positioning learners within a context that encourages a more embodied experience, as was evident in a large percentage of the course activities requires dialogic opportunities for pre-service teachers to develop personal and social understandings. A stronger emphasis on discursive practices leading to richer conversations might have promoted the social dynamic of positioning the pre-service teachers within opportunities to engage in citizen science rather than in preparation for its use.

Additionally, increased opportunities for conversation might have encouraged pre-service teachers to make sense of transitions between theory-practice and practice-theory. While safe spaces were constructed within the interviews, not all participants were afforded this luxury and thereby were not provided with time and feedback for asking questions and making sense of the process of learning to teach science. Evidence of value in conversation was presented when Sarah, in the larger focus group discussion, told the secondary participants of the study that ‘they didn’t have the same chance of coming to understand things as those individuals who got to talk things over with Stacey’. On some level this indicates a need for teacher preparation courses to encourage opportunities for this type of interaction as a way of allowing all parties (teachers, learners, collaborators) to grow from the experience of working with others.

Implications

The implications for this research are divided into areas of science teacher preparation, methodology, theory, and future research. While these are addressed separately, many of these ideas can and are connected in many ways. Therefore, they should be considered in ways that are appropriate for the contexts in which the reader finds most beneficial.

Implications for science teacher preparation

Ideas related to science teacher preparation were plentiful in this research. The findings of the study suggest implications for science teacher educators in how courses could be structured differently and in understanding some of the areas which others are utilizing for their own instruction. Some of these implications address:

- Valuing alternative frameworks for conceptualizing science teacher preparation
- Including multiple learning contexts
- Developing more democratic classrooms
- Incorporating multiple resources, such as co-educators
- Concerted effort to blur disciplinary boundaries/ Be intentionally inclusive of all content

While the context for the study was a science teacher preparation course, the larger goal of the instructor was to encourage participants to utilize citizen science pedagogy. The data suggest different ways that courses of this type could impact science teacher education. As indicated in the discussion on practice to theory/theory to practice, the idea of helping pre-service teachers develop an understanding of how to translate what they have learned and relate it to their future teaching is critical. While there were obvious dilemmas for Morgan, in representing theory-practice/practice-theory, the course design was significantly different than what was expected by many and suggests the need for continued exploration with future courses. What does this mean for other science teacher educators? When designing a course, or implementing activities, it is not necessary to choose either ‘practice to theory’ or ‘theory to practice’; evidence suggests that both are useful (and often expected) in teacher preparation programs.

Citizen science calls for democratizing science education. A less teacher-centered approach in teacher preparation courses could encourage a more democratic learning environment that could allow for the voice of pre-service teachers to become apparent. This is often a difficult process since it means the science teacher educator must step back from being the obvious expert, to being an individual who guides the learning process and truly serves as a mediator facilitating productive dialogue and creating opportunities for decision-making.

Opportunities for dialogue and time for individual reflection as well as group interactions are essential for encouraging the development of philosophy (ecojustice, in this case). Evidenced through the encounters with the pre-service teacher participants was their lack of understanding about the philosophical basis of the course learning experiences. The inclusion of co-educators within teacher preparation courses helps establish connections between valuable knowledge holders who, in turn, may broaden the community of learners and provide resources which are often required for the pre-service teachers to gain confidence in their teaching.

In the context of science teacher preparation, knowledge about teaching is produced through interactive experiences which allow the pre-service teachers to draw from understanding of content. The point where information of the discipline intersects with the understandings and experience pre-service teachers carry within is the ‘zone’ where knowledge is created. For the most part, even when pre-service teachers understand the tenets of citizen science, they struggle to create a vision of how it might be enacted in disciplines not grounded in life science. One way of addressing this challenge would be to incorporate co-educators with content expertise outside the realm of life science (i.e. astronomy, physics, or chemistry). Through their involvement, the pre-service teachers could gain an understanding of how citizen science might be applicable across various scientific disciplines, as well as gain insight into the connections between different fields of study. Inclusion of multi-disciplinary co-educators could also provide strength to Morgan's argument of citizen science pedagogy as an interdisciplinary approach to teaching.

Lastly, this study suggests the need for science teacher educators to blur the boundaries that often exist between disciplines in order to promote a more inclusive approach to teaching science that is community focused and less isolated to one field of study. Throughout the conversations about citizen science, the argument has been made that it allows for multiple content areas to interact through a community-driven, advocacy focused event. This attempt to blur those boundaries requires a concerted effort by the science teacher educator to address his or her intentions early in the course, so that the pre-service teachers are able to more fully comprehend the approach which is being taken. While it is likely obvious to many science educators that science is comprehensive and inclusive of more than one discipline, it is often difficult for the pre-service teachers to fully grasp this concept. Therefore, if citizen science is used as a framework the science teacher educator should bring in examples illustrating the connections across disciplines for increasing the potential of it being accepted as viable.

Theoretical implications

Secondly, this research provides a clear connection to some theoretical ideas which exist in science teacher education. While other avenues of theoretical implications may exist, those outlined below were especially significant in this study:

- Framing 'methods' as philosophy requires a new mindset
- Embodied learning promotes advocacy

- Connections naturally exist between definitions of community and embodied learning

Framing a science teacher preparation course as a philosophical endeavor has additional implications for the kinds of experiences needed for pre-service teachers to develop a vision of how they might act on their theoretical and pedagogical understandings. While admittedly it was challenging for the non-biology majors to make connections between citizen science pedagogy and their own disciplinary experience, of greater importance is the need for pre-service teachers to see the course experiences in light of the larger ecojustice philosophy. In this sense, a teacher preparation which aims to help pre-service teachers develop a philosophy must blur the artificial boundaries between disciplines through practical examples connected to prospective teachers' lived experiences.

Challenging traditional philosophies of teaching and learning can be difficult, but the prospective teachers take away so much more from the course when faced with alternatives. As mentioned in chapter one, the idea of teaching for social justice is often tainted with doubt when those who focus on the more content-driven science denigrate the value and possibilities for teaching in ways that are more inclusive of ideas such as ecojustice. The diversity in science teacher educator beliefs challenges the field of education while making the process of learning to teach difficult for those pre-service teachers enrolled in courses which do focus on a larger framework for science learning and teaching. Challenges are placed in front of the learners and they have to learn how to navigate through the assumptions they hold about teaching, in an effort to better prepare them to engage in becoming a teacher.

Positioning the learner within opportunities to engage what they already know with all that they are may help them develop greater abilities to teach similarly. Creating experiences which engage the ‘full learner’ (mind, body, and senses) in learning how to teach may make for a more meaningful and possibly relevant encounter. Furthering the notion of embodied learning, the notion of fostering community is inherent in situated, relevant experiences which engage the participants on multiple levels. As indicated previously, communities are comprised of members who have emotional investments in success and partnerships with others in the group. These connections suggest an experience in which negotiation, equity, and engagement in the success of others is of vital importance. All of these factors aid in the established success of the community and promote a sense of belonging which is akin to what embodied learning entails.

Methodological implications

The methodological implications were highlighted in the discussion of hermeneutic ethnography as a research methodology. However, here are additional ideas of significance developed throughout this experience that may prove valuable to others considering following a similar research path. The primary issues which arose are:

- Plentiful quantities of data
- Time-consuming and mentally arduous
- Promotes a new level of self-understanding
- Blurring of lines between researcher and participant

Methodologically, using a theory of understanding to understand how pre-service teachers make meaning presents unique challenges. Sizeable quantities of data must be collected if there are to be true opportunities to make sense of actions, beliefs and observable experiences. The sheer quantity of data required a method of organization in which to keep accurate records of when, what, who, and where; since in this type of research, it's impossible to know what will be valuable until it's needed, everything has to be documented. In this research study, I utilized an excel spreadsheet to document the process of data collection and to organize materials for analysis. Another process which I found valuable was in taking copious notes, and attempting to expand those notes as soon as possible after the encounter. Some of these interactions, while not making it verbatim into the dissertation, served as a way of helping me understand how others were experiencing the course and provided a foundation upon which to build future observations and interviews.

Having piles of data was beneficial since it helped to create a better, more comprehensive, understanding of what 'really' happened in the research study – a necessity for ethnographic research. Another side-effect of having massive quantities of data is knowing how to best analyze what you have, which in my case included time for coding and revisiting the transcripts with a committee member. Having an additional set of eyes can help in deciphering what the data may be saying. An additional committee member was consulted throughout the research study in an effort to help make sense of my role as a researcher doing a hermeneutic ethnography. It was found that discussion with 'experts' in the field helped in understanding more about the process and in becoming a part of the process. Engaging in the process of hermeneutic ethnography makes it very much an embodied experience, one in which it becomes crucial to maintain some semblance of self while taking on the cause of others.

In terms of research methodology, hermeneutic ethnography was phenomenal in that being involved in the learning and interactions of the remaining participants was not only possible but required. For understanding to have developed as it did, thorough immersion was an absolute, providing a perspective that, while time-consuming, encouraged relationships to develop and personal growth to take place. My existence as both a teacher and a researcher were dramatically influenced by embedding myself within the process. Understanding my role on multiple levels necessitated keeping a journal, which in turn enabled modifications in my own knowledge and beliefs about teaching and learning. Undertaking hermeneutic ethnographic research meant positioning within a context which is familiar. However, the positioning necessitates maintaining an outsider perspective in an effort to prevent undue influence on how the participants interact and in how the data comes together and is understood in relation to the larger body of literature for which it is intended to promote.

The very nature of hermeneutic ethnography requires the line between researcher and participant to be intentionally blurred. Undertaking this type of research means attempting to place oneself in the experience as the participants, trying to make sense of what is happening not through the eyes of the experienced but of those experiencing. Often a difficult task, it becomes one of constant reflection on personal beliefs and intentional ideas which present challenges in how sense is made of what is unfolding in the research setting. Hermeneutic ethnography does not allow for separation, but requires an understanding of how the self is posited within the study and forces the self to expand personal beliefs to encompass others. It is difficult, but necessary for true understanding, to maintain the sense made by the participants in the setting – realizing that while you are a participant researcher, it is not your voice that must be acknowledged.

Implications for future research

Many different directions exist for future research in science teacher preparation. Two major approaches for future research are considered below:

- Continued focus on ecojustice philosophy
- Embodied learning as a basis for instruction in science teacher preparation
- Embodied learning as a methodology for research

Further studies should include how course structures could be modified for enhancing understanding and integration of citizen science within the secondary science classroom. In considering citizen science, it would be beneficial to follow teachers who were trained in this manner into their classrooms to determine the influence ecojustice philosophy has in their instruction. It would be interesting to shadow those pre-service teachers who bought into the ideas of citizen science in the schools and ascertain the extent to which the framework influences their actions and those of surrounding teachers and students. By contrast, it might also be valuable to follow up with those teachers who disavowed the use of citizen science to determine what, if any, aspects of ecojustice were exhibited in their praxis. Future studies might also examine other uses of citizen science as a framework within science teacher preparation. In the same vein, it would be interesting to study a secondary science classroom which was designed around the tenets of citizen science, particularly in relation to student's perception of science and learning science in such a context. Thus far, most of the research I have considered looks at teacher preparation, but the real crux for the idealized change to curriculum lies in whether or not the specific framework of citizen science proves beneficial for student learning. This avenue of research could take many directions which would in turn influence how I would organize and structure research in the teacher preparation courses.

A study of embodied learning within science teacher education courses or K-12 classrooms could prove influential in understanding how science can become more relevant to 21st century youth. Specifically, a study of learning to teach science in an embodied context could provide a potential avenue for research. As a researcher, the focus on embodied learning presents valuable implications for methodology. Continued research into the methodology would encourage the development of, through the lens of hermeneutics, an obvious relationship between how learning takes place, the researcher role in the process, and the potential for personal and professional growth. Hermeneutics entails fully experiencing the situation as a way of understanding what takes place and what meaning is being represented; embodied learning expands on that by including the full researcher. Future research could provide a more valid argument for the inclusion of learning that involves the entire being, in teacher preparation coursework.

While this body of research only presents one view of science teacher preparation, the comprehensive nature of the study provides science teacher educators a glimpse at different possibilities. By addressing citizen science pedagogy as a framework of organization for a science teacher preparation course, the aim of this research was to encourage teacher educators to consider the alternatives represented, along-side the pre-service teachers' responses and to promote reflection on their own praxis.

REFERENCES

Abell, S. K. (2007). Research on science teacher knowledge. In S. K. Abell, & N. G. Lederman (Eds.), *Research on science education* (pp. 1105-1150). Mahwah, NJ: Erlbaum.

Abrams, E., Southerland, S. A., & Silva, P. (Eds.). (2008). *Inquiry in the Classroom: Realities and Opportunities*. Charlotte, NC: Information Age Publishing.

Aikenhead, G. (2001). Integrating western and aboriginal sciences: Cross-cultural science teaching. *Research in Science Education, 31*, 337-355.

Aikenhead, G. S. (2006). *Science education for everyday life: Evidence-based practice*. New York: Teachers College Press.

Aikenhead, G. S. (2007). Humanistic perspectives in the science curriculum. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of research in science education* (pp. 881-910). Mahwah, NJ: Lawrence Erlbaum.

Allen, N. J., & Crawley, F. E. (1998). Voices from the bridge: Worldview conflicts of Kickapoo students of science. *Journal of Research in Science Teaching, 35*(2), 111-132.

Atkin, J. M. (1983). The improvement of science teaching. *Daedalus, 112*(2), 167-187.

Ball, D. L. (2000). Bridging practices: Intertwining content and pedagogy in teaching and learning to teach. *Journal of Teacher Education, 51*(3), 241-247.

Barab, S., Zuiker, S., Warren, S., Hickey, D., Ingram-Goble, A., Kwon, E., Herring, S. C. (2007). Situationally embodied curriculum: Relating formalisms and contexts.

Science Education, 91(5), 750-782.

Barton, A. C. (2009). Feminisms and a world not yet. In W. Roth, & K. Tobin (Eds.), *Handbook of research in North America* (pp. 409-425). Rotterdam: Sense Publishers.

Barton, A. C. (2000). Crafting multicultural science education with pre-service teachers through service-learning. *Journal of Curriculum Studies, 32*(6), 797.

Barton, D., & Hamilton, M. (1998). *Local literacies: Reading and writing in one community*. New York: Routledge.

Bauman, Z. (1978). *Hermeneutics and social science*. New York, NY: Columbia University Press.

Bell, B. (1998). Teacher development in science education. In B. J. Fraser, & K. G. Tobin (Eds.), *International handbook of science education* (pp. 681-693). Great Britain: Kluwer Academic Publishers.

Benzies, K. M., & Allen, M. N. (2001). Symbolic interactionism as a theoretical perspective for multiple method research. *Journal of Advanced Nursing, 33*(4), 541-547.

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen science: A developing tool for expanding science knowledge and scientific literacy. *BioScience 59*(11), 977-984.

Bowers, C. A. (2001). *Educating for ecojustice and community*. Athens, GA: University of Georgia Press.

Bowers, C. A. (2002). Toward an eco-justice pedagogy. *Environmental Education Research, 8*(1), 21-34.

Bradbury-Jones, C., Sambrook, S., & Irvine, F. (2009). The phenomenological focus group: An oxymoron? *Journal of Advanced Nursing*, *65*(3), 663-671.

Braschler, B. (2009). Successfully implementing a citizen-scientist approach to insect monitoring in a resource-poor country. *Bioscience*, *59*(2), 103-104.

Brice-Heath, S. (1982). Questioning at home and at school: A comparative study. In G. Spindler (Ed.), *Doing the ethnography of schooling: Educational anthropology in action* (pp. 103-131). New York: CBS College Publishing.

Brossard, D., Lewenstein, B., & Bonney, R. (2005). Scientific knowledge and attitude change: The impact of a citizen science project. *International Journal of Science Education, 27*(9), 1099-1121.

Bryan, L. A., Atwater, M. M., & Trumbull, D. (2002). Teacher beliefs and cultural models: A challenge for science teacher preparation programs. *Science Education, 86*(6), 821.

Cahoon, G. P., & Richardson, J. S. (1950). The preparation of teachers. In Central Association of Science and Mathematics Teachers, Inc. (Ed.), *A half century of science and mathematics teaching* (pp. 178-197). Menasha, WI: George Banta Publishing Company.

Chiappetta, E. L., & Adams, A. (2004). Inquiry-based instruction: Understanding how content and process go hand-in-hand with school science. *The Science Teacher, 70*(2), 46-50.

Cobern, W. W., & Aikenhead, G. S. (1996). Worldview theory and conceptual change in science education. *Science Education, 80*(5), 579-610.

Cochran-Smith, M., Shakman, K., Jong, C., Terrell, D. G., Barnatt, J., & McQuillan, P.

(2009). Good and just teaching: The case for social justice in teacher education. *American Journal of Education, 115*(3), 347-377.

Cone, N. (2009). Community-based service-learning as a source of personal self-efficacy: Preparing pre-service elementary teachers to teach science for diversity. *School Science & Mathematics, 109*(1), 20-30.

Cooper, C. B., Dickinson, J., Phillips, T., & Bonney, R. (2007). Citizen science as a tool for conservation in residential ecosystems. *Ecology and Society, 12*(2), 11.

Costa, A. L., Baker, W., & Shalit, S. (2008). Norms of collaboration: Attaining communicative competence. In *The school as a home for the mind: Creating mindful curriculum, instruction, and dialogue* (2nd ed., pp. 141-164). Thousand Oaks, CA: SAGE.

Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process*. Thousand Oaks, CA: Sage.

Darling-Hammond, L. (2000). How teacher education matters. *Journal of Teacher Education, 51*(3), 166-173.

Debesay, J., Naden, D., & Slettebo, A. (2008). How do we close the hermeneutic circle? A Gadamerian approach to justification in interpretation in qualitative studies. *Nursing Inquiry, 15*(1), 57-66.

deMarrais, K. (2004). Qualitative interview studies: Learning through experience. In K. deMarrais, & S. D. Lapan (Eds.), *Foundations for research: Methods of inquiry in education and the social sciences* (pp. 51-68). Mahwah, NJ: Erlbaum.

DeWitt, J., & Osborne, J. (2007). Supporting teachers on science-focused school trips: Towards an integrated framework of theory and practice. *International Journal of*

Science Education, *29*(6), 685-710.

Ellen, R., & Harris, H. (2000). Introduction. In R. Ellen, & P. B. Parkes A. (Eds.), *Indigenous environmental knowledge and its transformations: Critical anthropological perspectives* (pp. 1-33). Australia: Harwood Academic Publishers.

Elmesky, R. (2006). Poverty and science education. *Teaching and learning science: A handbook. (pp. 193-199).* Westport, CT: Praeger.

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (1995). *Writing ethnographic fieldnotes*. Chicago, IL: University of Chicago Press.

Flyvjberg, B. (2001). *Making social science matter: Why social inquiry fails and how it can succeed again.* New York, NY: Cambridge Press.

Fraser-Abder, P., Abell, S. K., & Trumbull, D. J. (2009). Models of secondary science teacher preparation. In A. Collins, & N. Gillespie (Eds.), *The continuum of secondary science teacher preparation: Knowledge, questions, and research recommendations* (pp. 23-32). Rotterdam: Sense Publishers.

Gallagher, S. (1992). *Hermeneutics and education*. Albany, NY: State University of New York Press.

Geertz, C. (1973). *The interpretation of cultures: Selected essays*. New York: Basic Books.

Giddens, A. (1982). Hermeneutics and social theory. In *Profiles and critiques in social theory* (pp. 1-17). Berkeley, CA: University of California Press.

Glasson, G. E., Frykholm, J. A., Mhango, N. A., & Phiri, A. D. (2006). Understanding the earth systems of Malawi: Ecological sustainability, culture, and place-based education. *Science Education, 90*(4), 660-680.

Goodall, J., H. L. (2003). What is interpretive ethnography? In R. P. Clair (Ed.), *Expressions of ethnography: Novel approaches to qualitative methods* (pp. 55-63). Albany, NY: State University of New York Press.

Gubrium, J. F., & Holstein, J. A. (2009). *Analyzing narrative reality*. Thousand Oaks, CA: SAGE.

Hammersley, M., & Atkinson, P. (1983). *Ethnography: Principles in practice*. London: Tavistock.

Handa, V. C. (2008). *Bridging communities and pre-service science teacher education through community immersion a collaborative action ethnography.* Unpublished dissertation for University of Georgia, Athens, Georgia.

Holbrook, J., & Rannikmae, M. (2007). The nature of science education for enhancing scientific literacy. *International Journal of Science Education, 29*(11), 1347-1362.

Holliday, A. (2007). *Doing and writing qualitative research* (2nd ed.). Thousand Oaks, CA: SAGE.

Hurd, P. D. (1998). Scientific literacy: New minds for a changing world. *Science Education, 82*, 407-416.

Hurd, P. D. (2002). Modernizing science education. *Journal of Research in Science Teaching, 39*(1), 3-9.

Jackson, P. W. (1983). The reform of science education: A cautionary tale. *Daedalus, 112*(2), 143-166.

Jenkins, E. W., & Jenkins, E. W. (1999). School science, citizenship and the public understanding of science. *International Journal of Science Education, 21*(7), 755.

Kaartinen, S. (2009). Meaningfulness via participation: Sociocultural practices for teacher learning and development. *Teachers and teaching: Theory and practice, 15*(5), 601-616.

Kang, N. (2008). Learning to teach science: Personal epistemologies, teaching goals, and practices of teaching. *Teaching and Teacher Education: An International Journal of Research and Studies, 24*(2), 478-498.

Karrow, D., & Fazio, X. (2010). Educating-within-place: Care, citizen science, and ecojustice. In D. J. Tippins, M. P. Mueller, M. van Eijck & J. D. Adams (Eds.), *Cultural studies and environmentalism* (pp. 193-214). New York: Springer.

Kawagley, A. O., Norris-Tull, D., & Norris-Tull, R. (1998). The indigenous worldview of Yupiaq culture: Its scientific nature and relevance to the practice. *Journal of Research in Science Teaching, 35*(2), 133.

Kelly, J. (2000). Rethinking the elementary science methods course: A case for content, pedagogy, and informal science education. *International Journal of Science Education, 22*(7), 755-777.

Klein, C. (2006). Science teaching and learning through the zoo, aquarium, and botanical garden. In K. Tobin (Ed.), *Teaching and learning science* (pp. 365-376). Westport, CT: Praeger.

Korthagen, F. A. J. (April 2001). Linking practice and theory: The pedagogy of realistic teacher education. (pp. 1-16). *Paper Presented at the Annual Meeting of the American Educational Research Association,* Seattle, WA.

Korthagen, F. A. J., Loughran, J. J., & Russell, T. (2006). Developing fundamental principles for teacher education programs and practices. *Teaching and Teacher*

Education, 22, 1020-1041.

Lake, C. B. (2006). "The knowledge that one does not know". In K. J. Vanhoozer, J. K. A. Smith & B. E. Benson (Eds.), *Hermeneutics at the crossroads* (pp. 82-92). Bloomington: Indiana University Press.

Lang, M., Drake, S., & Olson, J. (2006). Discourse and the new didactics of scientific literacy. *Journal of Curriculum Studies, 38*(2), 177-188.

Liang, L. L., Ebenezer, J. V., & Yost, D. S. (2010). Characteristics of pre-service teachers' online discourse: The study of local streams. *Journal of Science Education and Technology, 19*(1), 69-79.

Lynch, S. (2001). "Science for all" is not equal to "one size fits all": Linguistic and cultural diversity and science education reform. *Journal of Research in Science Teaching, 38*(5), 622-627.

Martin, S. N. (2009). Learning to teach science. In W. Roth, & K. Tobin (Eds.), *Handbook of research in North America* (pp. 567-586). Rotterdam: Sense Publishers.

Maulucci, M. R. (2008). Intersections between immigration, language, identity, and emotions: A science teacher candidate's journey. *Cultural Studies of Science Education, 3*(1), 17-42.

Michrina, B. P., & Richards, C. (1996). *Person to person: Fieldwork, dialogue, and the hermeneutic method*. Albany, NY: State University of New York.

Miele, E. A., & Powell, W. G. (2010). Science and the city: Community cultural and natural resources at the core of a place-based, science teacher preparation program. *Journal of College Science Teaching, 40*(2), 40-44.

Morgan, D. L. (1997). *Focus groups as qualitative research* (2nd ed.). Thousand Oaks, CA: Sage.

Mueller, M. P., & Bentley, M. L. (2007). Beyond the "decorated landscapes" of educational reform: Toward landscapes of pluralism in science education. *Science Education, 91*(2), 321-338.

Mueller, M. (2008). EcoJustice as ecological literacy is much more than being "Green!" *Educational Studies, 44*(2), 155-166.

Northfield, J. (1998). Teacher educators and the practice of science teachers. In B. J. Fraser, & K. G. Tobin (Eds.), *International Handbook of Science Education* (pp. 695-706). Netherlands: Kluwer.

Olson, J. K., Cox-Petersen, A., & McComas, W. F. (2001). The inclusion of informal environments in science teacher preparation. *Journal of Science Teacher Education, 12*(3), 155-173.

Orr, D. W. (1992). *Ecological literacy: Education and the transition to a postmodern world*. Albany: State University of New York Press.

Peshkin, A. (1982). The researcher and subjectivity: Reflections on an ethnography of school and community. In G. Spindler (Ed.), *Doing the ethnography of schooling: Educational anthropology in action* (pp. 49-67). New York: CBS College Publishing.

Prasad, P. (2005). Hermeneutics: The interpretation of texts. In *Crafting qualitative research: Working in the postpositivist traditions* (pp. 30-42). Armonk, NY: ME Sharpe.

Preissle, J., & LeCompte, M. D. (1984). *Ethnography and qualitative design in* *educational research*. Orlando, FL: Academic Press.

Prior, L. (2003). *Using documents in social research*. Thousand Oaks, CA: SAGE Publications.

Rock, P. (2001). Symbolic interactionism and ethnography. In P. Atkinson, A. Coffey, S. Delamont, J. Lofland, & L. Lofland (Eds.), *Handbook of ethnography* (pp. 26-38). Thousand Oaks, CA: SAGE.

Roth, W., & Barton, A. C. (2004). *Rethinking scientific literacy*. New York: Routledge.

Roth, W., & Lee, S. (2004). Science education as/for participation in the community. *Science Education*, *88*(2), 263-291.

Sachs, A. (1995). In Peterson J. A. (Ed.), *Eco-justice: Linking human rights and the environment*. Washington, DC: Worldwatch Institute.

Schwab, J. (1962). *The Teaching of Science as Enquiry*. Cambridge, MA: Harvard University Press.

Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and the social sciences* (3rd ed.). Columbia University, New York: Teachers College Press.

Silvertown, J. (2009). A new dawn for citizen science. *Trends in Ecology & Evolution, 24*(9), 467-471.

Sleeter, C. E. (2001). Preparing teachers for culturally diverse schools: Research and the overwhelming presence of whiteness. *Journal of Teacher Education, 52*(March/April), 94-106.

Smith, J. K. (1993). Hermeneutics and qualitative inquiry. In D. J. Flinders, & G. E. Mills (Eds.), *Theory and concepts in qualitative research: Perspectives from the field* (pp. 183-200). Columbia University, New York: Teachers College Press.

Smith, L. K., & Newsome, J. G. (2004). Elementary science methods courses and the *National Science Education Standards*: Are we adequately preparing teachers? *Journal of Science Teacher Education, 15*(2), 91-110.

Spindler, G. (1982). General introduction. In G. Spindler (Ed.), *Doing the ethnography of schooling: Educational anthropology in action* (pp. 1-13). New York: CBS College Publishing.

Spindler, G., & Spindler, L. (2000). Teaching and learning how to do the ethnography of education. In G. Spindler (Ed.), *Fifty years of anthropology and education 1950 - 2000: A Spindler anthology* (pp. 247-263). Mahwah, NJ: Erlbaum.

Stetsenko, A. (2008). Collaboration and cogenerativity: On bridging the gaps separating theory-practice and cognition-emotion. *Cultural Studies of Science Education, 3*(2), 521-533.

Strauss, A. (1987). *Qualitative analysis for social scientists*. Cambridge: Cambridge University Press.

Tippins, D. J., & Mueller, M. P. (2009). As if local people and places mattered: A relational, ecological and pragmatist framework to guide projects of rural science education. In W. Roth, & K. G. Tobin (Eds.), *The world of science education: Handbook of research in North America* (pp. 542-559). Rotterdam: Sense Publications.

Tippins, D. J., Mueller, M. P., van Eijck, M., & Adams, J. D. (Eds.). (2010). C*ultural studies and environmentalism: The confluence of ecojustice, place-based (science) education, and indigenous knowledge systems*. New York: Springer.

Tobin, K. G. (2006). *Teaching and Learning Science: A Handbook*. Westport, CT: Praeger Publishers.

Tobin, K. G., Tippins, D. J., & Gallard, A. J. (1994). Research on instructional strategies for teaching science. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 45-93). New York: Macmillan.

Trumbull, D. J., Bonney, R., Bascom, D., & Cabral, A. (2000). Thinking scientifically during participation in a citizen-science project. *Science Education, 84*, 265-275.

Vanhoozer, K. J. (2006). Discourse on matter: Hermeneutics and the "miracle" of understanding. In K. J. Vanhoozer, J. K. A. Smith & B. E. Benson (Eds.), *Hermeneutics at the crossroads* (pp. 3-34). Bloomington, IN: Indiana University Press.

Wilson, S. M., Floden, R. E., & Mundy, J.F. (2002). Teacher preparation research: An insider's view from the outside. *Journal of Teacher Education, 53*(3), 190-204.

Wilson, K., & Stemp, K. (2010). Science education in a 'classroom without walls': Connecting young people via place. *Teaching Science - the Journal of the Australian Science Teachers Association, 56*(1), 6-10.

Windschitl, M. (2005). Guest editorial: The future of science teacher preparation in America: Where is the evidence to inform program design and guide responsible policy decisions? *Science Education*, *89*(4), 525-534.

Wolcott, H. F. (1982). Mirrors, models, and monitors: Educator adaptations of ethnographic innovation. In G. Spindler (Ed.), *Doing the ethnography of schooling: Educational anthropology in action* (pp. 68-95). New York: CBS College Publishing.

Wolcott, H. F. (1987). On ethnographic content. In G. Spindler, & L. Spindler (Eds.), *Interpretive ethnography of education: At home and abroad* (pp. 37-57). Hillsdale, NJ: Erlbaum.

Wolcott, H. F. (2002). Ethnography? or educational travel writing? In Y. Zou, & E. T. Trueba (Eds.), *Ethnography and schools: Qualitative approaches to the study of education* (pp. 27-48). Lanham, MD: Rowman & Littlefield Publishers.

Yore, L. D., & Treagust, D. F. (2006). Current realities and future possibilities: Language and science literacy - empowering research and informing instruction. *International Journal of Science Education, 28*(2 & 3), 291-314.

Zembylas, M., & Barker, H. B. (2002). Preservice teacher attitudes and emotions: Individual spaces, community conversations and transformations. *Research in Science Education*, *32*(3), 329-351.

APPENDIX A

Sample form, consent for participation

I, ________________________________, agree to take part in a research study titled "Participatory ethnography on citizen science and worldview mediation during a secondary science methods course", which is being conducted by Stacey Britton, Department of Mathematics and Science Education at the University of Georgia, 706-548-2376, under the direction of Dr. Deborah Tippins, Department of Mathematics and Science Education at the University of Georgia, 706-542-1763. This dissertation research project is being conducted during the Block 1 Methods Course, August 2009 - December 2009. The purpose of this research study is to observe what happens in a secondary science methods class when citizen science is used as the guiding framework for instruction.

There are no personal benefits to participating, you will receive no compensation. Any data that is collected will be used for completing a dissertation, with names and other identifiers being removed to maintain confidentiality. All material related to this research will be maintained by the researcher in a secured location and used for educational purposes.

By signing this consent form you:

- Understand that participation is voluntary and that you can refuse to participate or stop taking part at any time without giving any reason, and without penalty or loss of benefits to which you are otherwise entitled.
- May request information be returned, removed from the research records, or destroyed.
- Agree to be observed, during the class meetings and any outside activities deemed relevant, as part of this study.
- Agree to be participate in audio-recorded interviews on three separate occasions as part of this study, each interview will last approximately 60-90 minutes. These audio-recordings will be maintained by the researcher in a secure location with transcribed interviews being made available to participants upon request.
- Agree to be part of two audio-recorded focus group discussions as part of this study, each focus group meeting will last approximately 60 – 90 minutes. These audio-recordings will be maintained by the researcher in a secure location with transcribed discussions being made available to participants upon request.
- Agree to allow researcher access to class assignments, with this having no influence on your course grade.
- Agree to allow researcher to use internet-based, class discussions available via web environment or through email correspondence. Internet communications are insecure and there is a limit to the confidentiality that can be guaranteed due to the technology itself. However once the materials are received by the researcher, standard confidentiality procedures will be employed - identifiers will be removed and pseudonyms used.
- Understand that any information that is obtained in connection with this study may be used in educational writings.
- Understand that you will not be identified by name in any papers or publications that may result from this study, and your individually-identifiable information will remain confidential unless required by law.
- Understand that the researchers and/or UGA will hold the copyright for any materials published as a result of this study.

You are free to withdraw your participation at any time should you become uncomfortable. If at any time you wish to remove yourself from the study, please notify me; any data collected to the point of removal will be used in the study, without harm or benefit to the student. No discomforts or stresses are expected; no risks are expected. If you have any questions or concerns regarding the research please contact me at 706-548-2376. Thank you very much for your help and I look forward to working with you during the semester.

Sincerely,
Stacey Britton
Doctoral Student, Department of Mathematics and Science Education
College of Education, University of Georgia

Stacey A. Britton_______________ ______________________________

Name of Researcher Signature Date
Telephone: _706-548-2376____________
Email: _biolady24@yahoo.com_________

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.
Please indicate your level of voluntary participation.
______ I agree to participate in **ALL** aspects of the research project including observation, interview, focus group discussions, course assignment reviews.
______ I agree to participate in observations only.

___________________________ ______________________________

Name of Participant Signature Date

Please sign both copies, keep one copy and return one to the researcher.

Additional questions or problems regarding your rights as a research participant should be addressed to The Chairperson, Institutional Review Board, University of Georgia, 612 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu

APPENDIX B

Interview protocols

Protocol for Interview 1 - Individual

Worldview

1. Describe where you grew up, in terms of setting.
    a. How much contact have you had with nature throughout your life?
    b. What type of contact have you had with cultures different from your own?
        i. When did you have experience with different cultures?
        ii. What were the similarities and differences between your own culture and those with which you interacted?
        iii. If you had contact, how did you accommodate different beliefs than your own?
2. What does worldview mean to you?
    a. Worldview is a term that sometimes refers to how you came to believe and act in a certain way. In light of that definition, or your own definition, how would you define your personal worldview?
    b. What has influenced how your worldview developed?
    c. How do you feel it differs from others?
3. Tell me about your prior academic experiences in science.
    a. Non-academic?
    b. How have these experiences influenced your ideas about science teaching and learning?

Content area and teaching

4. What is your specialty area and what factors influenced that decision?
5. What does teaching look like in your given specialty area? Describe a typical classroom experience if you were a student in (physics if specialty, chemistry, biology, etc.).
6. How do you anticipate this course influencing your ideas of teaching and learning in your content area?
7. After being introduced to the syllabus, what are your initial thoughts regarding the course?

Citizen science

8. What does citizen science mean to you?
    a. How would you anticipate teaching in your content area using a citizen science focus?
    b. What aspects of the curriculum would citizen science fit?
    c. Describe a typical experience in a secondary classroom with a focus on citizen science.
9. What value do you believe citizen science has for students? For the population as a whole?

Protocol for Interview 2 - Individual

Worldview

1. Tell me about worldviews you have been exposed to through this course.
    a. How do these alternative worldviews relate or differ from your own?
    b. What influence have these viewpoints had on your ideas about science, teaching, and learning?
2. Worldviews are often what guide us to make decisions. What decisions have you made in the course that relate specifically to your own beliefs and understandings of science, teaching, and communities?
    a. How have you shared your views with others?
    b. Were there differing opinions?
    c. If so, how did you accommodate them?
3. What discussions have you had in the course that exposed you to altering viewpoints? How have you integrated those ideas with your own beliefs?

Content area and teaching

4. What have you learned about teaching in your specialty area?
5. How have the experiences of the class influenced your ideas about being a teacher? About the role of the student?
6. How do the techniques demonstrated and discussed provide you with a background for becoming a successful science teacher?

Citizen science

7. Tell me about what you are learning about citizen science.
8. Where do you see the notion of citizen science fitting into education and your own classroom?

Protocol for Interview 3 - Individual

Worldview

1. Tell me about your worldview.
    a. How did you handle situations in which you were faced with worldviews that differed from your own? Please give specific examples.

Content area and teaching

2. What types of issues are you discussing in your reflective journal? Describe some of the topics you have mentioned in those reflections.

Citizen science

3. Tell me about the photo-essay you completed for the course.
    a. How did it develop? What was the basis for your collection of pictures?
    b. How does it represent your learning through the course?

Protocol for Focus-group Interview 1

Worldview

1. How would you define worldview?
    a. From where does your unique worldview originate?

    b. How would others have the same or similar worldviews?
2. What have you discovered about worldviews from being in this course?
    a. Your own and others?
3. How have the experiences of the course influenced your own beliefs?
    a. What experience influenced your ideas the most? Why?
    b. How does learning enable worldviews to be uncovered?

Content area and teaching

4. What have you learned about science teaching and learning from the course experiences?
5. Describe aspects of teaching that you have seen and will attempt to emulate or avoid?
    a. Why were they significant?
    b. How do you imagine the teaching strategies you witnessed playing out in your own classroom?

Citizen science

6. What are you learning about citizen science?
    a. How do you see it fitting into your own classroom?
7. What relationship have you seen between the field experiences and the notion of citizen science?
    a. What about these experiences can you relate to you content area?
    b. What importance would you attach to citizen science as a pedagogy for the secondary science classroom?

Protocol for Interview 1 - Instructor

Worldview

1. Tell me about your current worldview.
2. How did that come to be? How will that influence how you teach this course?

Content area and teaching

3. Tell me about the structure of this course.
4. How did you come to design the experiences and assignments you currently have in the course?

Citizen science

5. What about this course represents the ideas of citizen science?
6. What does citizen science mean to you as an individual?
7. How do those ideals influence your class decisions?

Protocol for Interview 2 - Instructor

Worldview

1. How do you address different worldviews that exist in your classroom?
2. Tell me about an example of encountering and negotiating learning with individuals who have different worldviews than your own.

Content area and teaching

3. What do you hope to accomplish in this course, in terms of content teaching?
    a. What has guided those goals?
    b. What are items being used in class that seem to work for what you want to accomplish?
    c. What are your goals for this group of students, this class in particular?
    d. How are you working to accomplish this?
    e. How have these goals changed since the onset of the course?
    f. What challenges have you encountered in using citizen science as an organizer for the course?
4. What tools are you incorporating to help students understand expectations within the teaching profession?

Citizen science

5. Describe how the students reacted to your description of citizen science and the methods of incorporating those ideals in your instruction.
6. What feedback have you received in terms of students integrating citizen science into their teaching?
7. How does citizen science 'fit' into everyday teaching?
    a. How do you share that with students?
    b. What has influenced your ideas regarding citizen science?

Protocol for Interview 3 -

Worldview

1. What influence have students and this course had on how you address and incorporate worldview into your teaching?

Content area and teaching

2. What do you feel was the strongest influence on students learning to become teachers in this course?
    a. How would you restructure things to address weaknesses?
    b. What would you change about the course?
3. What strengths do you feel exist in the course?

Citizen science

4. What makes citizen science a viable framework for teaching this course? Why did you incorporate those ideals over some other idea?