A CASE STUDY EXPLORATION OF UNDERGRADUATE STUDENTS' EXPERIENCES IN A SCIENCE SERVICE-LEARNING COURSE: UNDERSTANDING THEIR MEANING-MAKING THROUGH REFLECTIVE DISEQUILIBRIA

by

GRETCHEN PERKINS KING

(Under the Direction of DEBORAH TIPPINS)

ABSTRACT

The purpose of this study was to examine undergraduate science majors' experiences through reflective disequilibria in a science service-learning course. This qualitative case study sought to understand how undergraduates made meaning out of experiences teaching science in local K-8 classrooms. Dewey's (1933) notions of reflection were used as a theoretical framework because it assumes that a reflector experiences a disequilibrium that prompts him/her to reflect on their experience to better understand their situation. It also acknowledges that to be effective, reflection must happen individually and in community.

Data collection methods included written journal entries, audio-recorded group discussions around hypothetical scenarios, and semi-structured interviews. Data was analyzed using Jay and Johnson's (2002) Typology of Reflection to assess students' levels of reflection and thematic analysis. The emergent themes are divided into two categories: themes related to the experienced disequilibria and undergraduate reflective responses. Four themes involving students' disequilibria are discussed. FOCUS students experienced the most disequilibria around their role in the classroom, the socio-economic and other perceived barriers to learning they felt

their students experienced, a desire to ensure that science was taught accurately and appropriately, and the desire to teach their students how to be successful in science and education. Four themes involving reflective responses are also discussed. In their reflections, FOCUS students needed to be able to identify with the topic of reflection to offer reasonable solutions to problems. Group discussions were beneficial for lesson planning and discussing challenges that students faced. Students reflected on issues of privilege in written reflections, but not in group discussions. A reflective taxonomy guided students to think more deeply about their service-learning experiences.

Findings have implications for future science education research and practice. Implications for practitioners include better structural supports for student reflection both individually and with their peers, particularly around difficult topics like socio-economic issues and privilege. Practitioners are encouraged to engage their students in collaborative reflection and to engage them in multiple opportunities to reflect deeply. In science education research, there is need for more in-depth research on reflective disequilibria in science service-learning and the use of reflective writings as data.

INDEX WORDS: Qualitative case study; science education; service-learning; undergraduates; reflection; disequilibria; cross-age peer tutoring

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DEDICATION

I dedicate this dissertation to several people without their influence, support, and encouragement, I would not have been inspired to or have completed this work:

To my husband, who supported me relentlessly throughout this whole project.

To my parents, who were the first to inspire me to love learning and pursue my dreams.

To my teachers, past and present, who helped to instill in me a love and passion for learning and taught me to never stop challenging myself. Mrs. Mary ("Grandma") Eley, Mrs. LuAnn Scott, Dr. Deborah Waller—you exemplify what it means to be an educator. Thank you.

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To Dr. Tippins, thank you for supporting me through this entire process, even when I took way too long to write three pages. Thank you for your encouragement, your gentle reminders to get my head back in the game, and all the time you spent editing this document. You helped make an academic out of me..

To my committee members--Dr. Knauft, thank you for giving me the privilege of teaching your class and always being willing to lend a hand or a supportive ear. I enjoyed every minute of Project FOCUS. To Drs. Hodges and Kittleson, thank you for serving on my committee, providing valuable insights and comments, and providing me with numerous opportunities to grow as a scholar.

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION

Looking out at the sea of bored faces staring down at the cellphones in their laps, I struggled to wrap up class in a meaningful way. Today's topic was standardized testing. Despite being products of high-stakes testing environments, these students had few opinions on standardized testing and fewer opinions on testing in their partner classrooms. I felt lost--I had thought about testing when preparing for the class, but never came up with a reason for testing being on our syllabus. "So what should we take from all of this information on testing?" I asked, hoping someone would have insight. A nervous hand rose, "We'll be parents one day—I guess we can use this to decide whether our kids should take exams?" The clock ticked to 3:20, collectively the students started rustling, looking eagerly toward the exit, waiting to be dismissed. I felt defeated, my heart sinking—another unsuccessful class.

In the above impressionistic tale, the researcher narrates a time during the first semester she taught a service-learning course for science majors learning about education. She was frequently frustrated during that first semester. The students seemed bored with the educational discussion topics; the researcher was frustrated because she felt as if she was not teaching in ways that were applicable or relevant to students' own classroom experiences.

During the second year of the researcher's doctoral studies, she had the opportunity to teach a service-learning course for undergraduate science majors entitled Fostering Our Community's Understanding of Science (Project FOCUS, for short). That first semester, Fall

2013, she placed 48 students in science classrooms around the local community and attempted to guide them through a crash course in science education theory and practice. During the discussion sessions in Fall 2013, numerous students were unengaged. The researcher struggled to connect the discussion topics to what students experienced in their classrooms every day. Some of the university's brightest and highest-achieving students were sitting in the classroom, but the researcher labored to connect local classroom experiences to what was discussed on campus.

Over the next few semesters, the researcher worked alongside a second teaching assistant and the course instructor to change the curriculum of Project FOCUS. They attempted to more directly address challenges students described experiencing in their local classrooms. By incorporating active-learning strategies, the graduate teaching assistants were able to engage a larger percent of the class. Still, the researcher wanted to know more about the experiences that the students were having in their classrooms. The science majors enrolled in the course were not studying to become teachers; their career goals included becoming dentists, doctors, and veterinarians. What did this opportunity to teach science in a classroom offer to these students? The need to understand what service-learning offers university students helped to shape this study.

What is Service-Learning?

Service-learning is a type of experiential learning. Experiential learning is the process of learning from a concrete experience and reflecting upon that experience to gain a deepened understanding. For an experience to be defined as experiential learning, reflection must occur during or after the experience (Joplin, 1981). Experiential education can include internships, field experiences, community service, and service-learning, among many others. These experiences can seem similar, creating a problem for anyone trying to distinguish between the

different subsets of experiential learning. As a category of experiential learning, defining the term service-learning is not a simple task; researchers have endeavored to pin down an adequate definition (Furco, 1996; Sigmon, 1979). In fact, "'service-learning' has been used to characterize a wide array of experiential endeavors from volunteer and community service projects to field studies and internship programs" (Furco, 1996, p. 2).

Project FOCUS began in 2001 as an initiative to address issues of a perceived lack of hands-on science lessons in local elementary and middle grades classrooms. A parent in the local community approached a university faculty member hoping to establish a university partnership to secure science teaching supplies. Instead, the service-learning program was born, supplying not only materials for hands-on science lessons, but science content experts as well. Project FOCUS filled a community need with volunteering, while providing university students with opportunities to use their science content in real-life contexts. While the purpose of the course began with the intent to fill a community need, it has evolved to become equally focused on the service provided and university student learning. Teaching assistants put great emphasis on student reflection to support learning. Course aims included developing a sense of community involvement that persists after graduation and enhancing students' communication and leadership skills. The rationale for this study is discussed in the next section.

Rationale for the Study

Service-learning courses have become part of an educational reform movement, pushing to create more civilly-minded citizens (Berv, 1998). In 2011, the U.S. Department of Education released a report urging institutions of higher education to implement requirements for students to engage in civic learning (The Civic Learning and Democratic Engagement National Task Force, 2011). Putting greater emphasis on civic engagement in higher education has become a

priority for many universities (New, 2016). Service-learning courses have arisen in many university contexts, including teacher preparation (Barton, 2000; Bernadowski et al., 2013; Boyle-Baise and Sleeter, 1998), the humanities (Houshmand, 2014; Jones and Hill, 2001), and science content courses (Benore-Parsons, 2006; Lee, 2012). Service-learning courses have also been developed to provide students context for the content that they have learned. As King and Richie (2012) note, context-based science helps students to see the relevance of the content, develop deeper understandings, and increase interest in a specific science discipline or their motivation to learn science. With the push to increase context-driven and civic learning, there is similarly a desire to demonstrate the benefits of service-learning. Benefits of service-learning courses documented through research include increased awareness of and tolerance for diversity (Jones and Hill, 2001), increased self-efficacy (Bernadowski et al., 2013) and community engagement (Bauer-Dantoin, 2008). Focusing on these outcomes does not provide, however, an examination of how university students conceptualize their service-learning experiences. Scott, Knauft, and Oliver (2007) demonstrated that participating in Project FOCUS helped students to better understand their own science learning, through teaching children science. However, what the literature on service-learning research has not yet presented is how that learning is occurring. Researchers have touted that reflection is a key component in the learning in service-learning courses, but has not addressed how students use reflection to process their experiences (Cone & Harris, 1996). Much of the research in service-learning courses emphasizes the positive outcomes and benefits of service-learning, but does not address the nature of the issues that students reflect on in depth. This study seeks to understand how students are conceptualizing and reflecting on issues they experience during a science service-learning course. Understanding the different disequilibria that students choose to reflect on in a science service-learning course and

how they deal with those tensions can help university instructors form directed learning opportunities to foster personal and professional growth.

Overview of the Literature Review

The literature review of this study encompasses an analysis of empirical studies that examine reflection in both science service-learning contexts and science teacher preparation programs. Studies of reflection in the context of science teacher preparation programs were included in the review of literature to address similarities between the context of Project FOCUS and science teacher preparation programs. Though the undergraduates who participated in FOCUS were not preparing to be teachers, they were engaged in similar activities to students enrolled in a science teacher preparation program.

Reflection is a topic emphasized in science teacher preparation programs (Hatton & Smith, 1995). In elementary teacher preparation, researchers that examined reflection sought to understand development of scientific identities and positive attitudes toward science (Wilson, Bradbury, & McGlasson, 2015) and pre-service teacher beliefs about science (Correia & Bleicher, 2008; Seung, Park, & Narayan, 2011). Wilson, Bradbury, & McGlasson used reflections to demonstrate that service-learning experiences helped pre-service elementary teachers understand connections between science content and the community and to develop more positive attitudes toward science. Correia and Bleicher (2008) recommended the explicit teaching of reflection to pre-service science elementary teachers to help them make connections between course content and themselves, the field placement, and the world. Research studies that utilized reflection in secondary science teacher preparation examined how reflection impacted student achievement (Cengiz & Karatas, 2015), helped to develop views of multicultural science (Barton, 2000), and improved prospective teachers' pedagogical understandings (Lebak &

Tinsley, 2010). The research conducted in both the elementary and secondary science teacher preparation contexts did not include a discussion of how the pre-service teachers conceptualized reflection or what specifically they chose to reflect on during course experiences. For the most part, researchers concluded that reflection is beneficial to science teacher preparation, but focused on the outcomes, not how the reflection occurred or the significant tensions central to it.

Similarly, research studies on undergraduate service-learning programs are also focused on the positive outcomes of those courses (Vogelgesang & Astin, 2000). The empirical studies that examined reflection in science service-learning courses were divided by the type of service the course provided: peer teaching, creation of educational materials and research as service-learning. In most of the studies reviewed, reflection was included, but rarely emphasized. Researchers did not put much value in the written reflections undergraduates wrote, rarely utilizing them for data and focused more on the positive outcomes of science service-learning experiences. For example, Morgan Theall and Bond (2013) found, using survey data, that students felt that they had learned content and science pedagogy through a peer-teaching chemistry service-learning course, but did not give specific examples of their perceived learning and experiences. Utilizing students' reflections could have provided more evidence regarding student perceptions of their learning. Baur-Dantoin (2008) was one of the few researchers to incorporate both written and oral reflective tasks into a service-learning course on the topic of women's health. However, these reflective statements were only used to support survey data.

The literature review in Chapter Two describes the research conducted about reflection in both science teacher preparation and science service-learning contexts. An online system that searched multiple databases including ERIC and EBSCO Host was used to search for empirical studies related to reflection in science contexts. Across the science education literature, reflection

was a large and important part of learning in both science service-learning courses (Bringle & Hatcher, 1996) and pre-service science teacher preparation courses (Hatton & Smith, 1995). However, researchers rarely examined the specific topics that students chose to reflect on or how they utilized reflection in their learning.

Research Purpose and Questions

The purpose of this study was to examine the disequilibria that students wrestled with in their reflections on science service-learning experiences and how those students reconciled tensions they encountered along the way. Researchers (Astin et al., 2000; Butin, 2003; Cone & Harris, 1996) agree student learning occurs through reflection in and on service-learning experiences. Butin (2003) emphasized, "service learning does not provide transparent experiences; reflection is required to provide context and meaning" (p. 1677). In a mixed methods study of 22,000 undergraduate students, Astin et al. (2000) found reflection to be the pedagogical feature that fostered connections between the academic content and the service experience. Because Dewey posited that feelings of disequilibrium are required for reflection, this study expected that students experienced feelings of disequilibrium throughout their service-learning experience.

The following questions guided this study:

1. How do students describe feelings of disequilibrium in their service-learning experiences in weekly written reflections and in-classroom dialogues?
    a. To what extent do students' feelings of disequilibria embody issues of science teaching and learning?

2. Using Dewey's notions that disequilibrium is required for reflection, how do students describe attempts to reconcile feelings of disequilibria emerging from their FOCUS experience?
    a. How do students' attempts to reconcile feelings of disequilibria change over the course of the semester?

Overview of the Theoretical Framework

This study was framed theoretically through Dewey's notions of reflection. When categorizing modes of thinking, researchers have distinguished between reflective thought and responsive thought. Reflection is not choosing the best solution, it is a conscious effort to suspend judgement and examine all evidence about a puzzling situation (Dewey, 1993; Schön, 1983). Another hallmark of reflective thought is there must be a puzzling, odd, or unsettling experience that triggers reflection. Dewey (1933) called this feeling a disequilibrium. According to Dewey (1933), a feeling of disequilibrium must occur for a person to engage in reflection. Dewey described the necessary conditions of reflection as being a "forked-road situation" (p. 9). A forked-road presents a traveler with a dilemma—he/she must figure out which path to choose. The traveler searches for evidence to suggest which path he/she should choose. Similarly, when a person is confronted with an incident that shakes what he/she thought he/she understood, he/she "metaphorically climb[s] a tree; try[ing] to find some standpoint from which [he/she] may survey additional facts and, getting a more commanding view of the situation, may decide how the facts stand related to one another" (Dewey, 1933, p. 9). Based on these ideas, the researcher assumed that students enrolled in the FOCUS program experienced disequilibrium either during their lesson planning, in their partner classroom, or during the university reflection sessions. A thorough discussion of the various ways reflection is conceptualized and the reflective

taxonomies that can be used to recognize and understand reflection can be found in Chapter Two. The theoretical framework, its theoretical assumptions, and implications for the present study are discussed more fully in Chapter Three.

Overview of the Study Context

This study took place in an undergraduate science service-learning course in Spring 2016 at a large university in the southeastern United States. The service-learning course, called Project FOCUS, was in its fourteenth year at the university at the time this study was conducted. Undergraduate science majors who enrolled in the program were placed in elementary and middle grades classrooms in Carbon County (pseudonym). Undergraduates spent three hours per week in their partner classroom. The role that each student took on in his/her classroom was individually negotiated between the student and his/her cooperating teacher. Some students taught hands-on science lessons weekly, as the program intended. The lesson plans varied, too. Some students strictly adhered to the grade level standards for their hands-on science lessons, while other teachers asked the FOCUS student to challenge their children by going above grade-level standards and teaching units that were of special interest to either the FOCUS student or the children in the classroom. Other undergraduates worked one-on-one with children in their classroom, helping to provide enrichment on a variety of subjects. Undergraduates also attended a once-a-week reflection course, taught by a graduate student in science education. During the reflection session, undergraduates engaged in reflection and learned about educational topics with significance to science teaching and learning.

Overview of the Methodological Framework

This study used an interpretive case study methodology. Case study methodology allows researchers to answer how and why questions (Yin, 2009). Case studies are characterized by

inquiry into a bounded system, which can include a unique program, project, class, or person (Simons, 2009). The rich description of real-life contexts allows researchers to provide readers with tangible examples instead of abstract ideas and hypothetical examples (Merriam, 2009). It also allows the ideas to play out in messy, realistic ways. Case study methodology was employed because the setting in which the study took place was highly contextual. Case study also allows for the collection of multiple types of data.

The participants in this study were sixteen undergraduate science majors enrolled in Project FOCUS in the Spring semester 2016. Each of the sixteen students who participated in this study were teaching in different classrooms and schools in Carbon County. The disequilibria they felt were mediated by the sociocultural contexts, including such factors as different administrators, teachers, students, and science content they encountered. Among the sixteen study participants, five participants volunteered to take part in the study as primary participants. Primary participants allowed the researcher to focus on their reflection on disequilibria in-depth.

Case study methodology also allowed the researcher to collect multiple types of data. All sixteen participants wrote weekly reflective journal entries that explored a disequilibrium that they encountered each week. Participants also participated in focus group discussions around a disequilibrium scenario. These disequilibrium scenarios, based on Van Manen's (1988) impressionistic tales, were written by the researcher and her critical friend, drawing from their knowledge of struggles students encountered in previous semesters during Project FOCUS. Impressionistic tales are vivid depictions of a special, important, or memorable moment in time (Bryan & Tippins, 2005). Primary participants completed all of the same tasks in the study as the rest of the participants, but they were also asked to participate in three one-on-one semi-

structured interviews with the researcher. Thematic analysis was used to analyze the data. A detailed description of the methodology is found in Chapter Three.

Definition of Salient Terms

- **Science Service-Learning Course:** an undergraduate course focused on science that emphasized equally its mission to serve the community and learning objectives that fulfilled an identified community need (Furco, 1996) and incorporated an aspect of reflection (Bringle & Hatcher, 1996).

- **Reflection:** the conscious effort of a person to suspend judgement about a certain situation to examine it from multiple perspectives before choosing whether to act (Dewey, 1933).

- **Reflection-in-action:** reflection on a situation during the moment that it is happening and making an adjustment to the situation according to prior experiences or knowledge (Schön, 1983).

- **Reflection-on-action:** critically evaluating one's own actions after the situation and explaining why he/she made those choices (Schön, 1983).

- **Disequilibrium:** a "puzzling situation" (Loughran, 2002, p. 14), tension, or moment of unease that causes a person to reflect (Dewey, 1933).

Overview of the Study

Chapter One provided a description of the rationale for the study. It also included an overview of the literature, service-learning, theoretical and methodological frameworks. Chapter Two includes a review of the literature on reflection in pre-service science teacher education and

science service-learning courses. Chapter Three provides an expanded description of the study context, theoretical framework, and methodology. Chapter Four discusses the themes and interpretation of the data collected through interviews, journal entries, and case-based focus group discussions. Chapter Five concludes the dissertation with a discussion of the themes in terms of the research questions, implications for future research and practice, and concluding remarks, including the current status of the course.

An in-depth discussion of the purposes and definitions of service-learning begins the next chapter. Chapter Two also contains a review of literature regarding the use of reflection in pre-service science teacher education and science service-learning courses. The chapter concludes with a summary of the literature review and a preview of Chapter Three.

CHAPTER 2

LITERATURE REVIEW

This chapter includes a review of empirical studies related to reflection in undergraduate education and science service-learning courses. A discussion of the various ways service-learning is defined, the paradigms that frame it, and challenges in studying it begins the chapter. Following that, current conceptualizations of reflection are discussed. Finally, the chapter is concluded with a discussion of how and why reflection and service-learning can be connected and how both concepts are related to the study of an undergraduate science service-learning course.

Service-Learning

Service-learning is a form of experiential learning. Experiential learning is the process of learning from a concrete experience and reflecting upon that experience to gain a deepened understanding. For an experience to be defined as experiential learning, reflection must occur during or after the experience (Joplin, 1981). Experiential education can include internships, field experiences, community service, and service-learning, among many others. All of these experiences can seem similar, creating a problem for anyone trying to distinguish between the different subsets of experiential learning. As a category of experiential learning, defining the term service-learning is not a simple task; researchers have endeavored to pin down an adequate definition (Furco, 1996; Sigmon, 1979). In fact, "'service-learning' has been used to characterize a wide array of experiential endeavors from volunteer and community service projects to field studies and internship programs" (Furco, 1996, p. 2).

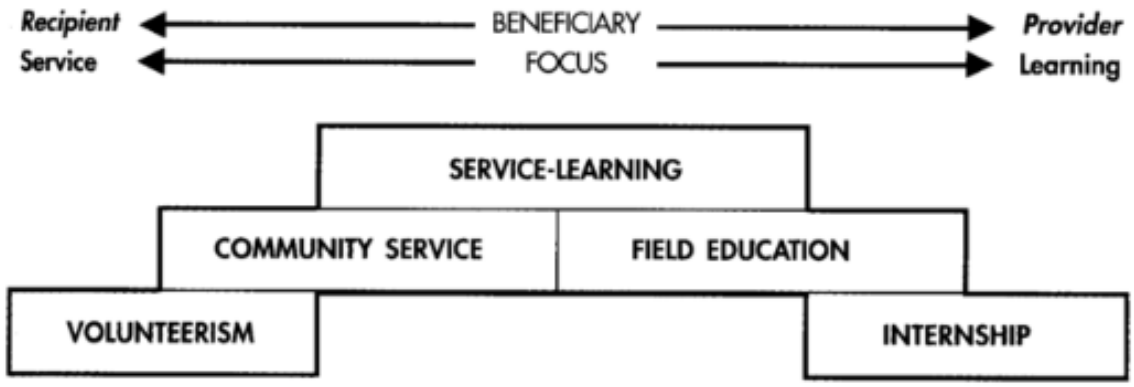
Numerous councils and governmental associations have also defined service-learning. The Council for the Advancement of Standards in Higher Education (CAS) has described service-learning as, "a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development" ("The Role of Service Learning Programs: CAS Standards Contextual Statement," 2006, p. 2). The Corporation for National and Community Service has taken the definition of service-learning a step further, concentrating on the idea of structured opportunities: service-learning is "the combination of community service and classroom instruction, with a focus on critical, reflective thinking as well as personal and civic responsibility" (Gottlieb & Robinson, 2004, p. 5).

Sigmon (1979) emphasized that reciprocity is crucial to service-learning. Both those performing the service and those receiving the service must benefit for the program to be considered service-learning. This idea is unique to the notion of service-learning. With volunteerism and community service, the benefits are primarily only to those being served. In field experiences and internships, the primary focus is on the learning goals—not on the service being provided or the benefits to the community. True service-learning lies in the middle of experiential education, the balance between service and learning (Furco, 1996).

The literature is inconclusive in terms of a commonly held definition of service-learning (Furco, 1996). Therefore, the research done on service-learning courses encompasses a vast range of definitions. The balance between the service and learning experiences is important for understanding who is receiving the service and where the learning is occurring (Figure 2.1). For example, some researchers consider a teaching internship, in which the focus is on the learning of the student enrolled and not on the service, a service-learning course. On the other end of the

spectrum, a course where students volunteer at a soup kitchen, but do not connect their service to the course content could also be categorized as service-learning.

Figure 2.1. Furco's (1996) spectrum of experiential learning



In this study, service-learning courses are those in which a service is being provided to the community that is mutually beneficial for the community and the student, where the emphasis for the student is on both providing the service and the learning objectives. As Furco (1996) noted, it is difficult to assess how a service-learning program defines itself without full access to the course requirements. However, a commonly accepted part of service-learning programs is the fact that they incorporate a form of reflection. Researchers emphasize that reflection is necessary for learning to occur in SLC (Hatcher & Bringle, 1997). The "reflection activities are a critical component of effective service-learning because they connect service activities to course content" (Hatcher & Bringle, 1997, p. 179).

Purposes of Service-Learning

There are numerous theoretical perspectives from which researchers have structured their service-learning courses, research, and practice (Handa, 2008). These paradigms determine the values, goals, activities, and reflection that occur during the course. The service-learning

framework adopted by the instructor effects the type of research that can be done on these experiences as well.

Boyle-Baise (1999) created a framework for thinking about the primary objective for a service-learning program. This framework provides guidance by incorporating the student perspective as well as the instructor's intentions. Boyle-Baise (1999) developed the Views of Service framework as a response to the issues in her service-based multicultural education class for pre-service teachers. Boyle-Baise hoped that the prospective teachers would see inequalities in their service experiences, which would spark conversations about societal inequities. When the pre-service teachers did not initiate dialogue about inequality, Boyle-Baise determined the pre-service teachers' view of the purpose of service was different than her idea of the goal of service. In this framework, Boyle-Baise (1999) proposed five different ways that people view service: conservative, liberal, communitarian, radical democratic, and post-modern.

The conservative view of service is that service is a charitable endeavor (Boyle-Baise, 1999). The impetus for charitable acts can either be from a functional or spiritual perspective. From a functional view, the person believes that his/her service is a social obligation. By performing service acts, he/she is settling a debt they owe society. A person with a spiritual motivation for service considers the act of giving to be a moral obligation. His/her service is a gesture of generosity and caring for the less fortunate. According to Boyle-Baise (1999), a service-learning program born from a conservative perspective can support deficit viewpoints and ignore the sources of inequality.

The liberal perspective of service is that acts of service help to create a "just and fair society" (Boyle-Baise, 1999, p. 7). The purpose of service-learning in this paradigm is to provide a workforce for resources and communicate the importance of working toward eliminating social

and economic inequalities. An instructor with the liberal view of service-learning would want his/her students to learn about equality and justice, creating informed citizens who will endeavor to bring about social justice. The liberal perspective, like the conservative viewpoint, has been described as hyper-focused. Programs so devoted to creating equality have the potential to forget to help students learn to question the structures that created inequities (Boyle-Baise, 1999).

The communitarian perspective of service derives from a respect of cultural diversity and strong emphasis on civic duty. Democratic action is taken in programs informed by this paradigm because of the belief that too many rights and a lack of obligation can weaken society. Communitarians cross cultural, racial, and social boundaries to include a wide diverse of peoples to make the best moral decision for everyone. This border-crossing can be difficult for students to utilize because they can be hesitant to want to address the concerns of other groups (Boyle-Baise, 1999). However, many in the service-learning community adopt the communitarian paradigm.

The radical democratic viewpoint is a combination of the liberal and communitarian paradigms. Radical democrats encourage a focus on power dynamics and culture, while working toward extending freedom. This perspective requires people to recognize their place in society and how their culture is contributing to the structures that create inequality. In addition, pluralism is embraced by the radical democratic paradigm. From this perspective, consensus cannot be good for everyone, because there are too many perspectives for everyone to benefit. A service-learning course with a radical democratic paradigm has an emphasis on helping students to understand pluralism, appreciate cultural diversity, and work to empower the disenfranchised (Boyle-Baise, 1999).

The final perspective Boyle-Baise (1999) suggested was the post-modern view of service. Like the radical democratic viewpoint, pluralism is emphasized, but it also encourages participants to build connections with those that are different than them. Instead of simply acknowledging the difference and advocating for additional freedoms, the post-modern paradigm promotes caring for other individuals and encourages students to investigate the dichotomy between self and other. The emphasis of the post-modern perspective is that both the service-learning participant and the community are working to build a community from which everyone will benefit.

Boyle-Baise's (1999) views of service are useful in looking at the perspectives of the service-learning program, its students, and instructors. If an instructor can identify which paradigms the participants have adopted, she can use that information to help bridge different perspectives. Most pre-service teachers, according to Boyle-Baise (1999) seem to either come from the conservative or liberal perspectives, which seem to ignore the ideas of transforming understanding of social inequity. However, many instructors and programs are striving for radical democratic or post-modern viewpoints (Boyle-Baise, 1999). Reconciling the perspectives of the students and the teacher are important in achieving the goals of service-learning programs.

Both the instructor's paradigm and definition of service-learning contribute to how the curriculum is presented to students. In the previous section, both paradigms and definitions of service-learning were presented. While not all perspectives included reflection as a component of service-learning, the literature widely agrees that reflection should be part of the service-learning experience (Hatcher & Bringle, 1997). In the next section, the concept of reflection is described in detail.

Reflection

Many researchers have considered the difference between stream-of-consciousness and reflective thought. Reflection is important for practitioners to improve their confidence in and communication of their professional knowledge (Schön, 1983). As a result, reflective practice has become a central part of many teacher preparation programs (Jay & Johnson, 2002; Zeichner & Liston, 1985), including those that prepare future science teachers. In the following section, the concept of reflection and taxonomies employed to recognize reflection are discussed.

What is Reflection?

John Dewey (1933) distinguishes controlled, or reflective, thought from uncontrolled thought by emphasizing the "conscious and voluntary effort" (p. 5) that an individual must undertake when reflecting. Reflection is not simply responding to a stimulus, but a conscious decision that a person makes. Donald Schön (1983) emphasized that reflection is different from simply implementing the best solution. "The purpose of reflecting is to untangle a problem or to make more sense of a puzzling situation" (Loughran, 2002a, p. 14). If an event does not occur that the practitioner finds unsettling, puzzling, or odd, there is no motive for reflection. Reflection must be a conscious effort according to Dewey (1933) and thus, must have a stimulus to elicit the beginning of the reflective cycle. Practitioners must realize that tensions exist to properly reflect on them.

Dewey's Notions of Reflection. Dewey (1933) described reflection as a rigorous, meaning-making process in which a person suspends judgment to more fully understand a situation. Reflection also starts with a particular kind of stimulus—presented in the form of a difficulty, shock, or emotional upheaval. The stimuli that causes reflection is one of the key ideas

behind Deweyan notions of reflection. Without a feeling of disequilibrium, a person would not need to reflect.

Dewey (1933) believed that once a person acknowledged a feeling of disequilibrium, the reflective process was a cycle of five steps: identifying the problem, defining the problem, suggesting solutions, reasoning, and concluding. According to Dewey, reflective process does not follow a particular order and can occur in different ways each time that a person reflects. Identifying and defining the problem can occur simultaneously or separately. A person can recognize that a problem exists without understanding the full extent of the issue at the time of identification. In the definition of the problem phase, a person then considers the parameters of the issue. Defining the problem is very important to what Dewey calls "*critical thinking,"* which is reserving judgment about a dilemma and analyzing the problem from all sides prior to proposing a solution (Dewey, 1933, p. 68). After understanding the issue fully, the reflector can then begin thinking of potential solutions to the problem. Once numerous solutions are formulated, the reflector starts to reason through them to come up with a viable one by linking the different options to previous life experiences, information, and extend his/her thinking. Only by fully exploring the options can an individual can move on to the final phase, conclusion. During this phase, the reflector implements the solution and tries it to solve a problem. This usually results in further reflection and modification of the solution to better fit the problem (Dewey, 1933).

Schon's Reflection In and On Action. Donald Schön (1983) emphasized that reflection is different from simply implementing the "best" solution. When professionals look only at the end goal—the best solution—they are employing technical rationality. Schön (1983) argued that technical rationality considers only the end goals of the problem (finding a solution) and causes

professionals to not carefully set the problem. Technical rationality is not appropriate for solving complex or unique problems; instead it should be used for issues where the answer is clear. For example, one might employ technical rationality when a doctor diagnoses a specific disease with a known treatment. The solution to his problem is simple: treat the patient for the disease that he has diagnosed. However, for those in the teaching profession, the answer is rarely as simple as giving out a prescribed treatment. Instead, the teacher must "set the problem," by doing what Dewey called defining the problem. Schön's (1983) "problem setting" includes considering the context, actors, and other factors to fully explore the problem to better understand the issue before designing possible solutions.

Reflection can take place after the problem has occurred as a look back or during the action to reframe the problem. Schön (1987) coined different terms to describe reflection for each of these scenarios: reflection-in-action and reflection-on-action. Reflection-in-action is the act of reflecting while the action is happening, the *action-present* (Schön, 1987, p. 26). Reflecting during the action allows the actor to make a difference to the present scenario, not only future ones. This type of reflection helps a person question their tacit knowledge, something that a person can do in the action, but has a hard time explaining how he/she does it. Schön (1987) gave examples of crawling, riding a bike, and juggling as tacit knowledge. Completing those actions becomes routine to someone who can do them well; however, if presented with a variation on the scenario, a person must use his/her tacit knowledge and reflection-in-action to adjust his/her behavior accordingly. After modifying his/her behavior, he/she might not be able to explain why those specific improvisations were utilized in that situation. When a person adjusts behavior in the moment, but later cannot explain why it was significant that he/she did so, this is reflection-in-action. However, if the person cannot explain why he/she made those

behavioral modifications in the moment, he/she might repeat the same mistakes if the event happens again. If he/she reflected on the actions taken after the situation has concluded, he/she can begin to identify the motivations for changed behaviors and can choose to use those modifications to inform future action. Reflection-on-action is critically important for reflective practitioners, because it can allow for changes in behaviors and outcomes in similar situations in the future. Without thoughtfully considering the reflection-in-action that took place, no future changes can be made because a person would not be able to articulate what adjustments were made.

Practitioners must realize that tensions exist to properly reflect on them. Helping students to recognize these tensions and then elaborate on them enough that they can define and explore the implications of the problem is one of the most important jobs of those who encourage reflective practice. Many different techniques can be used to help students learn to reflect including keeping journals, modeling the practice, and role-plays among many others (Loughran, 2002a). Additionally, it can be very hard to judge the level of a student's reflection because sometimes rationalizing a situation can seem like reflection (Loughran, 2002b). Reflective taxonomies can help researchers and teachers assess the depth to which reflection has occurred. In the next section, different taxonomies of reflection are discussed.

Taxonomies of Reflection

To further understand and foster reflection in practitioners, various researchers created taxonomies of reflection. These various ways of categorizing reflective thought both benefit and hinder research. In this section, five taxonomies of reflection will be discussed: van Manen's (1977) Hierarchy of Reflective Thought, Zeichner and Liston's (1985) modification of the

hierarchy, Jay and Johnson's (2002) Typology of Reflection, Harrison's (2012) framework for critical incident analysis, and Larrivee's (2000) Stages of Critical Reflection.

Hierarchy of Reflective Thought. The earliest of the reflective taxonomies, Max van Manen's (1977) Hierarchy of Reflective Thought grew out of hermeneutics and phenomenology. He outlined three levels of reflective thinking that can be used to understand alternative decisions and actions in curriculum design and enactment. At the lowest level, technical rationality, the reflector focuses on the best implementation of the curriculum to achieve the pre-determined educational goals. A practitioner who reflects at this level does not question the goals handed down from the administration or state, instead the teacher problematizes only on the teaching methods. Instrumental rationality, the next level of van Manen's (1977) hierarchy, is described as the level in which a teacher makes value judgments about the best practical action. These value judgments are based on the reflector's and his/her students' experiences, prejudices, perceptions, and assumptions. For an instrumental rationalist, the purpose of education is to communicate, share experiences and come to a common understanding. The highest level of van Manen's (1977) hierarchy is critical rationality, which is characterized by the reflector problematizing the structures and institution of education. The teacher would question the value of the knowledge to his/her students and to the social conditions, which led them to be goals of the system.

The Hierarchy of Reflective Thought could be applied in the field of science education to think about how teachers are reflecting on their classroom ideas. One of the strengths of this hierarchy is that it is designed around how a teacher thinks about the goals of education. This structure allows teachers to be cognizant of the reasons why they are teaching the things they are and make judgments about whether the goals are appropriate for their students. Another strength of van Manen's (1977) hierarchy is the degree to which it is grounded in the theories of social

science. However, the theory-laden nature of the hierarchy makes it difficult to apply to real-life scenarios. Another issue with the hierarchy is that van Manen (1977) emphasizes that a reflective teacher is one who reflects at all three levels, though mostly at the level of critical rationality. In the current context of education, this is a problem because teachers have little autonomy over what they teach. Researchers recognized some of these shortcomings and modified the Hierarchy of Reflective Thought to include additional categories for more practical application.

Categories of Reflective Discourse. Zeichner and Liston (1985) modified van Manen's (1977) hierarchy to fit real life scenarios with teachers and their supervisors. To do this, Zeichner and Liston (1985) created four categories of reflective discourse that involve the motives behind the practical decisions that teachers make: factual, prudential, justificatory, and critical discourse. Factual discourse is reflection on the actions that occurred during a specific situation or what will occur in future scenarios. If reflection is centered on an evaluation or suggestions to improve a situation that already occurred, it is prudential discourse. Justificatory discourse is the conversation around why a particular decision was made. If a reflector is involved in reflection that judges the reasons given for making a pedagogical decision or evaluating the values and decisions behind the content and methods of a particular curriculum, then he/she is involved in critical discourse. Each category is broken down into subcategories to make specific distinctions. Table 2.1 describes each subcategory in detail. Additionally, Zeichner and Liston (1985) listed six substantive categories to classify the conditions on which the teachers were reflecting. Those practical categories were: goals, curriculum and materials, procedures, students, lessons, and context.

By expanding the hierarchy to include four categories rather than three, Zeichner and Liston (1985) made it is easier to apply to teachers' reflection. The fourth category was added to

account for why actions were justified—whether they were decisions based on value or moral

Table 2.1. Zeichner and Liston's (1985) Categories of Reflective Discourse	
Factual Discourse	Reflection on the actions that occurred during a specific situation or what will occur in future scenarios
Descriptive Discourse	Description of a particular observation or a situation that can be verified through observation or experience.
Informational Discourse	Information that is important to reflection, but cannot be verified through observation or experience.
Hermeneutic Discourse	Reflection focused on the participants' meaning making.
Explanatory/Hypothetical Discourse	Reflection that attempts to find the origins of behaviors or results in the classroom.
Prudential Discourse	Reflection is centered on an evaluation or suggestions to improve a situation that already occurred; This reflection looks at how actions affect others.
Instructions	A pedagogical problem is posed and a singular solution is given.
Advice/Opinions	Two or more solutions are given for the same pedagogical problem.
Evaluation	A judgment (positive or negative) is made about a particular action.
Support	Encouragement or an empathetic response is given by a participant.
Justificatory Discourse	Reflection on the rationale behind the pedagogical actions that were or will be taken
Pragmatic Rationale	Decision criteria based on what is most efficient or effective.
Intrinsic Rationale	Decision criteria based on universal values or knowledge. Decision is made because it is valued.
Extrinsic Rationale	Decision criteria based on situations outside of the classroom. The action taken will benefit society or is necessary for student development.
Critical Discourse	Reflection that judges the reasons given for making a pedagogical decision or evaluating the values and decisions behind the content and methods of a particular curriculum
Pragmatic	Analysis of decisions based on the most efficient or effective action
Intrinsic	Analysis of decisions based on universal values of knowledge
Extrinsic	Analysis of decisions based on situations outside of the classroom context
Hidden Curriculum	Values embedded in the form and content of materials or instructional practices are analyzed

judgments. Additionally, modification from reflective thought to reflective discourse allowed for researchers to identify the categories of reflection in conversations between student teachers and their supervisors. Thought is a hard thing to analyze, but discourse is much more tangible. They were able to analyze the discourse to measure the percentage of thought units of both the logical and substantive categories of reflection. This allowed the researchers to understand what student teachers were reflecting on most often and where the program needed to focus to help student teachers learn to reflect in other categories. Using the categories of reflective discourse allowed

researchers to analyze data from both the student teachers and their supervisors. A system like this would be useful in categorizing the reflection of the FOCUS students because it allows for very structured analysis. However, a drawback to this categorical system was that only discourse could be used as a data source. Journaling was not used as a data source in this study.

Typology of Reflection. Jay and Johnson (2002) defined reflection as "a process, both individual and collaborative, involving experience and uncertainty" (p. 76). A reflective individual, according to their typology, would be able to concentrate on a facet of their pedagogy from multiple perspectives and discuss the boundaries of that facet to broaden their understandings of it in an effort to work to improve. The resulting typology is similar to that of

Table 2.2 Dimensions and guiding questions of Jay and Johnson's (2002) Typology of Reflection.

Dimension	Description	Guiding Questions
Descriptive	Problem is defined, including the parameters and goals	What is happening? Is this working, and for whom? For whom is it not working? How do I know? How am I feeling? What am I pleased and/or concerned about? What do I not understand? Does this relate to any of my stated goals, and to what extent are they being met?
Comparative	Problem is considered from multiple frames and perspectives	What are alternative views of what is happening? How do other people who are directly or indirectly involved describe and explain what's happening? What does the research contribute to an understanding of this matter? How can I improve what's not working? If there is a goal, what are some other ways of accomplishing it? How do other people accomplish this goal? For each perspective and alternative, who is served and who is not?
Critical	A renewed perspective of the problem is established and/or a judgment is made about an action	What are the implications of the matter when viewed from these alternative perspectives? Given these various alternatives, their implications, and my own morals and ethics, which is best for this particular matter? What is the deeper meaning of what is happening, in terms of public democratic purposes of schooling? What does this matter reveal about the moral and political dimension of schooling? How does this reflective process inform and renew my perspective?

Van Manen (1977) in that it has only three dimensions, rather than Zeichner and Liston's (1985) four categories, but is linked heavily to the ideas of Schön (1983, 1987). The three dimensions

are: descriptive reflection, comparative reflection, and critical reflection. These dimensions might be more aptly described as reflective phases to guide a teacher in the process of reflection. Instead of basing the typology on what teachers do, Jay and Johnson (2002) based their typology on what they believe teachers should do. To help guide teachers to be better reflectors, numerous questions were designed to accompany each phase, as seen in Table 2.2.

In the first dimension, the descriptive dimension, Jay and Johnson (2002) drew on Schön's (1983) concept of "problem setting." In the descriptive phase, reflectors delineate the problem, considering the parameters, and end goals. The guiding questions the authors provided for this step included what aspects of the practice are working or not working, what evidence he/she has to support those claims, and how he/she is feeling about the problem. These questions help to prevent the reflector from "reporting just the facts" (Jay & Johnson, 2002, p. 78). The facts could signal a vital piece of the puzzle that would otherwise go unnoticed if the parameters of the problem were not considered. The descriptive dimension does not offer numerous solutions or alternatives, so additional reflection is required to truly understand the issue.

During the comparative phase of reflection, the reflector thinks about alternate views of the difficulty, including others' perspectives, research, and possible improvements. It is what Schön (1983) describes as a "frame experiment," where the reflector considers numerous interpretations or frames of reference around the same problem. Jay and Johnson (2002) outlined questions for this phase including, "How do other people…describe and explain what's happening?" and "If there is a goal, what are some other ways of accomplishing it? How do others accomplish this same goal?" (p. 77). A teacher might consider the perspective of a person of a different culture, race, or gender from themselves or the standpoint of a student,

administrator, or parent. Multiple frames of reference are considered in this phase, but a limited view of the problem remains, necessitating a third dimension.

After considering the problem from multiple perspectives, the next phase of the reflection process is the critical dimension. This step includes reconciling all perspectives into one understanding of the problem and/or making a judgment about what action to take. The critical dimension takes into account broader contexts: socio-cultural, historical, and moral. Questions that reflectors should ask themselves at this level include: "Given these various alternatives, their implications, and my own morals and ethics, which is best for this particular matter?" and "What is the deeper meaning of what is happening, in terms of public democratic purposes of schooling?" (p. 77). Jay and Johnson (2002) emphasized that critical reflection is "making a decision through careful deliberation, whether that decision is to act or to continue the cycle of reflection" (p. 79).

The typology is particularly useful because it not only rates individuals' levels of reflection, but also can guide them to improve reflective techniques with guided questions. Jay and Johnson (2002) intentionally created some questions that were general and some that were targeted at specific contexts. The questions could be used for the structuring of reflective activities in FOCUS. The typology is better structured for practical application than van Manen's (1977) hierarchy because it provides concrete examples of the types of reflection teachers should be doing. It is also better formatted than Zeichner and Liston's (1985) scheme of reflective discourse, because it does not specify conversation as the source of reflective thinking. It leaves the demonstration of reflection open to not only discourse, but also written reflection. In addition, Jay and Johnson's (2002) framework guided teachers to look at a situation from multiple perspectives, which neither of the other two have considered. The other two systems

considered context, as do Jay and Johnson (2002), but they did not ask the reflector to step outside of his/her own viewpoint. By considering multiple points of view, the reflector can isolate certain facts for consideration, while making others less important. What is missing from this typology, however, is the substantitive categories that Zeichner and Liston (1985) outline. By failing to define differences between different subjects of reflection, the reflector could spend too much time on the descriptive dimension and never make it to the comparative or critical.

Critical Incident Analysis. Similar to the Jay and Johnson (2002) typology, Harrison (2012) designed a framework for reflection that a teacher could use to judge his/her own level of reflection to improve upon it. This reflection framework is intended to aid in the analysis of a critical incident. Harrison (2012) said that "almost everything in the everyday life of a school is a potential critical incident" (p. 37). While people tend to record negative events, Harrison emphasized that these could also be positive occurances. The incident chosen will become critical upon critical analysis; it is not critical without reflection. Intended to be used with a written reflection, the framework could also be used in discourse with a peer or mentor. Harrison (2012) outlined four levels of reflection: routine, technical, dialogic, and transformative. Each level includes a criterion for the focus of the reflection, types of questions the reflector is asking, and the change that will result from the reflection (Table 2.3). Routine reflection is described as being reflection in which the individual separates himself/herself from the situation. The focus of the reflection remains on the others involved in the situation and who is to blame. In routine reflection, the situation is analyzed for the situation's benefit and no personal growth occurs. Level two of the framework is technical reflection, in which the individual responds to the situation to improve it but does not make any changes to practice outside of that specific incident. Technical reflection is distinguished from routine reflection in that the focus of the

analysis is on the pedagogical choices. The next level of the framework, dialogic reflection, is much like the comparative dimension of Jay and Johnson's (2002) typology. Individuals consider new perspectives to better understand the situation. Considering these perspectives helps the teachers make changes to their practice in generalized situations. The highest level of reflection, transformative reflection, is the critical level of reflection. At this level, teachers are considering the contextual factors that effect the situation in the classroom. They challenge their own assumptions about these factors and the situation to become more aware of how their students are effected. As a result, their perspectives are altered in a way that fundamentally changes their practice.

Table 2.3. Harrison's (2012) Reflective Framework of a Critical Incident

	Level 1	**Level 2**	**Level 3**	**Level 4**
	Routine	**Technical**	**Dialogic**	**Transformative**
Definition	Reflector is separate from the situation.	Practical response to the situation; no personal change.	Other perspectives considered in deciding a course of action; new understandings of the situation.	Questions of ethical, moral, pedagogical, or other broad concerns asked; change in practice occurs
Focus…	…Is on how the situation effects the individual, how to maintain control of the situation, or on personal success	…Is on the specific methods and actions taken; changes are made to professional practice	…Is on how well students are learning	…Is on how the broader contextual issues affect the students and personally work to acknowledge and address the concerns.
Inquiry	Analysis is general and limited to critique of other people; personal change is not assessed	Questions relate only to the specific situation; no questions about context	Questions lead to new inquiries; new ideas are considered and actively sought	Long term consideration of the situation and context; individual challenges their own assumptions
Change	Situation is separate from reflector; no personal change occurs	Individual responds to the situation, but does not change their perspective	New understandings are gained, which change personal or professional actions	Perspective is changed, which changes practice at a fundamental level

Harrison's (2012) framework is different than the previous three discussed because it imposed the responsibility of assessing the level of reflection onto the reflector. While an

individual could use any of the previous frameworks to assess their own reflection, this framework is intended to be self-directed. It is useful because it forces teachers to consider honestly their own reflection on three separate criteria. Simply being aware of the other levels of reflection and reading the criteria for them could guide a teacher to think more deeply about his/her critical incident. It could also be used in a peer reflection period, where peers assess each others' reflections and provide guiding questions from higher levels of reflection.

Stages of Critical Reflection. Barbara Larrivee (2000) acknowledged that the reflective process is cyclical in her design of the reflection framework. This framework of critical reflection is built on a continuum between current practice and transformation of practice. There are three stages, each with distinctive characteristics, constantly in flux between the extremes as shown in Figure 2.2. The first stage, examination, is triggered by a behavior that causes concern in the reflector. Unease causes the teacher to question, challenge, or want to change his/her current practice. Once the teacher has noticed a pattern of behavior that contributes to the issue in the classroom, he/she has moved on to stage two of critical reflection, struggle. During this stage, the teacher experiences inner conflict and uncertainty around the behavior he/she has observed. Fear also plays a part in the reflective process, which can either be the impetus for change or cause a retreat. The reflector must make a choice: either to return to current practice out of fear or reluctance to change or to move on to stage three. Perceptual shift, the third stage, occurs when the teacher experiences a shift in understanding. This change in perception allows for "new patterns of thinking and access [to] new tools and strategies to respond more appropriately to classroom situations and circumstances" (Larrivee, 2000, p. 305).

The central theme of Larrivee's (2000) framework is the struggle that occurs during reflection. This is the critical piece of the process, because only by enduring the chaos of the

uncertainties and seeking to better understand the problem, can a reflector transform his/her practice. This emphasis on struggle sets the Larrivee framework apart from the others examined here. If presented with this framework, students might better understand that critical reflection requires struggle rather than a "quick fix" (Larrivee, 2000, p. 305). Another strength of this

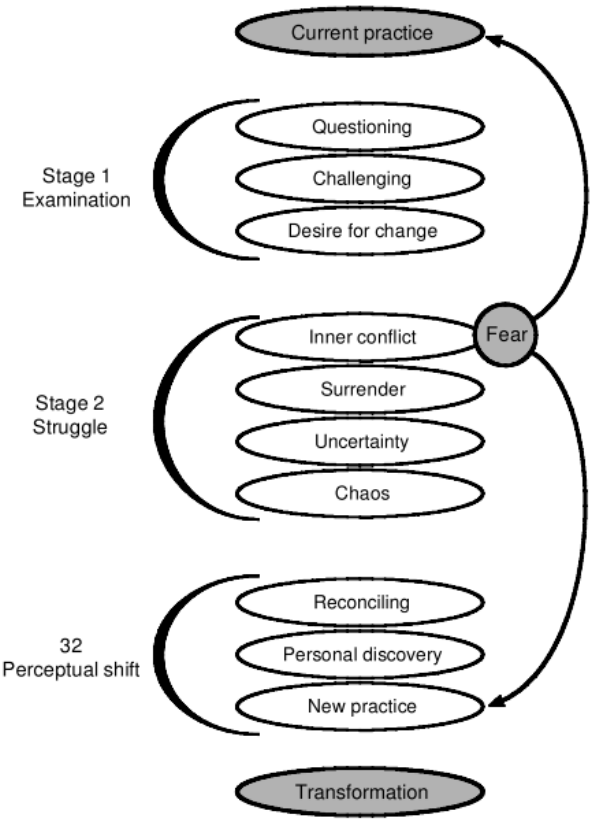


Figure 2.2. The stages of reflection illustrated on a continuum (Larrivee, 2000, p. 305)

framework is its focus on the cyclical nature of reflection. However, this framework lacks the evaluation system of the previous reflective frameworks. While a researcher could possibly assess which stage of critical reflection a piece of writing represented by looking for specific key words, Larrivee's (2000) framework would not be as easy to use or as detailed as Harrison's (2012) or Jay and Johnson's (2002). Additionally, Larrivee did not include reflection on context

or multiple perspectives in this framework, a theme that the other four frameworks considered to be the object of critical reflection.

The five frameworks examined in this section are all useful for examining reflection from a different perspective. While van Manen's (1977) and Zeichner and Liston's (1985) frameworks are more focused on being utilized for research purposes, the taxonomies of Larrivee (2000), Jay and Johnson (2002), and Harrison (2012) are designed for self-evaluation and improvement. A comparison of each of these frameworks considering their levels of reflection, source of analysis, and purpose of reflection is found in Table 2.4. Many of the levels of reflection are analogous

Table 2.4. A comparison of five frameworks for reflection.

Author	Levels	Source of Analysis	Purpose of Reflection	Unique Feature
Van Manen (1977)	Technical Rationality Instrumental Rationality Critical Rationality	Thought	Choosing between alternative actions in curriculum design and enactment	Emphasis on making curricular decisions
Zeichner and Liston (1985)	Factual Discourse Prudential Discourse Justificatory Discourse Critical Discourse	Discourse between peers or student and mentor	Purpose depends on the level of discourse	Designed for analysis of reflective discourse
Jay and Johnson (2002)	Descriptive Dimension Comparative Dimension Critical Dimension	Writing or Conversation	To isolate a facet of practice and improve upon it through reflection resulting in personal growth	Numerous guiding questions
Harrison (2012)	Routine Reflection Technical Reflection Dialogic Reflection Transformative Reflection	Writing	To better understand a critical incident with the goal of changing practice	Emphasis on self-evaluation to improve reflective thought
Larrivee (2000)	Examination Struggle Perceptual Shift	Thought	To understand and improve upon a behavior	Focus on struggle and the reflection cycle

from one framework to another. For example, though the purposes of reflection are different, Jay

and Johnson's (2002) Critical Phase level is similar to Harrison's (2012) Transformative Reflection. In each of these stages, the reflector must ask himself/herself what action he/she will take based on the larger contextual factors that he/she has considered through reflection. Jay and Johnson (2002) and Harrison's (2012) frameworks seem to be the most useful in analyzing reflection in writing due to the numerous guiding questions and focus on thorough reflection on a particular incident so that increased understanding will permeate all facets of practice.

In the previous section, the various ways of defining reflection and taxonomies to help researchers recognize different types of reflection were reviewed. Taxonomies of reflection from five different prominent researchers were reviewed to examine the many ways reflection could be conceptualized. In the following section, salient literature related to the use of reflection in undergraduate settings is reviewed.

Review of Salient Literature

In the following section, the research related to reflection and science-service-learning courses is presented. First, an overview of research on reflection in science teacher education is described. Next, the literature on undergraduate service-learning courses is reviewed. This literature review concludes with an in-depth examination of fifteen research articles using reflection in science service-learning courses.

What Research Says about Reflection in Science Teacher Preparation

As previously stated, reflective practice is prevalent in teacher preparation (Jay & Johnson, 2002; Loughran, 2002b; Zeichner, 1994; Zeichner & Liston, 1985). Reflection has been widely used in science teacher preparation. However, the foci of these studies varied widely. Some researchers examined teacher identity and beliefs through reflection (Correia & Bleicher, 2008; Wilson, Bradbury, and McGladen, 2015), while others studied how achievement was

effected by reflective journals (Cengiz & Karatas, 2015). In this section, articles on reflection with pre-service science teachers were examined and divided into elementary science teacher preparation and secondary science teacher preparation.

Elementary Science Teacher Preparation. Research studies related to reflection in the context of pre-service elementary science teacher preparation seemed to be focused on scientific identity (Wilson, Bradbury, and McGlasson, 2015), developing positive attitudes toward science (Wilson, Bradbury, and McGlasson, 2015), and beliefs (Correia & Bleicher, 2008; Seung, Park, and Narayan, 2011).

Wilson, Bradbury, and McGlasson (2015) examined pre-service elementary teachers' interpretations of their service-learning experiences and how those reflections impacted their scientific identity. The context for this study was that the pre-service elementary teachers were involved in service-learning activities that centered around environmental science prior to taking a science methods course. The authors used an interpretive qualitative inquiry methodology to "highlight the voices" of the students (p. 326). Forty-two future elementary teachers participated in the study over two semesters. Four themes emerged: (1) Learning: Physical experiences with science; (2) Learning: perspectives of pedagogy; (3) Interaction with others; and (4) Making an impact. Each of these themes was assigned a definition and all of the data associated with the theme was put into a table. Findings included that the service-learning experiences were meaningful to the pre-service teachers. It allowed them to see connections between the course content and issues in the community. Pre-service elementary teachers also developed more positive attitudes toward science.

Correia and Bleicher (2008) examined how pre-service elementary teachers made sense of service-learning experiences through reflective journals. The service-learning experience took

place at elementary schools for three hours a week for a duration of 13 weeks. Reflective journals were submitted online weekly. Correia and Bleicher (2008) found students made three different types of connections to their service-learning experiences: to themselves, to similar settings, and to the world. They noted the phrasing hallmarks that demonstrated the type of connections students made. For example, the phrase "I never thought" showed an unexpected event that can call an instructor's attention to a comparison that is about to be made (p. 45). Using emotional words, like "shocked" helped to indicate to researchers that reflection was occurring, as pre-service teachers drew on connections between past and present beliefs. Correia and Bleicher (2008) recommend using these phrasing markers and approaching reflection as a skill that can be taught to students explicitly.

Seung, Park, and Narayan (2011) examined 106 pre-service elementary teachers' beliefs about science teaching and learning in reflective metaphor writing. Students were asked to write personal metaphors that embodied their beliefs about the role of a science teacher at the beginning and end of the semester. They also wrote a three-page reflection that supported the underpinning beliefs of their metaphor. The researchers categorized each student into one of three groups representing beliefs about the role of a science teacher as traditional, constructivist, or a mix of the two. Comparisons were made between each student's belief at the start and end of the semester. The authors found that students' belief in the constructivist role of a teacher increased over the course of the semester, but students also tended to hold on to the belief in the traditional role as well. Instead of replacing the belief in a traditional, teacher-centered, model of learning with a belief in a constructivist model, students tended to add constructivist views to their traditional model, transforming their belief system from traditional to mixed, rather than traditional to constructivist.

Secondary Science Teacher Preparation. In this section, studies that examined reflection with pre-service middle and high school science teachers are discussed. Research on the reflection of secondary science teacher preparation had a different focus than elementary science teacher preparation. Instead of focusing on pre-service science teachers' beliefs and attitudes toward science, researchers examined how reflection impacted student achievement (Cengiz & Karatas, 2015), views of science pedagogies (Barton, 2000; Lebak & Tinsley, 2010), and tensions surrounding micro-teaching experiences (Sezen-Berrie et al., 2014).

Cengiz and Karatas (2015) conducted a case study of 14 pre-service science teachers enrolled in a general chemistry laboratory course to examine how reflective journals effected students' achievement. They found that the majority of the pre-service teachers felt that the reflective journals were effective tools for fostering learning. In particular, keeping the journal increased their motivation and helped them to gain ownership of their learning. The second major finding was that, while the reflective journals were useful in helping them to question teaching strategies, they did not question their own studying strategies, and therefore, there was no significant difference between the pre- and post-achievement tests. However, the reflective journal writing only took place for eight weeks of the semester, which might not be enough time for students to develop deep levels of reflection in their writing.

Barton (2000) explored pre-service secondary science teachers' views of multicultural science education through a service-learning project. The study was a case study of eight students enrolled in the secondary science education program. For the service project, students worked at a homeless shelter implementing science lessons and getting to know their students. Weekly reflective sessions helped students to discuss multicultural science issues and to reflect on what science is and should be. Barton (2000) reported that the participants broadened their

understanding of culture and of multicultural science pedagogy, questioned their own knowledge and practice, and made connections between multicultural science and issues of political power within schools.

Using a model of collaborative reflection, Lebak and Tinsley (2010) had science teachers videotape themselves teaching, share the tapes with peers during weekly meetings, and then engage in collaborative reflection. Case study methodology was used to examine three science teachers enrolled in an action research course. Findings included that the participants began to question each other's teaching strategies, make suggestions about how to change pedagogy, and help each other make decisions about useful strategies. The researchers found that when one teacher involved in the collaborative reflection started to use inquiry in his classroom, the others soon followed his example and incorporated it into their own practice.

Sezen-Barrie et al. (2014) examined the aspects of a teaching experience that pre-service teachers reflected on and the tensions they experienced through a CHAT perspective. Twenty-three pre-service science teachers participated in the ethnographic case study. Students developed lesson plans in pairs and then implemented them with a group of middle school students. These microteaching experiences were video-taped. The pre-service teachers then watched the video of their teaching and recorded a voice-over reflection of their teaching. Student pairs were also required to submit written reflections on their microteaching experience. Findings included that the pre-service teachers did not mention tensions surrounding scientific practice in their reflections. Tensions did arise, however, in the division of labor during teaching—pre-service teachers had difficulty knowing where it would be appropriate to stand during the microteaching experience to gain students' attention.

The studies presented in this section demonstrated that research on reflection varies widely throughout science teacher preparation. The majority of the studies examined the results of reflection within the particular context, whether it was changed beliefs, attitudes, or practice. Only one study examined the specific tensions that pre-service teachers wrestled with when they were involved in reflective teaching (Sezen-Berrie et al., 2014). This seems to indicate that more research needs to be done on what pre-service teachers choose to reflect on and why they choose those particular topics. In the next section, studies of undergraduate service-learning courses are examined.

What Research Says about Undergraduate Service-Learning

There are many varieties of service-learning courses at the undergraduate level. Because scholars disagree on what constitutes a service-learning experience, it makes it difficult to compare research on individual programs. The goals for each individual service-learning program varies widely. In spite of this, researchers are committed to proving that service-learning benefits students. Studies in this section of the literature review were organized in terms of personal outcomes, learning outcomes, social outcomes, and large scale program comparisons.

Personal outcomes. Research at the undergraduate level has emphasized personal growth as a positive outcome of service-learning experience. Students who helped facilitate a therapeutic leisure program as part of a service-learning experience became more self-aware (Cooke, Kemeny, Rosegard, Ross, & Stevens, 2014). In a study of pre-service teachers, Bernadowski et al. (2013) found that when students participated in a service-learning experience embedded in course content, students' self-efficacy improved.

Learning outcomes. Many researchers focus on the learning outcomes that occur as a result of the service-learning component of various courses. This is not to say that service-

learning experiences increase students' fact recall or factual understanding, but it seems that students who are involved in service-learning are able to better apply what they learn and have deeper understandings of concepts (Strage, 2000). Strage (2000) compared the mid-term and final exam scores of two cohorts of 477 pre-service teachers. One cohort spent 20 hours observing pre-school aged children through one-way glass and making observations about the behavior of the children. The other cohort engaged in a 20-hour service-learning project in which they were placed in a pre-K, elementary, or middle school classroom and kept a weekly journal of their experiences. On the mid-term, the students engaged in the service-learning experience significantly outperformed their peers on the essay portions of the test, but there were no significant differences between the multiple-choice portions. This suggests that service-learning enriched the experiences of the students so that they were able to think more critically in their essays. The reflective journals gave the students practice in connecting theoretical course content to the real-life classroom experience. On the final exam, students involved in the service-learning experienced greater gains than their peers. This suggests that the impact of service-learning takes time to develop and may not be seen immediately (Strage, 2000).

Social outcomes. A large majority of the body of literature related to undergraduate service-learning courses is related to the students' experience of society's issues. When students were working with a food pantry or an AIDS outreach organization, they encountered people different from themselves and had to endeavor to embrace multiple perspectives (Jones & Hill, 2001). Jones and Hill (2001) interviewed six students placed in these types of situations and found that they had become committed to the organizations and people they worked with and decreased engaging in stereotyping behavior. Students described an increase in their levels of care and compassion for people different from themselves. The authors suggested that

intentionally designing service-learning programs with these outcomes in mind could help students become aware of multiculturalism (Jones & Hill, 2001). In another study, undergraduates who were mentors to high school students through a service-learning program, had increased awareness of issues of poverty as a result of interacting with their mentee (Hughes, Welsh, Mayer, Bolay, & Southard, 2009). When journaling about their experiences, undergraduates expressed frustration with the problems their mentees mentioned casually. They also had to face their own misconceptions about issues of poverty and realized the privilege in their own lives (Hughes et al., 2009).

Large Scale Program Comparisons. Some researchers focused on large data sets comparing multiple different types of service-learning programs rather than individual, isolated programs. Astin, Vogelgesang, Ikeda, and Yee (2000) conducted an extensive four-year mixed methods study of more than 22,000 undergraduates from various colleges across the United States. Their study found that students who participated in service activities during college had significantly better academic performance, self-efficacy, and community engagement than their peers who did not participate in some form of service. In addition, researchers found that participation in a service-learning course improved the academic performance and community engagement of students compared to those who participated in community service outside of coursework. Participating in a service-learning program had the strongest effect on a student's decision to choose a service career.

The most important aspect of the Astin et al. (2000) study was that it compared community service and service-learning programs and tried to illuminate the specific aspects of service-learning that distinguished it from community service. To come to these conclusions, researchers surveyed students from numerous universities to determine what the effects of

service-learning on students were. Once they had identified specific differences between students with service-learning experiences and students with volunteer experience, they sent out additional questionnaires with space for written responses so that students could explain their choices. Faculty members from various universities were also interviewed to investigate how service was incorporated into curriculum.

Vogelgesang and Astin (2000) used that same data to compare students who participated in service-learning courses to those who only had community service experience and those who had not engaged in service activities at all. Those who participated in service learning experiences had higher grade point averages, growth in writing and critical thinking skills, and increased commitment to promoting racial understanding and activism when compared to their peers (Vogelgesang & Astin, 2000).

The previous section described undergraduate service-learning research in terms of the outcomes touted by researchers. The articles reviewed in this section were not exclusively science related. In the next section, what the research has said about reflection in science service-learning courses is examined in depth. This review considered not only the results of the studies, but how well those results were supported by the data and how the researchers conceptualized reflection and service-learning in their articles.

What Research Says about Reflection in Science Service-Learning

In this section, the empirical research on service-learning courses that scrutinized the learning that occurred through reflection with an emphasis on science service-learning courses were examined. The articles were methodically selected by searches on a university's online database system, which includes many educational databases including ERIC and EBSCO Host. The inclusion criteria for an article to be analyzed in this review were:

- peer-reviewed, empirical study
- undergraduate service-learning program
- situated within a science content course (earth, life, physical) class

Table 2.5. Databases, search terms, and non-duplicate results for the review of literature of science service-learning courses.

Database	Search Terms	# of Results	# Included	# Excluded	Reasons for the exclusions
GALILEO	"undergrad*" AND "service-learning" AND "reflection" AND "science"	10	**0**	8	Excluded Disciplines
				2	Conference Proceedings
GALILEO	"undergrad*" AND "service-learning" AND "reflection" AND "biology"	0	--	--	--
GALILEO	"undergrad*" AND "service-learning" AND "chemistry"	18	**6**	6	Program Evaluation/ Description
				2	Conference Proceedings
				1	Excluded Disciplines
				1	Project-based Learning
GALILEO	"undergrad*" AND "service-learning" AND "chemistry" AND "reflection"	0	--	--	--
GALILEO	"undergrad*" AND "service-learning" AND "biology"	17	**5**	5	Conference Proceedings
				3	Program Evaluation/ Description
				2	Overlap from Chemistry search
				1	High School Context
				1	Scientific Research
GALILEO	"undergrad*" AND "service-learning" AND "physics"	7	**0**	3	Conference Proceeding
				4	Excluded Disciplines
GALILEO	"undergrad*" AND "service-learning" AND "geology"	5	**1**	3	Conference Proceedings
				1	Not within the discipline
GALILEO	"undergrad*" AND "service-learning" AND "life science"	0	--	--	--
GALILEO	"undergrad*" AND "service-learning" AND "earth science"	1	**0**	1	overlap with geology search
GALILEO	"undergrad*" AND "service-learning" AND "physical science"	0	--	--	--
GALILEO	"undergrad*" AND "service-learning" AND "science education"	33	**3**	7	Overlap from other searches
				13	Excluded Disciplines
				3	Conference Proceedings
				5	Program Description/ Evaluation
				1	Non-target Population
				1	Award
Total Number of Articles Found					91
Number of Articles that Met the Criteria					**15**

Based on Sigmon's (1979, 1997) and Furco's (1996) ideas that internships and other field education experiences should not be included in the category of service-learning, programs like nursing that require field experiences were excluded from this literature review. The search terms were constructed to decipher a very particular subset of the literature. Table 2.5 identifies the search terms, database, and the number of results of those searches. The table also provides specific reasons for why articles were excluded from the review, including articles situated in disciplines outside of the realm of this review, program descriptions and program evaluations. For example, for the first search performed, the search terms used were "undergrad*" AND "service-learning" AND "reflection" AND "science". That search resulted in 10 results. Of those results, none of them fit the criteria because eight were from excluded disciplines and two would have fit the criteria except that they were abstracts from scientific conferences. After 11 searches, 91 articles were examined with only 16 meeting all the criteria for the review.

Critical Analysis. The purpose of this literature review was to critically review and evaluate empirical studies pertaining to the learning in science service-learning courses and to understand how reflection was utilized in those contexts. The following questions guided this critique of the literature:

- How do researchers define service-learning? How do the service-learning definitions differ between articles?
- What are the learning objectives in a science service-learning course?
- How is reflection being utilized for learning in service-learning courses situated in science?

The analytical approach this literature review used was two pronged. First, the critique examined the definitions of service-learning in each article by seeking the extent to which the course meets

the above definition of service-learning. Then, the critique examined whether or not the authors provided enough evidence of the learning that they claim occurred through the service-learning and the extent to which reflection was used in the learning process. For analysis purposes the articles were entered into a spreadsheet. Each article was read and notes were created on the main points, reflection usage, service-learning definition, methods, and findings. Articles were categorized into rough groups and then each article was examined in depth, looking for connections between the findings and claims.

Findings. In this section, the findings from each of the 15 articles reviewed are discussed. The articles were categorized by the service performed. In the first section, articles that examine peer teaching were described. In the next section, articles that describe the creation of educational materials were examined. The third section, research as service-learning, discussed the analysis of the articles that used research to improve the community. A summary of the data in terms of the research questions was organized into Table 2.6 and Tables 2.7-2.9. Table 2.6 organized each article reviewed in this section by the five dimensions of service-learning represented in the study: 1- Experiential Learning; 2 - Meets Community Needs; 3 - Service and Learning Goals Equal; 4 - Enhances Learning; and 5 – Reflection. Table 2.6 also listed the type of service-learning performed and the name of the course examined in the article. Tables 2.7-2.9 summarized the learning and service objectives and type of reflection students engaged in, organized by type of service performed.

Peer Teaching. Peer teaching is one of the more prevalent projects in science service-learning courses. Most commonly, peer teaching in service-learning courses is cross-age, where undergraduate students teach K-12 students.

Table 2.6. Definitions provided by authors examining undergraduate science service-learning courses.

Year	Author	Service Provided	Course	Dimensions of Service-Learning				
				1	*2*	*3*	*4*	*5*
2015	**Stevenson & Peterson**	Cross-Age Peer teaching	Human Dimensions of Wildlife	✓				
2009	**Santas**	Research as Service-Learning	Biology Research Course, spanning 3 semesters	✓	✓	✓	✓	✓
2007	**Owens & Foos**	Research as Service-Learning	Geology Service Learning	✓	✓	✓	✓	✓
2013	**Morgan Theall & Bond**	Cross-Age Peer teaching	General Chemistry		✓		✓	
2004	**Liu et al.**	Research as Service-Learning	Engineering and Environmental Geology & Engineering and Environmental Geophysics	✓	✓	✓	✓	✓
2012	**Lee**	Cross-age Peer teaching	Principles of General Chemistry	"Classic example of service-learning (p.2)"				
2010	**Kim**	Cross-Age Peer teaching	Elementary Science Methods	✓	✓	✓	✓	
2012	**Harrison**	Educational Materials	Advanced Biochemistry	✓	✓	✓	✓	
2008	**Hark**	Educational Materials	Genes, Genomics, and Society		✓	✓	✓	
2006	**Gutstein**	Cross-Age Peer teaching	Science Education Outreach Program	✓			✓	
2013	**Glover**	Cross-Age Peer teaching	Organic Chemistry Lab	✓	✓	✓	✓	✓
2014	**Flener-Lovitt**	Educational Materials	Climate Change: Chemistry and Controversy	No Definition				
2014	**Chrispeels et al.**	Cross-Age Peer teaching	Biology of the Human Condition		✓	✓	✓	
2008	**Baur-Dantoin**	Educational Materials	Biology of Women	✓			✓	✓

In science service-learning courses, the process often involves providing a hands-on science experience to the local community (Cartwright, 2010). The papers described in this section all involve cross-age peer teaching: Chrispeels et al. (2014), Glover et al. (2013), Gutstein et al. (2006), Kim (2010), Lee (2012), Morgan Theall and Bond (2013), and Stevenson and Peterson (2015).

Chrispeels et al. (2014) studied the learning gains of undergraduate students in a non-majors biology lab with a service-learning component. Service-learning was defined as a pedagogical method that enhances the learning of course objectives with meeting the needs of the community. In this study, the service-learning was a project situated within a course. Halfway through the semester, the biology students began using their lab periods for a service-learning project in which undergraduates visited either middle or high school classes to lead a genetics experiment. The undergraduates were shown the experiment by their instructor prior to implementing the lessons, but were not given any guidance on how to lead the lesson. Researchers used assessments, both pre- and post-service-learning experience tests and the final exam to assess learning gains. On the posttest, students who were teaching in high school classrooms performed better than their classmates teaching in middle school classrooms on short answer questions. Researchers believed that the undergraduate students who taught high school biology had to prepare in more depth to teach the concepts and, therefore, learned the content more thoroughly. On the final exam, both groups of students performed better on questions related to the content of the service-learning compared to the questions that only pertained to lecture content. Because the study did not involve formal reflections on the content, researchers can only guess at the reasons for differing cognitive gains between students placed in middle and high school classrooms. Written reflections from students could have shed light on the

differences in preparation for or during the genetics lab between the middle and high school students. Test scores alone do not seem adequate for understanding how the learning gains occurred.

In a similar study using cross-age peer teaching, Glover et al. (2013) studied a four-part service learning module situated within an organic chemistry course. Service-learning was defined as an experience that simultaneously meets community needs, course goals, and provides an opportunity to reflect to gain greater understanding of content and civic responsibility. In the project, undergraduate students taught high school chemistry students to prepare azo dyes and dye t-shirts. Undergraduates did the lab first on their own and then, in a later class, were assigned 2-3 high schools students to lead through the lab. Each undergraduate had to decide on his/her own how he/she would lead the lab. Several data sources were incorporated into the study: pre-reflections, observations by the instructors and graduate students, a post-lab discussion, and attitudinal questionnaires. Researchers found that the undergraduates were more engaged in this lab than in previous labs. Undergraduates were aware that they had to teach the information to younger students and they realized that dyes had real world applications from the pre-reflection essay they wrote. The attitudinal questionnaires found that the undergraduates felt that they had learned about citizenship and diversity. Glover et al. (2013) incorporated all the important parts of their definition of service-learning into the module that they created for the organic chemistry lab. The perspectives of the observers on the post-lab reflections seemed to be more important in the consideration of the data than what the students actually said. Reflection could have been better explained and used to help understand what students felt they learned through the activity. In addition, student questionnaires did not focus on student learning, but student attitudes about

the service-learning experience and did not provide any insight into the reasoning behind why students felt these things.

In another cross-age peer teaching service-learning course, Gutstein, Smith, and Manahan (2006) examined the Science Education Outreach Program (SEOP). This 1 credit hour course surveyed various science topics over 11 semesters with the objective of introducing science education to university students. Gutstein et al. (2006) described service-learning as a participatory learning environment with the goal of teaching students transferable skills in a real-life setting. This definition only fit two of the criteria defining service-learning in this study: that it is experiential learning and that it enhances learning. The authors did not mention a reciprocal relationship between the community and the university, a reflective component, or attempting to meet the community's needs through service. However, students in the course were required to write a summary reflection on their experience, which seems to suggest that the authors did value this component of service-learning to some degree. While the projects did vary by semester, cross-age peer tutoring was used most often. When the university students were learning about animal science, they created and implemented lessons in third grade classrooms about animals. During the semester on community gardens, students designed and implemented lessons that used the school garden. Gutstein et al. (2006) examined data from 11 semesters to identify the impact that the service-learning course was having on undergraduate students. Using retrospective surveys, reflective essays, and interviews, the authors found that the students learned about educational theories and improved their learning strategies. Like other articles mentioned in this category, reflection was used but not the focus of the research. Researchers randomly selected only 4 reflective summaries from each of the 11 semesters to use to support the survey data and interviews (Gutstein et al., 2006). In addition, the article did not seem to

support that students had learned any transferrable skills, only that they had a better understanding of educational theories and improved their own learning strategies. Researchers did not ask the students how they used what they learned in new contexts.

Kim (2010) also approached service-learning in science from an educational perspective. In her 2010 article, Kim examined the service-learning component of a science methods course in an elementary teacher preparation program. In this course, undergraduates participated in service-learning projects that involved cross-age peer teaching including hosting a "reverse science fair" (p. 323) and helping with an after school program. Kim (2010) used the Bringle and Hatcher (1996) definition of service-learning, which incorporates four of the five dimensions of service-learning: experiential learning, meeting community needs, giving learning and service objectives equal weight, and enhancing content learning. Reflection, the only dimension not included in the definition, was also heavily included in the course. Kim (2010) had her students turn in a service-learning portfolio, which was comprised of a description of service-learning, the student's personal goals for the service-learning, and multiple reflections about their experiences throughout the project. The objectives of incorporating the service-learning component in the course were to increase pre-service teachers' confidence in teaching science and enhance their understanding of scientific inquiry. Reflections demonstrated that the pre-service teachers did feel more comfortable teaching inquiry-based science as a result of the service-learning projects, after initially expressing fear of science. The reflections also showed that 43% of the pre-service teachers reported an improved content knowledge related to the topics they taught their elementary students. Kim (2010) incorporated more reflection than many of the science service-learning courses reviewed in this study thus far, without including it in her definition of service-learning. Both of the learning and service objectives were present in her study, but it seemed that

there was more focus on the learning objectives in this particular case. The service objective was to support local elementary students in helping them to create their science fair projects or to host a reverse science fair to teach them various science topics. The use of reflection seemed to focus more heavily on what the pre-service teachers were learning, rather than both the learning and the service.

Lee (2012) also placed her undergraduates in a teaching role in her general chemistry course for nurses. The optional service-learning project gave the future nurses the opportunity to tutor high school students in chemistry. If the undergraduates opted to take part in the service-learning project, they earned extra credit for each related assignment they turned in. The learning objectives of the service-learning component in Lee's (2012) course was to increase her students' motivation in the course, as well as to provide them with practice with chemistry content and increase content understanding. Lee did not provide service objectives for the general chemistry course. In addition, she defined the course as a "classic example of service-learning" (p. 2), but did not clarify what features make a course service-learning. While the service part of the service-learning course was a little weak, the course did seem to qualify as a service-learning course. The undergraduates did provide a service to the local community, in helping high school students to learn chemistry, while at the same time they were learning chemistry. In addition, the undergraduates turned in weekly reflections on their tutoring experiences. These reflections, along with exam scores and surveys, were used to determine whether the service-learning was beneficial to the undergraduates. Two themes emerged from the data: undergraduates had an improved understanding of chemistry and increased development as socially responsible citizens. The reflections written by students were used as

support for each of these themes. The survey and exam data were not the center of the research, unlike many of the articles presented thus far.

Like Lee (2012), Morgan Theall and Bond (2013) studied a service-learning project situated in a general chemistry course. In this course, undergraduates enrolled in the course planned and conducted a Halloween Science Night for the local community. Students chose, practiced, and prepared their lessons for two weeks during their laboratory period, before implementing it for the community. To add rigor to the project, undergraduates submitted a report about the chemistry behind the activity, an explanation of the observations the audience should be making, and a description of why those observations were important conceptually. While this could be a considered a reflection on their experience, particularly if it was written after the Halloween Science Night was completed, the authors did not consider the report a reflection. Morgan Theall and Bond (2013) used Cartwright's (2004) definition of science service learning, which was "college students helping elementary and secondary students learn to perform hands on experiments" (p. 1009). In particular, Morgan Theall and Bond (2013) pointed out is that there is no formal reflection in science service learning. This definition is limited and only met two of the five criteria this review considered important for service-learning: that community needs are met and enhances content learning for undergraduates. Not only was there no reflection incorporated into the course, but also it seemed that the course lacked equal emphasis on service and learning. This course seemed to be more heavily weighted towards student learning, rather than the importance of the service being provided. To evaluate their program, Morgan Theall and Bond (2013) used surveys to assess student attitudes and learning throughout the project. Students in the course felt that they had learned chemistry concepts and how to teach science throughout the course. However, less than half of the class responded to the

open-ended questions on the survey. Formal reflection might have been better for gathering data about what students gained through their experience. It also could have helped the students process their experience more in-depth.

In a wildlife biology course, Stephenson and Peterson (2015) also involved their undergraduates in cross-age peer teaching in an attempt to improve their interpersonal relationship skills. The course partnered with Project WILD, an environmental education program. Students enrolled in the course completed a six-hour training course to become Project WILD certified. Then, groups of undergraduates conducted a one-hour Project WILD lesson in a local elementary classroom. Stephenson and Peterson (2015) used a very loose definition of service-learning in their article, equating it only with experiential learning. No particular focus was given to the needs of the community or placing much importance on the learning or service. Stephenson and Peterson (2015) did require the students to write a final reflection, even though they did not include this in their definition of service-learning. However, only a pre- and post-survey about student perceptions of education, was used to gather the data about this service-learning project. The authors found students involved in the service-learning project thought that they were more likely to use education in their future career whereas students in the control group did not feel that teaching skills were valuable. While the survey data was able to show comparisons between students in the control group and those that participated in service-learning, it was not able to give an explanation as to why the service-learning group had the perception changes.

Table 2.7. Objectives and reflection used in the studies that used peer tutoring in science service-learning courses

Year	Author	Course	Objectives		Reflection	
			Learning	*Service*	*Oral*	*Written*
2014	Chrispeels et al.	Biology of the Human Condition	- Enhance understanding of concepts in human biology	- Provide a hands-on biology experience to middle and high school students	None	None
2013	Glover	Organic Chemistry Lab	- Enhance knowledge of chemistry - Enhance understanding of complex societal issues	- Provide a hands-on chemistry lesson to high school students	- discussion amongst observers about what they believed students learned	- pre-reflection - post-reflection
2006	Gutstein	Science Education Outreach Program	- Introduce science education to undergraduate students - positively impact students' career goals and academic skills	- Varied by semester	- interviews with select participants at the end of the course	- Summary Reflection
2010	Kim	Elementary Science Methods	- Enhance pre-service teachers' understaning of scientific inquiry - Improve pre-service teachers' confidence in teaching inquiry-based science	- Support school community's need through multiple projects	None	- Service-Learning Portfolio - Purpose of Service-Learning - Reflective Journals - Personal Goals
2012	Lee	Principles of General Chem	- Increase students' investment in course - Practice chemistry - Increase content understanding - Apply content in different settings	None	None	Written
2013	Morgan Theall & Bond	General Chemistry	- perform chemistry demonstrations - choose and lead a demonstration that appeals to all age groups - enhance chemical knowledge	- provide opportunities for the community to learn chemistry through hands-on demonstrations that are not typically part of the K-12 curriculum	None	None
2015	Stevenson & Peterson	Human Dimensions of Wildlife	- improve the "soft skills" of wildlife biology majors	- introduce wildlife biology to elementary students	A reflective activity occurred, but the format was not specified.	

Overall, the articles that embraced peer tutoring as the method of service-learning varied widely on their definitions of service-learning, objectives, and uses of reflection. Authors like Kim (2010) and Lee (2012) placed particular emphasis on their students reflecting on their

experience, both in the course and in analyzing the data about the course, but did not include it in their definition of service-learning. Other authors mentioned that undergraduates performed some sort of reflection, but did not place any emphasis on it when collecting data for research (Chrispeels et al., 2014; Stevenson and Pearson, 2015). Researchers may have been better able to tie their objectives to their data had they utilized some sort of reflection, instead of survey data or exam scores.

Creation of Educational Materials. Another form of service-learning in science relates to the creation of educational materials for the local community related to the content of the course. Students who create these materials are still having to learn to communicate scientific information to the public, but often do not utilize the curricular materials in the same ways that students who engage in peer teaching do. In this section, the courses in which undergraduates created science related educational materials are reviewed: Bauer-Dantoin (2008), Flener-Lovitt (2014), Hark (2008), and Harrison et al. (2012).

Bauer-Dantoin (2008) studied an upper-level elective entitled, "The Biology of Women." Students enrolled in this course were required to complete a 15-20 hour service-learning project pertaining to a specific interest that they chose and found themselves. Examples of projects students have completed included assisting midwives with pregnancy classes and raising awareness of breast cervical cancer risk factors among university students. Bauer-Dantoin (2008) used the 2006 National Service-Learning Clearinghouse definition of service-learning, which states that service-learning is a pedagogy that teaches civic responsibility while enriching learning through "meaningful community service" and reflection (p. 13). The course instructors discussed with students, in-depth, the difference between service-learning and volunteerism. They hoped this discussion would encourage students to be diligent in choosing their project

locations and duties. After deciding on their field site, students were required to submit a paper detailing the anticipated service and learning components of the project. At the end of course, students wrote a three page reaction paper about their experience and, specifically, the service and learning aspects of the project and gave an oral presentation about their project. Bauer-Dantoin (2008) used a student survey, in addition to the oral presentation and written reflections, as data for the study. She found that students benefited from understanding the difference between volunteer work and service-learning. Service-learning projects fostered community engagement, increased learning, and provided real-life challenges and opportunities. While the main source of data in this paper was the survey, researchers noticed that more depth of learning was evident in student discussions (oral reflection) and in reaction papers (written reflection) (Bauer-Dantoin, 2008). However, only small segments of each of these reflections were used in the paper as support for the survey results. The definition given for service-learning at the beginning of the paper included a reflective component, but no weight was given to the reflections in the findings of the paper. All findings were based on the survey results and supported by statements made by students in oral or written reflections.

Flener-Lovitt (2014) studied an introductory course about climate change that sought to create scientifically literate students and enhance their content knowledge about climate change. As the final project for the course, students worked closely with a local museum to create training documents that would help the staff respond to and dispel public misconceptions about climate change. Flener-Lovitt (2014) did not define service-learning in her article, but the project seemed to respond to a need in the community and incorporated a reflection activity. The reflection was not on the experience of creating the educational materials, but instead on the material taught throughout the course. In particular, the reflections asked students to consider

various aspects of the nature of science and use their learning to make an argument. In addition to the final reflection, Flener-Lovitt (2014) used exam scores, anonymous surveys, presentations, and discussions as data to evaluate student learning in the course. The reflections seemed to be weighted equally to the other data sources in this article. The written reflections helped the undergraduates figure out their misconceptions about climate change and also connect scientific concepts to their values. While the students did provide a service in the course by creating the educational materials for the course, they never saw them implemented. This course seemed more weighted to the learning aspect rather than a balance of the two. Using the service-learning project as a final assessment of course knowledge, rather than a project that built throughout the semester did not truly meet the criteria of a service-learning project.

Hark (2008) also had her students create materials during a survey course. In this survey course for non-science majors, undergraduates learned about genetics by creating instructional materials for local high school biology teachers. Hark (2008) defined service-learning as a course that provided civic learning, community service, and enhances academic content. The definition did not include a description of experiential learning or a reflective component. However, the author integrated five written reflections into the course, which were designed to help students consider the strengths and weaknesses of the instructional materials, group dynamics, and process peer review. These five reflections, along with the creation and presentation of the instructional materials, helped to achieve the stated goal of the course, preparing scientifically informed citizens. Hark (2008) found that the students believed that the service-learning project helped them to learn more deeply, improved presentation skills, and strengthened their ability to discuss science with the public. The article did not specify where Hark (2008) gathered this data from, but it is assumed that it was collected from the written reflections. Specific examples of

student reflections would have been helpful to support these lofty claims. Hark's (2008) service-learning course seemed to have its downfall in the service category. The students did not feel connected to the classrooms that were going to use their instructional materials and were uncertain whether the materials would actually be used in the classroom. Many of the students expressed an interest in implementing the lessons themselves, or at least observing the lessons while they were being implemented. Much like Flener-Lovitt (2014), the service-learning project in this course just seemed to be a final project that happened to be used in the community after it was finished.

Harrison, Dunbar, and Lopatto (2012) studied the service-learning project of an advanced biochemistry course. The students enrolled in the course created pamphlets on a health concern to leave in a local homeless shelter. The objective of the pamphlet was to help people understand the biochemistry behind the health concern and to suggest preventative measures or treatment. The course objectives included helping students to understand and apply biochemistry in real-life settings and communicate scientific data through writing and speaking. Harrison et al. (2012) used the American Chemical Society's definition of service-learning, which is that a service-learning course should have curricular goals, community partners, and civic goals integrated into an activity that students can perform. The idea of reflection was not considered as part of this definition. Although there was a final written and oral report on the service-learning project, the authors never referred to this as a reflection, nor did they outline what students were expected to do for either of the assignments. Therefore, this service-learning project is not considered to have a reflective component. Instead, surveys were given to students to assess the outcomes of the course. Harrison et al. (2012) found that students were more motivated to learn and had an increased sense of personal satisfaction as a result of this service-learning project. If reflections

had been more prominent, it might have been possible to know more about what students learned and how.

Table 2.8. Objectives and reflection of studies that examined science service-learning courses that used the creation of educational material.

Year	Author	Course	Objectives		Reflection	
			Learning	*Service*	*Oral*	*Written*
2008	Baur-Dantoin	Biology of Women	- Enhance understanding of women's health - Create an awareness about community needs	- Provide various health-related services to women in the community	- Class discussions - Final presentation	- Summary Reflection (3 pg.)
2014	Flener-Lovitt	Climate Change: Chemistry and Controversy	- Increase scientific literacy - Enhance understanding of climate change	- Create a training document to help musuem staff respond to climate misconceptions	None	- Short papers that answered questions about the nature of sciece
2008	Hark	Genes, Genomics, and Society	- Prepare students to act as scientifically informed citizens	- Create instructional materials related to genetics for biology teachers to use in HS classrooms	None	- 5 reflections (2-3 pgs. each)
2012	Harrison	Advanced Biochemistry	- Understand and apply biochemistry to human health and disease - Interpret and critically analyze biochemistry journal articles - Communicate scientific data in both written and oral formats	- Create a pamphlet on a health concern relevant to persons living in homeless shelters to inform them on the biochemistry of that topic	None	None

The courses included in this section incorporated a service-learning project where undergraduates created educational materials for the local community. The articles reviewed all were purposeful in their incorporation of learning objectives, but sometimes the emphasis on service seemed to be forgotten. This is possibly because neither the students nor the instructors were able to see their products making a difference or being implemented in the community. This type of service-learning does seem more feasible in some ways than the peer teaching methods because it does not take the same amount of time commitment or inconvenience the

students. The majority of the work does not take place in the community. However, the service emphasis does seem to be lost or at least buried under the important learning objectives. In addition, reflection is not used as frequently as in the case of peer teaching, possibly because the undergraduates did not experience as many disequilibria because their contact with diverse groups of people was limited.

Research as Service-Learning. These undergraduate science courses had students conducting scientific research around particular topics that were relevant to the local community. In some cases, the projects were chosen for the class, but in others, the students were free to select their own topics. Unlike peer teaching and the creation of instructional materials, there were fewer articles that examined courses using research as service-learning. In this section, the articles that used research as service-learning were discussed: Liu et al. (2004), Owens and Foos (2007), and Santas (2009).

Liu, Philpotts, and Gray (2004) examined the service-learning projects of two upper-division geoscience courses. Both courses sought to help the community by solving local geological and geotechnical problems, while simultaneously fostering interest and giving undergraduates the opportunity to enhance their abilities through real-world application of knowledge. Liu et al. (2004) defined a successful service learning course as one that "meets actual community needs, involves collaboration between the school and the community, provides structure for students to think, talk, and write about what they did and saw during the actual community service, provides students with the opportunity to use newly acquired skills and knowledge in real-life situations in their own communities and fosters the development of a sense of caring for others" (p. 176). This definition meets all of the criteria for a service-learning course. However, while the authors state a good course allows students time to reflect, they never

specified how reflection occurred within the courses they studied. It was unclear how the authors gathered their data.

Owens and Foos (2007) also studied a service-learning course in the geology field, supporting Liu et al.'s (2004) belief that geoscience courses are ideal candidates for service-learning courses that bridge undergraduate research, teaching, and learning. The learning objectives of this course were to demonstrate that science can be used to solve environmental problems, gain an understanding of the relationship between biotic and abiotic factors in an ecosystem, and conduct a research project to gain an understanding of the nature of science and scientific inquiry. Owens and Foos (2007) did not develop any service objectives for their course. However, they defined service-learning as a "deliberate connection between the learning objectives and the service with substantial opportunity for students to reflect on the service experience" (p. 212). This definition fulfills all the criteria of a good service-learning course. Reflection was incorporated into the service-learning experience through weekly emailed journal prompts, where students reflected on the nature of science by discussing their fieldwork. In addition to the reflections, students also completed a survey and a final report about their service-learning project. The reflections were a large part of the data collection for this study and helped researchers examine how students were reasoning through their learning.

Santas (2009) used service-learning in a three semester upper-level biochemistry course on research. The service-learning research project was designed to support a local conservation center, known as the Wilds. The learning objectives were for the students enrolled in the course to research, design, and execute biochemistry research on a relevant topic. These objectives were closely tied to the definition of service-learning Santas (2009) presented. This study defined service-learning through many different principles, but the most important of which is that it

serves the community with specific learning intentions and reflection on both the learning and service. Santas (2009) presented the case study of one student enrolled in the the three semester course series. It was unclear how reflection was being conducted over the course of three semesters, however, during the last semester in particular, the instructor and undergraduate met weekly to discuss the progress of the project. This could have been one way reflection was incorporated into the course. In addition, it was unclear how the data for the study was gathered. Santas (2009) described many cognitive and manipulative skill benefits for the student in the case study, but did not support them with data.

Of the three types of science service-learning, research as service-learning is the most un-studied. There were significantly fewer studies conducted on research as service-learning than the other two categories. This could be because designing a course with a research component for every student in a course is difficult and requires a lot of planning. It also may be that developing meaningful community involvement on research projects is difficult. Authors had difficulty explaining how their students completed research projects related to community needs and connecting them to the reflections that they claimed were essential to service-learning courses.

Discussion. This literature review examined a wide array of science service-learning courses, categorized into three main groups: peer teaching, educational material development, and research as service-learning. Several articles about science service-learning were excluded from this review because they were either course descriptions or abstracts from scientific conferences. Thirteen of the excluded articles were abstracts of conference proceedings, suggesting that academia is interested in this field but have not yet assimilated it into peer reviewed journals. This could be for many reasons, but it could possibly be related to the

Table 2.9. Objectives and reflection used in the studies that used research in science service-learning courses

Year	Author	Course	Objectives		Reflection	
			Learning	*Service*	*Oral*	*Written*
2004	Liu et al.	Engineering and Environmental Geology & Engineering and Environmental Geophysics	- foster student interest in earth sciences through community service - enhance students' ability to learn by applying course material to real-world problems - cooperative learning	- enhance university outreach through interactions with local communities by helping solve local geological and geotechnical problems	Unclear	Unclear
2007	Owens & Foos	Geology Service Learning	- gain an understanding of ecosystems, particularly the relationship between abiotic and biotic components - gain an understanding of science as inquiry and NOS by conducting a research project - gain an appreciation for how science can be used to solve environmental problems	None	None	Journals about the NOS in terms of the research they were doing
2009	Santas	Biology Research Course, spanning 3 semesters	- research, design, and perform biology research with a focus on providing a service	- provide support to a local institution, the Wilds	None	Not specified

tenuous definition of service-learning. In addition, many of the articles presented here could only narrowly be described as empirical articles. In truth, the articles were program descriptions with only a small amount of data included to support their claims about their service-learning programs. In this section, the discussion of the findings is presented organized by the questions asked of the literature.

How do researchers define service-learning? How do the service-learning definitions differ between articles? Researchers defined service-learning in many different ways. Of the 15 articles reviewed, only two authors did not attempt to define service-learning. While Flener-

Lovitt (2014) offered no explanation of service-learning, Lee (2012) did claim that her course was "classic example of service-learning" (p. 2). The lack of definition emphasizes what Furco (1996) claimed, that researchers often take for granted that service-learning is a well-defined category. The remaining 13 articles reviewed in this paper all defined it in some way, most often using someone else's definition of service-learning. In this section, the similarities and differences between the definitions are discussed in terms of the definition established in the conceptual framework. Service-learning, a form of experiential learning, is a form of learning in which community needs are met through students performing a service while simultaneously learning and reflecting on the experience.

The majority of the articles reviewed in this chapter considered service-learning to be a category of experiential learning. The authors described experiential learning as activities or experiences that students had outside of the traditional classroom. Only one article, Stevenson and Peterson (2015) did not distinguish service-learning from experiential learning. It is important to note that authors emphasized that service-learning must include some sort of experience for students, because it is the experience that provides real-world applications and offers the opportunity for reflection.

Most of the articles reviewed also agreed that service-learning projects should meet a community need in some way. None of the articles did a particularly good job of arguing for why the community needed the service, but those that established that there was a community need articulated at least why the service was important. Bauer-Dantoin (2008) and Gutstein et al. (2006) did not include in their definition that satisfying a community need was necessary for service-learning. In both cases, the service-learning projects varied by semester and were open to student opinions. In Bauer-Dantoin's (2008) study, students often picked projects because they

were easy to achieve or they wanted to work in a group with their friends. While there is nothing wrong with motivating students to pursue the project in that way, it does not necessarily promote a service-learning agenda.

Furco (1996) pushed the notion for a course to truly be service-learning, it must have equal emphasis on service and learning objectives. Many of the articles in this review did meet the definition criteria. However, it was difficult to identify the service objectives in some of the articles. For example, Lee (2012) had very clearly defined learning objectives for her chemistry undergraduates when they tutored high school students, but no service objectives. She described the context of the community, but not what she hoped those being served would get out of the experience. There was not an example in this group, however, where learning objectives were pushed aside for service objectives, as Furco (1996) suggested has happened. Every single article that defined service-learning beyond experiential learning emphasized that one role of service-learning was to enhance the learning experience for students.

The most controversial aspect of service-learning definitions was the concept of reflection. Only five of the fifteen articles reviewed included reflection in their definition of service-learning. Morgan Theall and Bond (2013) even specified that science service learning did not use reflection, which set it apart from service-learning courses in other disciplines. However, eleven of the articles incorporated a reflection component into the course. This suggests that the science service-learning courses value using reflection in the classes, but it is not yet an integral part of service-learning. In addition, the researchers did not value the reflection as a meaningful part of data collection. Only two articles, Lee (2012) and Kim (2010) relied on students' reflection as a source of data. The other researchers used exam scores and survey data for the majority of their analysis, employing reflections only as anecdotal support of

their findings. Additional use of reflection as data or to encourage learning would be useful in science service-learning courses as reflection is one way that students can process their experiences and learn from them.

What are the objectives in a science service-learning course? The learning objectives for a science service-learning course were as varied as the courses themselves. Enhancing understanding of a specific content area was also an integral part of science service-learning courses (Bauer-Dantoin, 2008; Chrispeels et al., 2014; Flener-Lovitt, 2014; Glover, 2013; Harrison et al., 2012; Kim, 2010; Lee, 2012; Liu et al., 2004; Morgan Theall and Bond, 2013; Santas, 2009). This objective was reminiscent of the common thread through all of the definitions of service-learning. Another goal that came up repeatedly was the emphasis on the development of scientifically literate citizens who can discuss science with the public (Flener-Lovitt, 2014; Hark, 2008; Harrison et al., 2012; Stevenson and Peterson, 2015). This objective is particularly applicable to service-learning because undergraduates are often asked to explain complicated scientific information to the public in some capacity. Less popular, but also mentioned both in the objectives and in the findings, was increasing student motivation and engagement through service-learning (Lee, 2012; Liu et al., 2004).

How is reflection being utilized for learning in service-learning courses situated in science? As discussed above, most of the studies reviewed in this chapter integrated some form of reflection in the highlighted courses. Almost all of these implementations of reflection were written reflections in some form. Only three researchers mentioned using oral reflection at all (Bauer-Dantoin, 2008; Glover, 2013; Gutstein et al., 2006). Bauer-Dantoin (2008) was the only one of the three to mention that oral reflection during class discussions was a regular part of coursework. Glover (2013) utilized oral reflection with observers in the classroom watching the

service-learning being performed, but did not ask her undergraduates to participate in reflection outloud. Gutstein et al. (2006) only asked undergraduates to reflect through interviews at the end of the semester. Dewey's (1933) notions of reflection emphasize that reflection must take place individually and in community. Many of the service-learning programs reviewed incorporated the individual reflection, but not the community reflection, which can be represented by oral reflection.

Written reflections took many different forms in the eleven studies that utilized them. Often, the exact nature of the reflections was not specified, as in Liu et al. (2004) and Santas (2009). Other reflections were focused on the specific content of the course, rather than on the experience itself. None of the articles reviewed asked students to consider struggles they were having throughout the service-learning process or to explain how they planned to work through them. According to Dewey (1933), these students were not thoroughly reflecting on what they were learning because the instructor was not providing them with opportunities to explore disequilibria. An exploration of the disequilibria could have easily been incorporated into the prompts. For example, Owens and Foos (2009) asked students to respond to the question, "How has your work in the field in this course shown you that science is creative?" A follow up question could have been added to that one, asking students to consider the specific experiences that helped them to realize that science is or is not creative.

While not all researchers agreed on the same definition of service-learning, overall they promoted similar notions of what service-learning in science should look like. They also tended to have similar learning objectives for their students. What seemed to be woefully underrepresented in the field of science service-learning was an understanding of how students experienced reflection and how they used the everyday tensions of their service-learning projects

to improve upon themselves, their learning, and their community. More research needs to be done to understand how students are struggling through some of these issues and assimilating it into their lives.

In this chapter, the research on reflection and undergraduate science service-learning was presented. When examining reflection in teacher preparation programs, research has focused on beliefs (Seung et al., 2011) and attitudes (Wilson et al., 2015), as well as student achievement (Cengiz and Karatas, 2015). Overall, the research on undergraduate service-learning programs is primarily concerned with the positive outcomes that students experience. However, when examining in-depth the reflection in science service-learning programs, it seems as if reflection is not valued, despite it being incorporated into most of the programs described here. Out of all the articles examined in this literature review, only Sezen-Barrie et al. (2014) scrutinized the tensions that students experienced in service-learning. They did not find any tensions related to scientific practices, but instead found students struggling with their role in the classroom. However, Sezen-Barrie et al. (2014) only included data from one micro-teaching experience that took place in a college classroom, where middle grades students came to the university for a field trip. Their results might have differed if they had collected data over an entire semester with teaching experiences that occurred in schools. If feelings of disequilibrium are the catalyst for reflection as Dewey (1933) states and if reflection is a critical part of learning in service-learning contexts as Hatcher and Bringle (1997) insist, then more research needs to be done into the tensions that students recognize and struggle with in their service-learning experience, so students' reflection can be supported effectively.

Chapter Conclusion

The purpose of this chapter was to examine the recent literature on reflection and service-learning, particularly in relation to science education. This chapter included a survey of the varied definitions of service-learning and the many purposes instructors have in creating service-learning programs. It also reviewed definitions of reflection and the numerous taxonomies researchers use to recognize and understand reflection. More specifically, this chapter provided a basis for the study presented by making an argument using the literature. The following chapter describes the research design, methods, and analysis that was used in understanding students' disequilibria in an undergraduate science service-learning course.

CHAPTER 3

RESEARCH DESIGN AND METHODS

The purpose of this study was to understand how students reflect on feelings of disequilibrium throughout a science service-learning experience, Fostering Our Community's Understanding of Science (known as Project FOCUS). Project FOCUS is a three credit hour course for undergraduate science majors in which they teach hands-on science lessons in a local K-8 classroom. This interpretive case study was conducted in Spring 2016 with one section of undergraduate science majors enrolled in Project FOCUS. Case study is a method of social research that encourages an in-depth investigation of an exact context (Simons, 2009). This chapter begins with a description of the theoretical framework that guided the study. Subsequently, an explanation of the methodology and a rationale for using case study is presented. Next, the context of the case, course description, and a participant overview is described, followed by a description of the data generation methods and analysis. Finally, the chapter concludes with a description of the role of the researcher, her critical friend, and a statement of subjectivities.

Theoretical Framework

The theoretical framework for this study was built around Deweyan notions of reflection. In this section, the theoretical assumptions of Dewey's notions of reflection are considered. Dewey (1933) distinguished several different kinds of thinking, including beliefs, imagination, reflection, and stream of consciousness. What distinguished reflection, for Dewey, from the other modes of thinking was the focus on an inquiry into a situation. He used the illustration of a man

attempting to reason the direction to follow as an example of this type of thought, stating "reflection is aimed at the discovery of facts that will serve [a] purpose" (p. 9). As noted in Chapter Two, Dewey (1933) emphasized that reflection is a "conscious and voluntary effort" (p. 5), which means that a person chooses to actively engage in reflection. A stimulus must prompt the need for reflection to occur, giving a person the need for reflection. The dilemma that prompts reflection, which Dewey (1933) termed a disequilibrium, is one of the foundations of reflective thought. A disequilibrium can be a confusion, the "unexpected…a shock or an interruption needing to be accounted for, identified, or placed" (Dewey, 1933, p. 8). In this study, it was assumed that the FOCUS students would face disequilibria during their service-learning experiences.

The other foundation of reflective thought, per Dewey (1933), is that the reflector engages in an inquiry into the disequilibrium. This inquiry takes the form of five steps, outlined previously in Chapter Two. The reflector defines the disequilibrium, the context thereof, and engages in understanding the situation by suggesting solutions, testing their hypothesis of thought, and drawing conclusions. This is an iterative process. For the purposes of this study, the iterative process was attained by encouraging students to reflect both through written journal entries and orally by connecting personal experiences to impressionistic tales. Dewey (1933) also emphasized the importance of reflecting both as an individual and in community, to seek perspectives outside of one's own, and build knowledge and beliefs together. He stated, "a higher stage of curiosity develops under the influence of social stimuli" (Dewey, 1933, p. 29). Through collaboration, reflectors can gain access to experiences they themselves have not had and seek new perspectives. This perspective was incorporated into the study in focus group discussions, in which students discussed impressionistic tales centered around disequilibria in the

science classroom. The discussions gave the students the opportunity to not only compare their service-learning experiences, but to also revisit disequilibria they may have written about in their journal entries or to realize and elicit disequilibria they may not have written about. A continued discussion of the methods used for this study is presented later in this chapter. In the next section, case study methodology is discussed and a rationale for using case study methodology is presented.

Case Study

Merriam (1998) called case study "a catchall category for studies that are clearly not experimental, survey, or historical" (p.43). This inaccuracy has led researchers to define case study in many ways. For example, Merriam (1998) wrote case study "provides a unique example of real people in real situations, enabling readers to understand ideas more clearly than simply presenting them with abstract theories or principles" (p. 181). Yin (2009) defined case study as "an empirical inquiry that investigates a contemporary phenomenon in depth within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 18). Stake (1995) and Simons (2009) emphasized that case studies can be either qualitative or quantitative in nature. Qualitative case studies allow for naturalistic inquiry, which allows for "documenting complexity, interpreting in context…and communicating in the natural language of the participants" (Simons 2009, p.16). For the purpose of this study, case study is "an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, program or system in a 'real life' context" (Simons, 2009, p. 21). A hallmark of a case study is the thick, rich description of the context that sets it apart from other types of qualitative research.

Particularly central to the creation of case studies are the boundaries that create a unique situation to study. Merriam (1998) wrote, the case is "a thing, a single entity, a unit around which there are boundaries" (p. 27). Simons (2009) emphasized that "the essential task is to understand the distinctiveness of the individual case" (p.3). Because a case is a bounded system, it allows researchers to "fence in" the phenomenon they are going to study. These boundaries can be geographical, temporal, or definitional (Merriam, 1998). The boundaries can also be defined as an individual or a specific group of people sharing a common situation. The case in the context of this study was a unique class of students, enrolled in the same science service-learning course, who met once a week to discuss their experiences.

Researchers have categorized many different types of case studies. Arguing that distinguishing different types of case study by methods used, Stake (1995) defined three types of case studies: intrinsic, instrumental, and collective. An intrinsic case study is one that seeks to understand a particular context. Instrumental case studies are employed when the researcher wants to understand a phenomenon that is beyond the case. Collective case studies are used when several different cases are considered together to understand a phenomena related to all of them. The case in this study was instrumental because it explored how undergraduate students reflected on disequilibria in a science-oriented service-learning course.

Merriam (1998) also categorized case studies by the overall intent of the study. A descriptive case study "presents a detailed account of the phenomenon under study" (p. 38). Interpretive or analytical case studies also contain rich descriptive details, but also are used "to illustrate, support, or challenge theoretical assumptions held prior to data gathering" (p. 38). The researcher using interpretive case study methodology develops a conceptualization that represents the data and contributes to theoretical perspectives. The third category, evaluative case

studies, "involve description, evaluation, and judgement" (p. 39). The hallmark of this type of case study is that a judgment is made after all the data has been collected and analyzed. The case presented in this study was an interpretive case study. The case was used to build upon theoretical understandings of disequilibrium in light of Dewey's notions of reflection and Jay and Johnson's (2002) Reflective Typology.

Rationale for Using a Case Study Approach

Yin (2009) wrote that case study helps researchers answer the how and why questions about a phenomenon. Simons emphasized that "case study is not synonymous with qualitative methods" (p. 19). Instead, case study is defined by the bounded system. A singular classroom is a bounded system that represents the uniqueness that a case study needs. Case study is more than an observational study because it requires multiple types of data (Simons 2009). The methodology also emphasizes the understanding of complexity situated in real-life context (Simons 2009). Additionally, case study allows for the researcher to demonstrate multiple perspectives.

Case study was an appropriate choice for this research study because it allowed the researcher many advantages. Students enrolled in Project FOCUS were simultaneously both student and teacher. They were students when in the university setting, but ambassadors of science in the local community. Each student had a unique classroom context that contributed to their understanding of and reflection on disequilibria. Case study allowed the researcher to maintain and honor the contextual complexities. In addition, by bounding the case in a single class of students, the researcher was able to study not only how students reflected on disequilibria individually, but also was able to examine how students identified and reflected on disequilibria in the classroom community. Through the collection of individual journals,

interviews with primary participants, and focus group discussions, the researcher was able to simultaneously represent and study the community of learners and maintain the voices of the individual participants.

Critique/Support of Case Study

Case study has been critiqued for its limitations, including lack of a control, generation of large quantities of data, invasion into the lives of participants, lack of researcher subjectivity, and long and detailed reports of findings (Simons 2009). Flyvjberg (2006) argued against the five most prominent misunderstandings about case study research: (a) practical knowledge is less valuable than theoretical understandings. (b) generalizations are not possible with case study research which diminishes the scientific value of the research. (c) case study is most suited to producing the hypotheses while other types of research test them. (d) case studies are conducted to confirm biases. (e) summarizing and generating theory from case study research is difficult. Both Flyvbjerg (2006) and Simons (2009) argued that researchers' criticisms were not negative aspects of case study research. Instead, Flyvbjerg (2006) emphasized that context dependent research can help novices develop deeper understandings of complex issues. He also argued that in both the natural sciences and the social sciences, "the strategic choice of a case may greatly add to the generalizability of the study" (p. 226). However, Flyvbjerg also contended that "the force of generalization is underestimated" (p. 228). Of the third big misunderstanding of case study research, Flyvbjerg (2006) reasoned that while case study can be used to produce hypotheses, it is not only useful for that purpose. Addressing misunderstanding number four, Flyvbjerg argued that all research contains bias, which, if recognized by the researcher, can be useful in the research. For the last misunderstanding about case study research, summarizing and "closing" the case is not necessary (Flyvbjerg 2006). Instead, Flyvbjerg recommended allowing

the case to unfold naturally, through the "many-sided, complex, and sometimes conflicting stories that the actors have…told" (p. 238). Like Flyvbjerg (2006), Simons (2009) argued that the criticisms of case study are not necessarily weaknesses. While case studies do generate large quantities of data, that data adds to the rich description of the context, which better helps stakeholders understand the case.

This section included a discussion of diverse perspectives related to the methodology in the context of this study and provided a rationale for using a case study methodology. Case study was the best fit for this research because it allowed the researcher to examine a single context in-depth. The context of this study was a class of sixteen undergraduate students enrolled in a science service-learning course. In the next section, the context of the case study, including a description of the course and participants, is detailed.

Context of the Case Study

This study was situated in a science service-learning course at large university in the southeastern United States. The course, Project FOCUS, enrolls undergraduate students who are majoring in science to teach hands-on science lessons at local elementary and middle schools. Project FOCUS counts as a three-credit hour science elective and has become a popular choice for many students seeking to go to medical or veterinary school. The course typically enrolls between 40 to 80 students per semester organized into four sections. Each semester, an undergraduate science major admitted to the program is paired with a local elementary or middle grades teacher to teach 40 hours of science. Undergraduates spend three hours a week immersed in elementary and middle grades classrooms, hopefully becoming part of the classroom ecosystem. In its fifteenth year, Project FOCUS students have taught science to more than 20,000 elementary and middle grades students. Students also spend 50 minutes per week in a

reflection session at the university, where they discuss basic ideas in education such as student motivation, inquiry, and the development of lesson plans. During this time, students also share the weekly events of their partner classroom. A discussion of the admission requirements, classroom context, and course assignments is included below.

Admission Requirements

Project FOCUS students must apply to the program through an online application available on the course's website. Applicants must meet or exceed two basic requirements: a student must have an overall GPA of 2.5 or higher and have completed at least 12 credit hours of science content courses or 9 hours with 3 hours completed concurrently to Project FOCUS. The application asks students to discuss their expectations and goals for the course. Students must also explain their reason for being interested in the program and detail their experience working with children. The course counts as a three-credit hour science elective toward their degree. Once a student has taken Project FOCUS once, they may repeat the course up to three times.

Classroom Context

During the Spring 2016 semester, 51 undergraduate students were enrolled in the course. The fifty-one students were assigned to six local elementary and middle schools in Carbon County. Carbon County School District has approximately 13,000 students. Demographically, the district is 49% African-American, 24% Hispanic, 21% White, 4% Multi-racial, and 2% Asian. During the 2016-2017 school year, 92% of the students enrolled in Carbon County Schools were eligible to receive free or reduced lunch. In the following section, the schools in which students were placed are described.

Schools. Schools must opt into the Project FOCUS program. At the beginning of each new semester, the lead teaching assistant reaches out to the principals of schools in Carbon

County. Schools are chosen each semester by their proximity to the university (so students can travel efficiently in between classes) and how much university support they currently receive. In fifteen years of the program, the principals of Carbon County have become familiar with the Project FOCUS program and typically want their teachers to participate. How teachers are recruited depends on the principal and the school. Teacher recruitment is discussed alongside each of the individual schools. The number of schools that participate each semester fluctuates with the number of students that are enrolled in the course. As many as 13 schools have participated in one semester, but only between five to seven schools are typically needed. In Spring 2016, six local schools participated in the Project FOCUS program: Argon Elementary School (AES), Boron Elementary School (BES), Gallium Elementary School (GES), Hydrogen Middle School (HMS), Nitrogen Elementary School (NES), and Oxygen Elementary School (OES). Table 3.1 outlines each of the schools and number of teachers participating in Project FOCUS.

Table 3.1. Carbon County School population demographic data involved in Project FOCUS in Spring 2016

		School Population Demographic Data (2016)						
	# of FOCUS students	Total Number of Students	Free/Reduced Lunch (%)	African American (%)	Asian (%)	Hispanic (%)	Mixed-Racial (%)	White (%)
AES	13	370	92	79	1	12	3	6
BES	8	540	92	49	4	10	5	32
CES	1	486	92	34	1	8	4	53
GES	18	570	92	74	2	13	5	6
HMS	5	730	92	60	2	10	5	23
NES	2	490	92	49	0	26	5	18
OES	3	540	92	40	0	41	3	15

Argon Elementary School (AES) is one of the primary schools that Project FOCUS students are placed in. The principal of AES has requested every semester for a number of years that all teachers in the school receive a Project FOCUS student. The ability of the teaching

assistant to fulfill this request has varied by demand for the course. In Spring 2016, 13 students were placed at AES.

Boron Elementary School (BES) is the school in which Project FOCUS started. A large percentage of Project FOCUS students are also placed at BES. Many of the teachers who host Project FOCUS students have been working with the program since its inception. However, teachers at BES have to opt into the program and must express their interest to their principal. In Spring 2016, 8 students were placed at BES.

Gallium Elementary School (GES) is the final of the three core elementary schools in which FOCUS students are placed. Like at AES, the principal of GES is very supportive of the program and asks that each teacher receive a Project FOCUS student, if possible. In Spring 2016, 18 students were placed at BES.

Calcium Elementary School (CES) hosted one Project FOCUS student in Spring 2016. The program did not have an established relationship with the school, but Keisha, a returning student, worked in an afterschool program there. One of the teachers she was familiar with requested Keisha volunteer with her and the principal approved the placement. Since Keisha was heavily involved in the school already, the course instructors allowed her to carry out her FOCUS placement there as well.

The only middle school participating in Project FOCUS in Spring 2016 was Hydrogen Middle School (HMS). Teachers must express interest in hosting a Project FOCUS student to the principal to receive one. Due to the scheduling of middle school classes, sometimes a teacher can even receive two Project FOCUS students who teach at different class periods. In Spring 2016, five Project FOCUS students were placed with four HMS teachers.

Nitrogen Elementary School (NES) has also been very involved with the Project FOCUS program, but the involvement from teachers fluctuates. In Spring 2016, due to scheduling conflicts between students and teachers, only two Project FOCUS students were placed at NES. One of the students was a third time returning student who had worked with his teacher twice before and specifically requested her classroom.

Oxygen Elementary School (OES) also has fluctuating teacher participation, usually because of saturation from student teachers or practicum students. Teachers also have to express interest to their principal to receive a Project FOCUS student. In Spring 2016, only three FOCUS students were placed at OES.

Teacher Requirements. Teachers who host a Project FOCUS student in their classroom agree to take on a mentorship role. They agree to host the students for three hours a week and allow them to help with science in some capacity. The role and duties are left up to the teachers, but they are encouraged to allow their FOCUS student to bring in hands-on science lessons. The other requirement that the teachers must agree to is to complete three student evaluations collected electronically throughout the semester.

Course Assignments

As with all students enrolled in the course, students involved in the case study are required to complete several assignments. The primary requirement is that students spend three hours a week in their partner classroom for a total of 40 hours. Students track their hours through a log that their teacher must sign. In addition, students write 13 journal entries during the semester. Eleven of these entries are in the form of one-page reflective journal entries, developed to help students reflect on the events of their classroom. The first journal entry is a detailed introduction to their beliefs about science teaching submitted during the first week of the

semester. The final journal entry is an in-depth reflection on the entire semester with an emphasis on the big ideas the student understood from the course. All of the journal prompts for the Spring 2016 semester are listed in Appendix A. All journal entries described also created data for the study, described in a subsequent section.

In addition to the weekly journal entries, students also created a mini teaching portfolio over the course of the semester. The portfolio consisted of four parts: a teaching philosophy, two lesson plans, a student case study, and a short presentation. The teaching philosophy focused around the student's primary objective in the classroom. As part of this philosophy, students were asked to describe what they hoped to achieve in their classroom. Students also included two lesson plans that they taught that semester along with a reflection on each of those lessons. The student case study is a written reflection and illustration that students use to reflect on the particular methods that they use to teach science to a particular student. Students present this portfolio to the class in a brief five-minute presentation at the end of the semester.

While the logged hours and reflective assignments are critical to a student's performance in the course, the instructors also wanted to give control of a portion of a student's grade to the partner teacher. Therefore, three times during the semester, students received a grade from their partner teacher through an online evaluation. These three evaluations accounted for 20% of the student's final grade. In addition to a grade, students received individual feedback to help improve their classroom performance. Each teacher rated their FOCUS student on five categories: professionalism, collaboration, teaching, preparedness, and communication with students. The professionalism category included conduct in the classroom, timeliness, and appropriate attire. Collaboration included a section on communicating teaching plans to the teacher before class and working with the teacher to come up with lessons. The teaching

category asked teachers to rate the frequency at which the FOCUS student used hands-on activities and encouraged the class to inquire about the world. Under preparedness, teachers assessed whether the student had materials prepared on time and if the student had reviewed the content they were teaching for accuracy. Finally, teachers evaluated whether the FOCUS student spent equitable time with each student in the classroom and the student's confidence when teaching.

The remaining portion of students' grades in Project FOCUS was derived from his/her attendance in the reflection sessions and a recruitment presentation. The recruitment presentation is a small portion of their grade, but is important for sustaining enrollment in the course. Each student gave a brief presentation to another group of students at the university. The group could include a class, club, or meeting of students to inform them about Project FOCUS. There were few rules associated with this presentation. The only limitations were that students must complete this assignment individually and it must be completed on campus to a group of university students. As proof of his/her presentation, students turned in a fact sheet that included a signature of the faculty instructor or sponsor and a copy of a flyer or presentation he/she created as an advertisement.

In this section, the context of the case study was detailed. The case was bounded by a singular class of students, who, over the course of the semester, became a community of science partners in local elementary and middle grades classrooms. In the next section, the case is described including a description of the class members and profiles of the primary participants.

The Case

This research was conducted with one section of Project FOCUS in the Spring of 2016. This particular case was chosen because the class was taught by the primary researcher as the

teaching assistant and contained sixteen students, all of whom were willing to participate in the research. The other class that could have become the case, contained only six students, which did not represent a range of the students who enrolled in Project FOCUS in Spring 2016. Out of the sixteen students enrolled in the course, five students volunteered to be primary participants and the remaining eleven agreed to be secondary participants.

Participants

This study used purposeful sampling to choose participants. In a case study methodology, purposeful sampling is the most useful choice to gain the best insight into the topic being studied (Simons, 2009). All sixteen students in the course were invited to be primary participants. Only five students agreed to participate as primary participants in the study. Primary participants agreed to take part in three 30-minute interviews at the beginning, mid-point, and end of the semester. All sixteen students enrolled at the beginning of the course agreed to be secondary participants. Secondary participants completed all normal class activities, including written assignments and class discussions.

Overview of Participants

Sixteen students agreed to participate in the case study at the beginning of the semester. This section provides an overview of the study participants. All of the names and places in this study are pseudonyms. Eight of the students were male and eight of the students were female. All students were majoring in either pre-med, bioscience, chemistry, or physics, except for one student, Catherine, who was majoring in Agricultural Education. Seven students were African American, eight students were White, and one student was Asian. Two students, Sarah and Tamika, had parents who immigrated from Singapore and Nigeria, respectively. The majority of the students (13) were first time enrollees, while three students were repeating the course for the

second (Keisha) or third (Aaron and Justin) time. Midway through the semester, one student, Catherine, withdrew from the course. In Table 3.2, each participant's general demographic information and amount of participation in the course is provided. Primary participants are denoted with an asterisk beside their name. For example, Aaron is a male student, enrolled for the third time, during Spring 2016 placed at Oxygen Elementary School. He submitted all 13 of the assigned journals and participated in all 5 in-class group discussions.

Table 3.2 Summary of Participants

Participant	Demographic	Gender	School	Grade	Course Enrollment	Journals Submitted	Discussion Participation
Aaron	White	Male	OES	5	3	13	5
Caleb	White	Male	GES	3	1	11	5
Caroline	African American	Female	BES	K	1	5	2
Jasmine	African American	Female	HMS	6	1	13	5
Jewel	African American	Female	NES	Pre-K	1	13	5
Justin*	White	Male	NES	2	3	13	5
Keisha*	African American	Female	CES	K	2	12	4
Kelsey	White	Female	HMS	6	1	13	5
Parker	White	Male	BES	1	1	13	5
Sarah*	Asian	Female	GES	2	1	13	5
Suzanne	White	Female	BES	K	1	13	4
Todd	White	Male	GES	3	1	12	5
Tyler*	White	Male	AES	5	1	13	5
Tamika	African American	Female	GES	1	1	12	5
Travis	African American	Male	GES	4	1	5	3
Wade	African American	Male	GES	3	1	11	4

Primary Participants. In addition to the activities that all enrolled students completed, primary participants also took part in three semi-structured interviews. To be considered for primary participation, students had to meet specified criteria. Primary participants had to designate as a science major. While a few non-science majors enroll in Project FOCUS each

semester, students majoring in a science discipline comprise most of the course roster. All students enrolled in the case study section were majoring in a science discipline. Three of the students were enrolled in Project FOCUS for the first time. Two primary participants were returning students. These students were chosen because they had at least one semester of experience with service-learning reflection. If practice and experience contributes in improving an individual's level of reflection as Dewey (1933) suggests, then returning Project FOCUS students could demonstrate higher levels of reflection. In the next section, background information is provided about the primary participants: Justin, Keisha, Sarah, Tyler, and Wade.

Justin is a white male who grew up in a rural area in a southern state. He returned for his third semester in Project FOCUS as a senior in Spring 2016, having participated in FOCUS in the Fall of 2016 and Spring of 2015. Justin speaks slowly with a strong Southern accent and is passionate about helping kids learn science because of the early struggles he had with dyslexia in elementary school. He credits his success to his mother and a teacher he had that always believed in him.

Keisha is an African American female who grew up in a suburb of a large southeastern city. She describes diverse educational environments and credits those experiences as part of why she has been so successful in school. In her journal entries, she frequently described her disappointment with the large lecture classes and hands-off way that science has been taught to her at the university level. Keisha is deeply involved in the community surrounding the university, working for an after-school program at Calcium Elementary School in addition to enrolling in Project FOCUS for the second time in the Spring semester of 2016. Keisha's first semester was during Spring 2015. Unfortunately, due to family illness, Keisha retracted her

primary participant status and became a secondary participant, as she was unable to participate in the interview process.

Sarah is a soft-spoken female student who immigrated with her parents in elementary school from Singapore. Her mother is an elementary school teacher in a neighboring county and Sarah often drew comparisons between her schooling experiences in the United States and Singapore. The behavior problems in her classroom were always most prevalent on her mind.

Tyler, a senior majoring in biology, grew up in a Catholic school in the community surrounding the university. He emphasized that his current university is the first public education he has ever received. In his journal entries, he noted that small class sizes, personal relationships with teachers, and his parents influence helped him to thrive in school. He believed that science should be fun for all students, but may not be something that all students might need to know.

Wade, an African American male, and the only sophomore to volunteer as a primary participant for the course was shy and soft-spoken in class. He rarely spoke up during class discussions, but had a great deal to say on the one occasion the researcher was lucky enough to speak with him one-on-one. Unfortunately, Wade was only able to participate in the first interview of the semester, and, like Keisha, withdrew his primary participation status. His journals demonstrated a passion for science and he often had elaborate ideas for lessons, though he was never able to implement them in his classroom.

In the previous section, the context of the case and participants were discussed. This case was situated within a section of a service-learning course, in which students taught science in local Pre-K-8 classrooms. Sixteen undergraduate students from diverse backgrounds participated in the course. Table 3.1 summarized the participants, their demographics, school placement, and the data collected from each student. This section also discussed the five primary participants

(Justin, Keisha, Sarah, Tyler, and Wade) in detail. In the next section, the research design is discussed, including how data was collected and how that data was analyzed.

Research Design

This study used an instrumental, interpretive case study methodology. Simons (2009) defined case study as "an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, program or system in a 'real life' context" (p. 21). The purpose of a case study is to understand a specific topic in-depth through multiple research-based methods. A case study is instrumental because it seeks to understand a concept outside of the case itself (Simons, 2009; Stake, 1995). An interpretive, or analytical, case study, according to Merriam (1998), intends to analyze a phenomenon through rich descriptive data.

This study sought to understand students' reflection on service-learning experiences, the disequilibria they experienced, and how it impacted their actions within the course. A case study methodology is appropriate because it explores a phenomenon through multiple methods and allows for consideration of context (Merriam, 1998). Deweyan notions of reflection emphasize that reflection happens not only in isolation, but also in community (Dewey, 1933). Therefore, personal written reflections are not sufficient as the only way to understand reflection. In-class discussions about disequilibria were intended to shed light on the reflection happening within community. Interviews with primary participants were designed to demonstrate the connection between community and personal reflection. In this study, reflection in the context of Project FOCUS is theorized through the collection of data in multiple ways: interviews, group discussions of disequilibrium dilemmas, and written reflections.

Methods

A number of different methods were used to generate data in this study. Weekly written reflections, in-class discussions, and interviews with primary participants were all sources of data. Data generation was centered on students' service-learning experiences and the disequilibria they experienced in the process. A matrix of the methods that informed each research question is located below, in Table 3.3. In this section, written reflections, in-class discussions, and primary participant interviews are discussed.

Table 3.3. Matrix of data sources used to answer research questions.

Research Question	Written Reflections	In-Class Discussions	Semi-Structured Interviews
How do students describe feelings of disequilibrium in their service-learning experiences in weekly written reflections and in-classroom dialogues?	✓	✓	✓
To what extent do students' feelings of disequilibria embody issues of science teaching and learning?	✓	✓	✓
Using Dewey's notions that disequilibrium is required for reflection, how do students describe attempts to reconcile feelings of disequilibria emerging from their FOCUS experience?		✓	✓
How do students' attempts to reconcile feelings of disequilibria change over the course of the semester?	✓		✓

Written reflections. Each student was assigned to write a total of 13 journal reflections over the course of Project FOCUS. The weekly reflections were designed to help students process the classroom events. All written reflections were submitted on the university's online classroom system. Feedback to students was returned in the same manner. For the first three weeks of the course, students responded to various prompts designed to elicit their beliefs about science teaching and learning. After the first week of the course, students were asked to write a three-page reflection. This journal entry was intended to be a reflection on their own science

education and what they believed science teaching and learning should look like in elementary and middle school. The following prompt was given to the students:

> This is a three page double-spaced (at minimum) reflection that should address who you are as a person, a scientist, and a learner. This is a reflection, not a biography.
>
> Part One (about one page) - Describe your educational experiences. Discuss the value that your family placed on education. Give a specific example. Describe your favorite and least favorite educational experiences. What factors contributed to these experiences? Then, discuss your learning. What methods best help you to learn? How do you know you when you have truly learned a concept?
>
> Part Two (about two pages) - Take a snapshot in your mind of what you think an elementary science classroom is like today. Describe that classroom briefly. How many students do you imagine there are in a class? Describe the types of students that are in that classroom. What should a teacher know about their students? Do all of the children learn science? Why or why not? Which students in the classroom need your help (or the teacher's help) the most? Finally, discuss your expectations of being in the classroom. What do you imagine that you will gain from being in the classroom? What challenges might you face in the classroom?

During weeks two and three, two different prompts were given to the students to elicit their ideas about science teaching and learning. The prompts for these journal entries can be found in Appendix A. Once students entered their assigned classroom during week 4, the same journal prompt was used each week. The prompt given to students during weeks 4-12 was:

> ***This reflective journal should be a minimum of 350 words.***
>
> In the process of preparing or teaching science this week, think of a time that caught you off guard, made you uncomfortable, or that made you think. As you reflect on this event, answer these questions in 150 words or less:
>
> - Describe the event. What happened? When did it happen?
> - Describe the emotions you had in the moment to the thing that happened.
> - How did you respond in the moment? Why?
>
> Answer these questions in at least 200 words:

- Now thinking back to that event, how would you respond to the event now? Why?
- How did this event challenge your beliefs or values? Describe in detail.

Students reflected on something that gave them pause during their time in the classroom during that particular week. This prompt was constructed to be open-ended so that students could decide for themselves what was important. The word count was added to the prompt so that the students would spend more words reflecting than describing. In previous semesters, the teaching assistants found that without this requirement, students spent more time describing the event and less time reflecting on why the event happened and how they could learn from it. The final journal entry of the semester was the final reflective summary, where students considered everything they had done throughout the semester and summarized it in one three-page journal entry. In this journal entry, they spent time looking over their previous entries to generate themes they felt best represented their semester, using the following prompt:

> This should be a minimum of three pages, double-spaced.
>
> Look back at all of your journals from week 3 to week 14. In looking across all ten of these reflections, what are 3-4 common themes that you notice? If you need inspiration, consider how you talk about teaching, learning, students, and science.
>
> How have your beliefs on each of the themes changed over the course of the semester? Use specific examples from your journals to explain.
>
> Conclude the reflection with final thoughts about this course. What do you wish you had known when you first started that would have helped you be more successful? What would you do differently if you were to take this course again?

In-class discussions. Students participated in guided discussions based on Jay and Johnson's (2002) Typology of Reflection. Five times during the semester, students were given a short disequilibrium vignette centered around the discussion topic of the week. One part of each class was devoted to students analyzing the dilemma in small groups. They discussed the

complexities embedded in the vignette and their reactions to the vignette in small groups (typically 4 students per group). The object of this discussion was not to solve the dilemma, but instead for students to reflect on the vignette and consider it from multiple viewpoints. Guiding questions were provided for students to help facilitate the discussions. The disequilibrium vignettes were based, in part, on condensed versions of cases from the book, *Learning from Cases: Unraveling the Complexities of Elementary Science Education*, the FOCUS students' journal entries, and the researcher and critical friend's observations and experiences while teaching the course. The researcher and her critical friend developed these disequilibrium vignettes on a weekly basis. In total, five disequilibrium vignettes were used as the basis of class discussions.

The disequilibrium vignettes were based on Van Maanen's (1988) notion of impressionist tales. An impressionistic tale depicts a vivid picture of a special or important moment in time (Bryan & Tippins, 2005). The writing is intended to situate the reader inside of the moment—to experience what the writer was seeing, hearing, and feeling at that time. In addition to beginning dialogue between perspective teachers, impressionist tales allow teachers to "make explicit their beliefs about science teaching and learning" (Bryan & Tippins, 2005, p. 25). Appendix D lists all the disequilibrium scenarios over the course of the semester. For example, during the eleventh week of the course, students discussed misconceptions in science using the following scenario and discussion questions:

> This week, I taught a lesson on the layers of the Earth. I used a hands on activity that modelled the different layers and we talked about each one. Everything was going well, until Sam raised his hand and said, "B.o.B (famous rap artist) said the world is flat and I believe him, not you." I had heard of this controversy, but did not know much about it. I asked him, "Why do you think that? We looked at pictures of the Earth today--it is a sphere." He shook his head and said, "That's a picture, it's not real. Everything I see is flat. I turned to the rest of the class, "Do any of the rest of you think the Earth is flat?"

> Five more students raised their hands. Oh brother, I'm in trouble now. Science was over and I had to leave, but I can't let the students continue believing the Earth is flat. What can I do?
>
> Put yourself into the FOCUS student's position in this scenario. Use the questions below to help guide your discussion. Please be sure that you are all participating in the discussion.
>
> - Discuss similar experiences you have had and how you handled them.
> - What would you do in this situation?
> - What problems do you see in this scenario?
> - What assumptions are you making about teaching and learning science?
> - How does this change what you believe about teaching science?
> - How might you plan or teach differently as a result of your discussion today?

In addition to the disequilibria scenarios, during the last week of the course, students participated in a final group discussion where they reflected on what they had learned during the semester. The discussion guide for the final discussion included questions such as: What was one challenge you had to face over the course of the semester? How have you changed as a person this semester? The full discussion guide is listed in Appendix B.

Interviews. Three primary participants, Justin, Sarah, and Tyler, were interviewed three times throughout the semester. As previously stated, primary participant Keisha was not able to attend any interviews. The last primary participant, Wade, was only able to attend one interview, which was a combined version of the interview questions from the first and second interview guides. Each 30-minute semi-structured interview was designed to delve-deeper into students' reflective experiences. The first interview, occurring in the fifth week of the semester, discussed the student's educational background and initial impressions of his/her classroom. The researcher and participant conversed about the student's beliefs about science education, his/her history with service-learning and reflection, and the issues he/she believed they would face in his/her placement classroom. The second interview, during week nine of the semester, focused on the

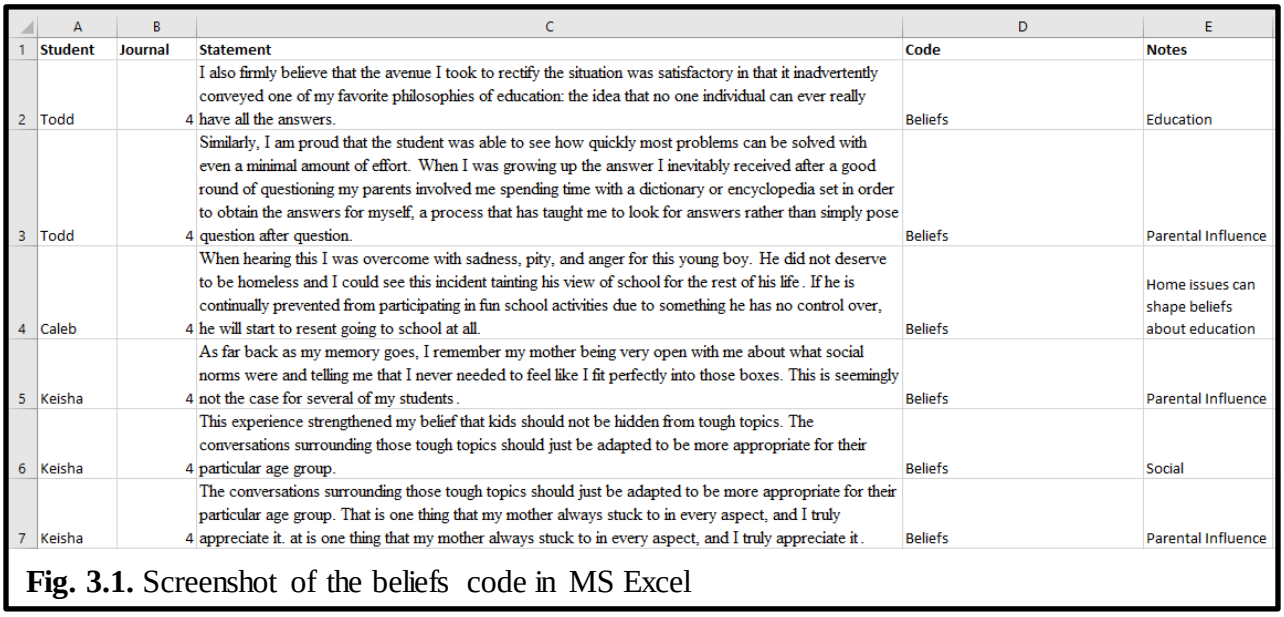
student's impressions of their placement classroom and experiences of disequilibria. The final interview, during week 15, had each student discuss his/her learning throughout the course of the semester. The primary participants looked back on the journal entries he/she wrote during the beginning (week 4), middle (week 9), and end (week 12) of the semester and discussed the resolutions of the disequilibria he/she wrote about in those journals. Participants used Jay and Johnson's (2002) Typology of Reflection to rate their level of reflectiveness and discussed how they could have improved their level of reflection. The reflective typology was only used during this interview with students because the researcher wanted to ensure that students were reflecting in authentic ways and not trying to please the researcher. The final interview also provided an opportunity for students to look back across the disequilibria they had experienced and draw comparisons.

Data Analysis

Simons (2009) emphasized that data does not speak for itself. Case study data, in particular, relies heavily on researcher interpretation to make sense of the data to "tell an eventual story" (Simons 2009, p. 118). Stake (1995) said, "There is no particular moment when data analysis begins," (p. 71). Using this philosophy, data analysis was initiated from the beginning of this study. As the semester continued, analysis helped the researcher understand the events and conversations occurring in the classroom. Analysis throughout the semester helped to improve the disequilibria vignette prompts. This is discussed more thoroughly under the section on Laura, the critical friend. The approach to data analysis in this study was two-fold. The data was first assessed for the students' level of reflection using Jay and Johnson's (2002) Typology of Reflection. Then, thematic analysis was performed to understand the common themes.

While Jay and Johnson's (2002) Typology of Reflection was helpful in understanding the levels at which students were reflecting on, it did not provide insight into how students were recognizing, understanding and processing disequilibria in their science service-learning experiences. The second and most important part of the data analysis for this study was thematic analysis. Thematic analysis, a derivative of grounded theory, is used to find patterns within data when theory is not or cannot be generated (Braun and Clarke, 2008). Braun and Clarke (2008) argue that thematic analysis is widely used, but often poorly understood. This section describes how the researcher went about analyzing the data using thematic analysis.

Many different methods of organizing the data were considered when beginning analysis. However, the data was ultimately organized in Word documents and Excel files. Each of the journals was read and coded in Microsoft Word. They were then chunked into sections by code



	A	B	C	D	E
1	**Student**	**Journal**	**Statement**	**Code**	**Notes**
2	Todd	4	I also firmly believe that the avenue I took to rectify the situation was satisfactory in that it inadvertently conveyed one of my favorite philosophies of education: the idea that no one individual can ever really have all the answers.	Beliefs	Education
3	Todd	4	Similarly, I am proud that the student was able to see how quickly most problems can be solved with even a minimal amount of effort. When I was growing up the answer I inevitably received after a good round of questioning my parents involved me spending time with a dictionary or encyclopedia set in order to obtain the answers for myself, a process that has taught me to look for answers rather than simply pose question after question.	Beliefs	Parental Influence
4	Caleb	4	When hearing this I was overcome with sadness, pity, and anger for this young boy. He did not deserve to be homeless and I could see this incident tainting his view of school for the rest of his life. If he is continually prevented from participating in fun school activities due to something he has no control over, he will start to resent going to school at all.	Beliefs	Home issues can shape beliefs about education
5	Keisha	4	As far back as my memory goes, I remember my mother being very open with me about what social norms were and telling me that I never needed to feel like I fit perfectly into those boxes. This is seemingly not the case for several of my students.	Beliefs	Parental Influence
6	Keisha	4	This experience strengthened my belief that kids should not be hidden from tough topics. The conversations surrounding those tough topics should just be adapted to be more appropriate for their particular age group.	Beliefs	Social
7	Keisha	4	The conversations surrounding those tough topics should just be adapted to be more appropriate for their particular age group. That is one thing that my mother always stuck to in every aspect, and I truly appreciate it. at is one thing that my mother always stuck to in every aspect, and I truly appreciate it.	Beliefs	Parental Influence

Fig. 3.1. Screenshot of the beliefs code in MS Excel

in Microsoft Excel (Figure 3.1). This allowed the data to be organized in any manner required by the researcher. In addition, it made it easier for codes to be changed and combined, as suggested by Simons (2009). In the screenshot in Figure 3.1, the data is sorted by the code "Beliefs." This

code came up numerous times throughout the journals. After each journal was read line by line, the researcher also wrote a memo in which she summarized the basic idea of the journal and then listed tensions that she saw. An example of the memo can be found in Figure 3.2. This memo was one of the first written after reading Caleb's journal entry about a homeless student in his classroom. The memos were written in hopes of maintaining the richness of the data and to prevent the coding from becoming "mechanical and formulaic" (Simons 2009, p. 121). The data was coded and then the codes were examined and collapsed when necessary. For example, the codes Role in the Classroom/Classroom Role and Making Solutions/Suggesting Solutions were combined because they are similar in nature but phrased differently. The researcher created concept maps to sort these codes and sub-codes and to examine how the codes were related. Codes that emerged repeatedly across multiple participants or multiple data sources became categories. The categories were used to make sub-themes and from those sub-themes, the themes emerged (Aronson, 1995).

9/7/16 Caleb J4: Socio-Economic Issues

In this impassioned journal, Caleb recounts a story in which a student was unable to take part in a paper plane flying contest because he had to leave due to being homeless. This struck the participant emotionally, which led him to use strong emotionally charged language. In reflecting on the story, he makes a commitment to make that student's science lessons as enjoyable as possible to help him learn to love school. He concludes with the idea that education is a way to cure the socio-economic issues students might face.

Disequilibria Observed:
Socio-Economic Issues (Homelessness), Decision-Making (Committing to fostering

Student Love for School), Education as Cure

Fig 3.2. Researcher analysis memo about Caleb's fourth journal entry

Researcher Role

Stake (1995) wrote that there are five roles a case researcher can assume: advocate, biographer, evaluator, interpreter, and teacher. The researcher in this study also adopted teacher and interpreter roles. Arguably, the teacher/researcher position is an important one in the course development. The Project FOCUS class is built collaboratively each semester with the co-teaching assistant and the professor. The course instructors make careful decisions about the topics that are taught, based on what they believe the students might need before the course begins. The teaching assistants adjust these topics each semester as it seems necessary. In addition to choosing the topics and activities for each class, their responsibilities as a teacher includes placing students in their partner classrooms, facilitating discussions during class, responding to students' journals, and guiding students to choose effective hands-on lessons. According to Stake (1995), the key role of the researcher is to be an interpreter. The interpreter works to solve the puzzle of the case and to uncover new connections to explain them to other people. As the interpreter, the researcher's responsibilities include maintaining the voices of the participants while simultaneously interpreting their meanings.

Role of the Critical Friend

In educational research, a critical friend is someone who offers critique, asks provocative questions, and becomes intimately familiar with context of the research. The critical friend "advocates for the success of the work" (Costa & Kallick, p. 50). For this study, the co-teaching assistant, Laura, fulfilled the role of the critical friend. She was knowledgeable about the context of the course because she also served as the instructor for two sections of the service-learning course. Laura and the researcher met once a week to plan each class period and to discuss the

progress of the research. Through the planning of the course, Laura helped to choose and write the disequilibrium dilemmas for class discussion.

Laura offered insight into what the researcher observed throughout the semester. She provided honest, thorough critique because she was similarly invested in Project FOCUS. This helped to keep the researcher's bias in check because the critical friend offered critique of the researcher's thoughts and asked probing questions to keep the researcher thinking more deeply about the course and the research. One of Laura's most important functions within this study was to help decide on and write disequilibrium scenarios. Together, Laura and the researcher routinely aggregated all students' journal topics to survey what the students were writing about each week. After each vignette discussion, Laura and the researcher discussed the students' reactions to each discussion question and made adjustments to the questions to facilitate better discourse between the students. For example, after the first disequilibrium scenario, Laura and the researcher agreed that students weren't putting themselves in the position of the student in the scenario. Students were making judgments about the person's mental competency, calling the student in the scenario "stupid" and unable to imagine themselves in the position of the student. Both teaching assistants also noticed that the undergraduates were struggling with the number of names in the vignette, so they made the decision to change the vignettes to first person, to help students put themselves into the person's position, and to reduce the number of names used in each scenario.

Researcher Subjectivities

As a first-year PhD student, I walked by a classroom in the afternoon and noticed some of my students from biology labs the year before. What were my former students, who were biology majors, doing in the education building? One evening before class, I was able to ask the

teaching assistant of the course that I had passed by what he was teaching in that course. "Project FOCUS," he said, "is a service learning course. Our students teach hands-on science lessons in local elementary schools." The program sounded amazing! I missed "doing science"—my classes were focused on educational theory. Luckily, a short time later, my advisor suggested that they were looking for another teaching assistant for the program. I quickly made an appointment to go see the professor in charge of the FOCUS program to learn more. After talking about his passion for the program and my love for science and teaching, I left feeling thrilled about the FOCUS program. A week later, when he offered me a place teaching the course, I happily accepted the position--looking forward to helping undergraduates convert kids into young scientists.

When the new semester started, I felt about as lost as I did when I started each of my degrees. Students would ask me questions about what they could expect in their classrooms, but I could not give them an answer. I was unfamiliar with the school system, the teachers, and the student demographics. I lacked the pedagogical content knowledge of how to teach topics that I only had a basic understanding of myself, despite having two degrees in science fields. A Master's in entomology only goes so far when teaching fourth graders about the solar system. The topics in education that I was teaching them that semester did not help them either. We would discuss grouping students by ability and while all of my students were gifted and could relate to the issues of tracking, it did not help them plan or teach their lessons. I struggled to conclude the class in meaningful ways with phrases like, "This topic will help you when you are the parent of a student." Additionally, the pedagogy I was using—mostly lecture with a few poorly executed discussions thrown in—was not modeling the techniques I wanted them to use. I was teaching how I had been taught, but students were on their cell phones and laptops. Class

discussions, something that I was familiar with participating in, but had very limited knowledge of how to facilitate fell flat. The same few students repeatedly participated, while the rest stared blankly at whoever was speaking. I knew I needed to change to make our discussion sections more beneficial to students—to help them have ownership of what they were learning in the classroom.

The changes made to the course occurred slowly over the next two semesters. The other teaching assistant and I worked closely together to implement our shared vision—a classroom of engaged, excited students who are passionate about science. We acquired white boards and required students to get up and move around the classroom, using active learning strategies. I chose to model these strategies because after we finished with an activity, I could pose the question, "How might you use this technique in your classroom?" We chose to replace the topics of standardized testing and tracking with misconceptions in science and problem solving strategy sessions. Each week, we devoted time to going around the classroom and getting each FOCUS student to talk a little about the lesson they had taught that week or a success or challenge they had in their classroom.

Our students are fortunate to have this opportunity to engage with their local community and discover whether or not they like to teach. As an undergraduate biology major, I was interested in going into teaching, but my experience in my education class, which was a 300-person lecture course, convinced me that I was not cut out for the profession. Nearly a decade later, I find myself enrolled in an education program. It seems like I took the long path to get here. After I graduated with my Bachelor of Science degree, I thought I was passionate about researching insect behavior. I studied termites for two years, becoming increasingly distracted by the biology lab that I was given to teach for my assistantship. I loved teaching that course more

than I enjoyed working in a solitary lab discovering what controlled termite behavior. My students' learning was much more fascinating. I have to wonder if I might have found a different path earlier if a FOCUS program had been offered at my undergraduate institution.

The course has many benefits to students in addition to helping them discover if they have a passion for teaching. Because undergraduates are paired with a classroom for an entire semester, they are able to form a bond with their K-8 students and the teacher. They celebrate their students' victories and are invested in finding ways to mitigate the challenges. By creating a classroom environment where students are eager to work together and help to solve each other's problems, they are building a learning community together

The FOCUS students come back to the discussion sections after their first experience trying to compare their elementary school experiences with those of the children in Carbon County. They struggle to find common ground with their students, often stating how there are many "bad" children. I believe that no child is a bad child, but is instead acting out for any number of reasons. I try to convey this to the undergraduate students, but the FOCUS students fall back on the good child/bad child dichotomy. My interactions with populations like Carbon County have been limited, however, and sometimes words fail me when students ask for advice on how to handle behavior issues in the classroom. This is an area that I would particularly like to develop because another benefit of service-learning is appreciating a diverse group of people.

As a researcher heavily involved in the program I was studying, I had several concerns. The one foremost on my mind was that, as the teaching assistant, the students would not be completely honest with me. Instead, they might tell me what they thought that I wanted to hear. I tried very hard to create an open environment where students could share their challenges and successes, so that we could celebrate or attempt to solve problems, accordingly. Another

challenge that I foresaw facing during this research process was the fact that I wanted to improve the course and help it survive and thrive at the university for years to come. While I know that our students were learning through this process—I feared finding the opposite. This is a bias I constantly kept in the back of my mind.

Ethical Concerns in Conducting the Study

Several safeguards for student protection were written into the IRB. While the researcher had knowledge of every participant's name, all assignments were graded according to rubrics and grades were not impacted by participation in the study. All journals were graded simultaneously and not coded for research purposes until after every student had received feedback. When disequilibria vignettes were written, details such as grade, topic, and names were changed to protect the student's and classroom identity. When the research was written up, all identifying information was removed from the journals, transcripts, and other work and replaced with suitable pseudonyms. Teacher's names were abbreviated to the first letter of their last name and classroom student's names were handled similarly.

Chapter Conclusion

The methodological framework was described in this chapter. The first section discussed the theoretical framework of the study, Deweyan notions of reflection, and the underlying theoretical assumptions of that framework. The second section introduced case study as a methodology and presented a rationale for using a case study approach. In the third section, the context of the case was described. The case was situated within a university science service-learning course which provided undergraduate students with an opportunity to teach science in local K-8 schools. Following the context, the case was described in detail including the participants and a description of how the data was generated and analyzed. Finally, the chapter

concluded with a discussion of the role of the researcher, including her critical friend and subjectivity statement. Chapter four will present the case with thematic representation of the study using impressionistic tales to represent the different themes that emerged throughout the case study.

CHAPTER 4

FINDINGS

In the first three chapters, the stage was set for presenting the case study of a class of Project FOCUS students during Spring 2016. The present chapter details the findings with respect to each research question, organized and discussed as themes. A combination of interviews, weekly written journal entries, and in-class discussions from a class of 16 students comprises the data analyzed and presented in this chapter. Each theme includes a representative impressionistic tale, a vivid description of a moment in time that was particularly memorable to the reflector (van Manen, 1977). In the first section, the reflective disequilibria described by students in their journal entries and group discussions are described. The second section highlights themes related to students' reflections on these disequilibria. Finally, the chapter is concluded and a preview of chapter five is presented.

FOCUS Students' Reflective Disequilibria

In this section, five themes are presented with respect to understanding the disequilibria science majors enrolled in Project FOCUS experienced throughout their service-learning experience. Dewey's notions of reflection suggest that a person must experience a disequilibrium to initiate any form of reflection. Through this case study, students' journal entries and class discussions were examined for evidence of reflective disequilibria. A focus on reflective disequilibria was encouraged using prompts either through a journal prompt, individually, or as an impressionistic tale in group discussions. In this chapter, students' words are represented

using italicized font. This helps distinguish the researcher's interpretation from student narratives. The themes related to disequilibria discussed in this chapter are:

1. FOCUS students described experiencing barriers to teaching.
2. FOCUS students identified several structural barriers that they believed hindered student learning.
3. FOCUS students questioned the accuracy and appropriateness of content taught in the partner classrooms.
4. FOCUS students believed they took on mentorship roles in their partner classrooms.

Theme 1: FOCUS students described experiencing barriers to teaching.

Particularly in the beginning of the semester (weeks 4 and 5), FOCUS students felt disequilibria related to their role in the classroom. Whether it was experiencing tension concerning their role in the classroom or feeling helpless to overcome multiple barriers to teaching, students spent a lot of time discussing in their journal entries and classroom discussions how they fit within the classroom ecosystem. In this first impressionistic tale, Suzanne (Journal 4) discussed her predicament in finding her "teacher voice":

At lunchtime, Ms. S asked me to stand at the back of the line and make sure all the kindergarteners behaved. They are supposed to be quiet and walk in a straight line, but the kids were so excited to see me, they wanted to stand next to me and grabbed at my hands so I would walk with them. They talked continually, walking two or three at a time, not at all in a straight line. From the front, I could see the displeasure on Ms. S's face and I was embarrassed for my

lack of control over the way they were acting. I told them to be quiet and face the front, but their excitement and attention could not be stopped. I didn't want to be mean. I could have been more authoritative and threatened to punish them, but I don't want any of them not to like me. It's only my first day—next time I'll do better.

Suzanne was not the only student struggling to find his/her teacher voice. Many of the students expressed the desire to improve on becoming an authority figure in the classroom with the power to both praise and discipline students as necessary. Parker summed up this feeling succinctly by stating in his fourth journal entry, "*I understand that my role is to help teach and be in a slightly authoritative (but not too much) position, I also want the students to consider me as their friend and that they can trust me."* Some students, like Jasmine (Journal 4) shied away from handling disciplinary problems because they did not feel it was their place. Jasmine stated in her fourth journal entry, *"At the time, I did not say anything. I let the teacher handle the student. I wanted to talk to the student about his behavior to really get to the bottom of his attention-seeking motives, but I knew that I could not and most likely would not ever be allowed the chance."* Others, like Tyler (Journal 4), felt as if they had overstepped their boundaries when accidentally giving students directions that were contrary to their partner teacher's instructions: *"The students were cutting out pieces to a Model T in social studies and after cutting out his pieces, one student asked me if he could go ahead and put them together. I said, of course, but the teacher got mad at the student and told him he shouldn't be putting it together yet. I felt horrible for getting the student in trouble."* Negotiating the boundaries between being a student and a teacher was difficult for many of the FOCUS students, even after being in the classroom for several weeks. After five weeks in the classroom, Tyler (Journal 9) wrote, *"As soon as the teacher stepped out of the room, one student asked if he could use the restroom. This made me*

feel uncomfortable because I was not sure if I was allowed to give the student permission to leave the room. I said yes and he returned before the teacher came back into the classroom. But while he was gone, I was so nervous. I started wondering what would happen if the student went running down the halls and misbehaving. Would I get in trouble for letting the student use the restroom?" However, another factor simultaneously contributed to students' feelings of uncertainty in their classroom roles—simply being offered the opportunity to teach.

Undergraduate students experienced numerous barriers to their ability to teach in the classroom. For example, six unique students (Aaron, Caleb, Jewel, Sarah, Todd, and Tyler) mentioned in a journal entry, that they were unable to lead a lesson because their classroom was focusing on social studies during the science period. Many of the classrooms Project FOCUS students were partnered with were organized in terms of rotating units of science and social studies. Students perceived other structural barriers to teaching as related to administrator or teacher decisions. In the impressionistic tale below, Tyler discussed how he arrived at the classroom prepared to teach his first lesson, but experienced one of these such barriers:

"*I walked into the school juggling several items, well-prepared for my first lesson on physical and chemical changes. My teacher had asked me to prepare the lesson and I had planned three mini-demonstrations to illustrate different changes to the fifth graders. I was nervous, but excited. I was prepared for any student scenario—I even practiced with my roommates. When I arrived at the classroom, my teacher greeted me at the door. "Where can I set up?" I asked. "Oh, I forgot to tell you, but one of our school's students is going to be in the district spelling bee today!" she answered. "We are going to watch that instead of doing science. Next week, we will be doing social studies, but you can bring your lesson back in two weeks." Simultaneously I felt both disappointed and relieved. I spent so much time preparing and*

worrying, and now I would have to wait another week before I could use the lesson. There is so much more time for worrying."

Jewel recounted a similar issue which she described in her fourth journal entry. Like Tyler, she had also arrived prepared to teach, but a school guidance counselor appeared unexpectedly to give a lesson to her preschoolers instead. She wrote, *"As I was sitting down to teach, the school's counselor arrived. My teacher was just as surprised as I was. The counselor's lesson took over an hour so I was left with only 15 minutes to teach. This was not enough time for me to teach the lesson so I would have to teach it the next time I was in the classroom. Leaving the classroom, I was disappointed that I did not get to teach my lesson."* Similar stories were described during times of social studies, testing, and for other school-wide events. Undergraduates' opportunities to teach were sometimes limited by forces outside of their or their teacher's control. In his final journal entry, Wade summarized the difficulties of simply getting to the time of the day when science was taught by stating, *"My classroom had a set schedule but often science would be left off it. The kids would be instructed to read or do something else instead."*

It was apparent from the data that many FOCUS students struggled to understand the classroom norms and how they fit within the teaching and learning context. It may be more than three hours a week is needed to develop an understanding of these norms. Since FOCUS students were not studying to become teachers, an extended placement in the classroom could present challenges. In some cases, it seemed that more explicit times for students and teachers to discuss classrooms norms and other issues was needed, but not always evident. While FOCUS students professed these barriers to teaching as frustrating and experienced disequilibria in trying to find

their place in the classroom, they also perceived the children in their classrooms in having to overcome numerous barriers to learning during times when science was being taught.

Theme 2: FOCUS students identified several structural barriers that they believed hindered student learning.

Through their positions in their classrooms, the undergraduates felt they were put into positions that made them feel emotional or helpless about their students. For many of the undergraduate students, the socio-economic context of Carbon County schools was very different from their own. Sarah, in her sixth journal entry, espoused, *"Sometimes I have to pause and remember that they most likely were not raised in the same type of environment I was, so the things I think would be unacceptable carry no weight with them. Understanding where each of my students is coming from will be the most challenging part of this semester."* These perceived differences struck a chord with many of the undergraduates throughout the semester. From experiencing instructional challenges to socio-economic challenges, undergraduates emphasized that they felt dissonance between their own experiences as adolescents and their students' experiences. Socio-economic challenges, communication issues, administrative decisions, and unmanageable behaviors were frequently mentioned as perceived barriers to student learning.

In this first impressionistic tale, Caleb discussed the educational ramifications of what he believed could happen to one student, whom he had just discovered was homeless:

"Today was the school-wide paper plane flying contest. A young boy in my class was incredibly excited and worked harder than anyone else on his work to finish early and start building his paper plane. He was respectful and quiet, waiting patiently for the last period of the day. Just as he began to build his airplane, he was called to the office to leave for the day. As he packed his things, I could see the tears in his eyes. I expressed my concern to the teacher, who

told me that the boy is homeless and when his caretakers come by to pick him up he must leave, regardless of the time. I was overcome with sadness, pity, and anger. This child does not deserve to be homeless! Incidents like these could taint his view of school for the rest of his life. If he is continually prevented from participating in fun school activities due to something he has no control over, he will start to resent going to school at all. I feel as if there is nothing in my power that I can do, but I am going to work very hard to make this boy's school experience one that he enjoys. I want him to learn to love school, regardless of the challenges he might face. Education can provide the escape he needs."

Not all undergraduates were privy to information on the stability of their students' home lives, though they all expressed the feeling that it was critical for a teacher to know the situations his/her students were facing at home. Stories of socio-economic challenges like the one that Caleb witnessed were described by many of the undergraduates. In her eighth journal entry, Jasmine wrote about an experience with a sixth grader who hadn't completed his homework the night before: *"He just seemed to be a kid that simply forgot to do his homework, but I was wrong. I asked why he had not completed his assignment at home, and his response had caught me off-guard. It turned out that the student did not have any type of wireless internet connect in his home, so he was unable to even attempt his homework. I never thought to think about the possibility of students not having something that is an important part of my everyday life: wireless internet connection. That student was and will most likely always be more disadvantaged compared to other students in most situations. I felt so sad and useless. At that moment, there was nothing that I wanted more than to be able to change his life, but I was not in a position with any type of power to do so."* Similarly, Todd reflected on an experience in his classroom during which a student was having trouble seeing his paper. Knowing a little bit about

the student's socio-economic status prompted Todd to do some research on the availability of vision care for lower income people, which he passed along to the teacher, after advising the student to mention his blurry vision to his parents. However, Todd concluded in his fifth journal entry that he felt powerless to help the student stating, *"It is extremely frustrating for me to witness a basic lack of health-related services as the product of what is purely socio-economic status. Similarly, it is maddening to know that these already disadvantaged students can be further vulnerable to problems that are so simply fixed. Yet again, I am struck with the feeling that with the right funding and resources these seemingly struggling kids could perform just as well as any others."* Closely related to the socio-economic challenges, the undergraduates discussed communication issues they observed in their classrooms. Keisha described such a communication barrier in her fifth journal entry and during a group discussion:

"This week in my classroom, I met a student named P. The teacher told him to introduce himself to me, but he would not speak. Ms. E immediately said that his silence was due to his shy nature. When we split into our work stations, P was in my group. I quickly learned that his silence was caused by something of a greater magnitude. It was a serious language barrier. I felt empathetic toward him because I could tell that he was giving a genuine effort on his work, but struggled to complete it in time. I decided to give him a little more attention and put a greater emphasis on the words that I said and made sure to slow down and repeat myself when speaking to him. Simply the smile on his face was enough for me not to regret showing him an extra bit of attention. I have seen in my experience working with students, that the key to effectively teaching is to relay the information to the students in a way that they can understand, rather it be verbiage or experiences that they have a true understanding of. Therefore, if a student cannot

understand the words that you are saying, it is unreasonable to think that they can understand the concepts that you are teaching with those words."

In her journal entry and her group's discussion on students with communication barriers, Keisha offered many practical solutions to help students like P out in the classroom. Many of the undergraduates felt that the administration needed to do more to support the students in the classroom. Critique of administrative decisions often were a central part of the discussion around barriers to student learning. Many of the FOCUS students expressed the belief that administrative decisions were also barriers to learning that could hinder a student's desire to learn. After experiencing a frustrating afternoon teaching, Caleb reflected in his sixth journal entry, *"I struggled to keep the students' attention during my magnetism lesson. The children were grabbing the supplies, stealing the pennies and nickels, and snatching objects from each other. My teacher explained that this was very common during science because it is the last period of the day and the children are riled up and ready to leave. I was somewhat perturbed and upset because the children were getting science every day at their most distracted period. Why not change the time of day when science was taught to keep them interested and engaged?"* Another administrator decision that was questioned in journals by students was administrator punishment choices. In the following impressionistic tale, Kelsey elaborated on an experience in which she believed administrative decisions involving an after-school program adversely affected a student in her classroom:

"E is one of my favorite students in Ms. C's first grade class. After my time in my FOCUS classroom, I work at a nearby after-school tutoring center. At the after school tutoring program on Thursday, I saw E sitting outside. He refused to go in the building, saying he did not want to do his homework inside. I questioned him, asking him why he would want to do that. Finally,

after getting frustrated, he told me he was not allowed in the building. I didn't believe him—surely, he was lying! The recreation center certainly wouldn't leave this little boy outside by himself! I walked inside to question the woman at the front desk, who told me that E was suspended for two weeks and was not allowed inside. I questioned the safety of leaving a six-year-old outside, but she informed me it was best to leave him outside alone because he would know to walk home soon. What can I do? If I stayed with E outside, I would be breaking the rules but if I continued inside, I would never be able to live with myself if something happened to him. I feel so powerless. Ultimately, I decided I had to trust the rec center and continued my way into the tutoring room, leaving E alone. I don't understand how the woman in charge could feel such little compassion when seeing E sitting alone on the sidewalk outside. Inside the tutoring center, I was paired with another student and working on math homework. I watched E through the window, sitting on the sidewalk waiting for someone to acknowledge him. After about fifteen minutes, E got up, grabbed his backpack, and walked home. I felt defeated.

I don't know why E was suspended from the rec center, but I am sure it was for good reason. I understand that he needed to learn a lesson and take responsibility for his actions, whatever they may be. However, leaving a 6-year-old boy alone and telling him he was not allowed inside was something that broke my heart. If I could be in the position again, I like to think that I would have gone outside and read with him. I feel that the rec center is a very positive experience for the kids to work on homework. If E no longer associates the rec center with optimism, he will hate doing homework and eventually, may not enjoy learning. This experience made me question whether the rec center's punishment to E was an effective way of teaching him a lesson in obedience or an act that discouraged learning. The situation is not

black and white, there are shades of gray. I strongly believe that continued support and encouragement is what E needs to be successful."

Like Kelsey, many of the students questioned decisions made by the administration when "punishing" students or attempting to hold them accountable for their actions. The FOCUS students viewed these administrative decisions as punishments and felt like they hindered students' learning. When undergraduates questioned administrator and teacher decisions that they viewed as a barrier to a student's learning, the discussion of these events invoked different emotions than when the decision was related to their own teaching. Words like powerless, defeated, and sad were used when FOCUS students discussed barriers to students' learning. The use of these words seemed to suggest that the FOCUS students felt like the situation was out of their hands and they lacked the ability to handle it. However, when FOCUS students experienced a barrier to their own teaching, they expressed frustration and disappointment, as if they should have fixed the problem themselves. Student behavior seemed to fall in the latter category—FOCUS students felt that they should be able to handle students and convince them to learn. FOCUS students viewed challenging student behavior as a barrier to learning for not only the student acting out but also the students in the rest of the classroom. Undergraduates struggled to understand why their students would act in ways so destructive that their own learning was hindered. In the following impressionistic tale, Sarah discusses the moment she came to the realization that disruptive behavior inhibits learning for all students, not just the ones who are being unruly:

"This week, I taught a lesson on friction with small groups of students. The lesson involved rolling cars down ramps onto different surfaces. My second group struggled with behavior and listening, so I felt as if they walked away from the lesson without gaining any new

knowledge. At the end of my lesson, one of the quieter students in the group looked at me, shook her head, and said, "This didn't work. Everyone was being bad." I could tell she was upset, and because I was in complete agreement with her, I replied by saying "I know, we're just going to have to work on that." At that moment, I was overwhelmed by the misbehavior of the last 20 minutes and simply had to agree with the student. I did not realize that some students felt cheated from learning because of the behavior of others. I always knew that behavior interfered with other students' learning, but I assumed those students who were being disrupted were unaware of their loss, especially when they were only in second grade. However, now I know that some students do understand the implications of being in a group of poorly disciplined children, and I need to work to make sure that the misbehaving students do not interfere with the learning of those who already enjoy learning."

Behavior issues were a common topic for consideration in both group discussions and the journal entries. In the third group discussion, Kelsey, Suzanne, and Sarah spent a significant amount of time discussing the behavior of their students and teachers in the context of the science classroom. The following conversation was typical of many of the FOCUS students:

> SUZANNE: "*We do small groups in kindergarten and the kids talk over me and they'll talk about different topics, like their weekend gymnastics class. And I tell them that gymnastics doesn't have anything to do with science, but it's difficult to get them to listen. One girl was not listening to me at all and I had to make her sit on the rug."*
>
> SARAH: "*That's how my entire class behaves."*
>
> SUZANNE: "*And I felt really bad for making her sit on the rug, but that's what the teacher told me to do. She said that you must be assertive."*

KELSEY: *"I'm in first grade and I was shocked by how mean the teacher is. But teachers just must act like that so that the kids listen. She really loves them, but she can't be nice for a long time."*

Stories of behavior issues that prohibited learning permeated journal entries and discussions all semester. In the final journal entry of the semester, 10 out of the 14 students that completed the assignment mentioned behavior issues as being a common theme they reflected on over the course of the semester. While many of the students in individual journal entries throughout the semester reflected on student behavior as driven by lack of engagement, struggles at home, or behavior disorders, in their final summary of the semester, many of the students began attributing student behavior to larger, more complicated structural issues. Of student behavior in her classroom, Sarah stated, *"Growing up nearby, I knew Carbon County schools had issues with controlling behavior enough to effectively engage students in learning, but I figured that my introduction to the class and prior experience working with kids would really help to shift that trend and excite students about science. I have come to learn that people sometimes do not realize that their actions are bad because up until they reach school, they have never been told that what they are doing is wrong. They may have lived several years thinking that some of their actions were acceptable, when those actions may only be acceptable in their home environment. It is difficult to teach a person that something they have always done is actually wrong, and it takes time and personal realization from the student before he or she is able to correct his or her actions in response."* Todd summarized his beliefs about classroom behavior and the administration in this way:

"Another striking event that took place while assisting my teacher gave me great pause as to the disciplinary nature of the modern school system. Upon entering my classroom on a

routine weekday my teacher advised me that her phone had gone missing earlier in the morning and that if it did not appear a search of the students was to take place via a resource officer, a standard procedure. While other teachers seemed oblivious to the implications of such a search, I found myself totally appalled by the idea of a blanket police search of nine and ten-year-old students, not to mention the outright abuse of a handful of rights that no one seemed to mind potentially violating. Fortunately for everyone involved the phone was located but my concerns remained unanswered: what exactly are we teaching students about the world they live in? How can we expect a struggling child to develop a positive world view if their rights are ignored from the very start, are we not creating disillusionment in the very place we should be fighting it the hardest? Similarly, I noted that misbehaving students from other classrooms were often delivered to our room by teachers that announced they were 'totally through with' the issue at hand, further teaching vulnerable students that their problems would be pawned off rather than actually addressed. While it would be easy to simply blame the teachers, I truly believe that my experiences indicate systemic issues rather than individual ones, problems that must be addressed if we ever expect our education system to flourish. I do not pretend to know the solutions but the problems are plain to see: our teachers need help if we expect students to succeed."

Sometimes FOCUS students felt that the barriers to learning they observed in their partner classrooms were insurmountable. They felt, like Todd, that the issues were beyond their control, even beyond the scope of their partner teacher. However, they also reflected on issues that were more in their control: the accuracy and appropriateness of the content they taught or helped to teach in their partner classrooms.

Theme 3: FOCUS students were concerned about content accuracy and appropriateness

When undergraduates mentioned their experiences with specific content or pedagogy in their school classroom, they often questioned the accuracy and appropriateness of the content, regardless of whether it was science related. Many of the FOCUS students questioned the nature of the science content or how it was taught, as evidenced in both during their group discussions and journal entries. However, some FOCUS students, like Aaron and Wade, never questioned content accuracy or appropriateness. They were both placed in classrooms in which they had very few opportunities to teach science lessons. Aaron often graded papers for his teacher, who was focused on preparing her students for standardized testing, while Wade only taught one lesson. Other FOCUS students, however, like Parker, Tyler, Kelsey, and Tamika, spent a considerable amount of time in their journals discussing the accuracy and appropriateness of the scientific content in lessons. For example, Tyler discussed, on several occasions, an experience he encountered with the periodic table:

"The teacher showed a Bill Nye the Science Guy episode during class to introduce the elements to the fifth graders. During the video, Bill Nye said that there were 92 elements. And it bothered me because I know that scientists have discovered and created more elements than that, but I didn't know how to approach my teacher. I didn't want to offend her or act like I knew more than her. She concluded the lesson by reminding the students, "Remember there's 92 elements!" It really bothers me that she is teaching them the incorrect information. That's a huge problem."

Tyler discussed this experience with his group members during the first reflection class discussion and again with the researcher during the first interview. He clearly was very troubled that the students were being presented with incorrect information, but was unsure how to approach the issue with his teacher. He brainstormed several ideas with his peers and the

researcher, but never reported approaching the subject with his teacher again. He did, however, in Journal entry 7 mention correcting his teacher's content knowledge on electricity:

"I felt uncomfortable when the teacher did something wrong during a lesson on electricity. She was trying to connect the circuit with an insulator and I had to correct her. I simply told her that I think the material was an insulator and she had realized what she had done. No one is perfect, but the students need to know the correct answer. If they thought that the insulator she showed them was a conductor it could change their whole concept of what a conductor is."

FOCUS students also questioned the accuracy of the content when they taught their own lessons. They often discussed the importance of being prepared with the correct information and being able to relay it to students without revealing any misconceptions. During a group discussion, Justin discussed his surprise when a student informed him that more than three states of matter existed: *"I can never remember Bose-Einstein condensates—I always have to look it up."* Like Justin, Kelsey was concerned about not only the accuracy of the content she taught but also with the way in which she taught it in her lessons. In her fourth journal entry, she described the lesson she planned on the underground railroad:

"Assigned to teach a lesson on Harriet Tubman and the Underground Railroad, I found a cute activity on the internet about making a quilt. The site explained that many slaves couldn't read as they escaped the safe houses, so quilts with certain designs to portray messages such as "continue to water", "continue on," or "it is time to pack up" were used. The students could create their own quilt design and color. I was so excited to have the students do this activity. But, when I got online to create a PowerPoint of the official designs from the Underground Railroad, I found articles explaining how these quilt messages were a myth perpetuated by teachers

attempting to make the Underground Railroad an art activity. I immediately knew I would have to change my lesson. I did not want to misrepresent the Underground Railroad to my students, but I had a limited amount of time to fix my mistake and design an accurate activity."

Scenario discussion five tackled a question of the accuracy of content and students all agreed that communicating accurate science content was more important than simply providing a "fun" experience with science. In fact, of that scenario, Jasmine stated, *"It doesn't effect what I believe about science. I just feel it reinforces that no matter what the age--granted you can't tell them everything--but whatever you do teach them, but you've got to teach them the real deal. Granted they're young but they can understand so much."* When reflecting on a social studies situation that had occurred during a previous semester, Justin emphasized, *"In conclusion, we as FOCUS students should do our best to help clear up any misconceptions that student may have developed, even if they do not pertain to science."*

In addition to being committed to insuring that the content was accurate in their classrooms, FOCUS students questioned the appropriateness of the content taught. Questions of appropriateness typically came about after teaching a difficult lesson, where students were struggling to learn the material. During a group discussion, Todd said flippantly, *"What do you teach a first grader about astrophysics?"* This statement seemed to echo his beliefs touted in journal entries and group discussions that complicated concepts could not be taught to young children. Other FOCUS students echoed similar beliefs and expressed frustration when students did not immediately develop an understanding of the scientific concepts they were being taught. In the following impressionistic tale, Tamika described an experience during which she struggled to teach animal classification to her kindergarteners:

"For this week, I taught a lesson about the basic needs of animals and then another lesson about animal classification. Tuesday's lesson went well; however, Thursday's lesson about animal classification brought up some confusion amongst the students. I started off the lesson with a video about animal classification and then lead an activity where students had to guess an animal's identity based on clues they were given. Even though we went over the five different animal classifications as a class several times, the students didn't seem to remember the category names. For example, some of the students continually named animals within each classification. If I were looking for the word "amphibian," instead, the students would say "frog" or "salamander." This became frustrating because it seemed as if a lot of the students didn't remember the material we just discussed. Honestly, I was very surprised by this occurrence. Before teaching the lesson, I didn't believe this lesson would be very difficult for the children. So, I felt discouraged because some of the students were having a hard time."

Similarly, Sarah was frustrated by the experiment she had been teaching on gravity. When she was helping a student, she knew that the answer he had written down was scientifically incorrect, but thought that due to the way that the experiment had been carried out that it was probably the phenomenon he had experienced. She explained in her fifth journal, *"This week, my class learned about gravity. Each group was given several objects. The students were supposed to drop two the objects at the same time and figure out which one dropped first or if they hit the floor at the same time. As I walked around, I noticed that the objects were hitting the ground at different times even though they were supposed to hit the ground at the same time. I was displeased with the results because I saw many students dropping one slightly before the other, or holding the two objects at different heights. Even though I tried to correct them, they were still getting the wrong results. When I asked a student which one hit the ground first, he*

responded with "the marble." My response at the time was "okay, go ahead and write that down," because I knew the marble probably did hit the ground first.

Thinking back, I probably would have asked the student to repeat the experiment again, ensuring that his hands were level and that both objects were dropped at the exact same time. Then, after he agreed that they hit the group at the same time, I would ask him why he thought the previous result was different. This way, he would be able to understand and articulate any factors that could have affected the results of the experiment, and he would learn that even small errors could dramatically affect the results of an experiment. This experiment challenged me to rethink the scientific process. I knew what was supposed to be happening, but more than half of the students did several tests and all results pointed to one object dropping faster than the other. It was frustrating to observe that even with multiple trials, not even the majority of the results were correct. I know that this was largely due to human error, but it made me reconsider whether this experiment was suitable for students this age."

Other than the accuracy and appropriateness of science content, FOCUS students expressed very few disequilibria specifically related to science in the classroom. However, some FOCUS students did reflect on their struggle to engage their students with scientific content. Parker, in particular, used many of his journal entries to reflect on his first-grade pedagogy:

"From the hands-on volcano lesson to the dolphins & whales lesson I taught, a lot about my teaching style changed. Much of this had to do with my early presentation of the material but also teaching the students in the small group, conversational style was not an appropriate method for such a young age. I think I tried it because that is what an ideal college classroom would be like but obviously, these students are not ready to learn at a style suited for a college classroom. Teaching them in this way caused me to lose control of my small groups and not

much learning happened. Understanding this was important in the development of my teaching style so I didn't keep trying to teach them in a way that didn't work. This was a great example on how you must present in a way that is appropriate for your audience. In my case, I had to teach them with materials presented in a way that would help instead of hinder their ability to learn the material."

Parker discussed in his journal often trying out new techniques to engage his students in his lessons. In one lesson, he chose to teach about dolphins and whales, even though the topic was not explicitly in the first-grade curriculum, because he had noticed that many of the students in his class had expressed interest in the creatures. While the conversational style that he chose to use during his lesson on dolphins and whales did not work the way he planned, as the semester progressed, he got better at structuring his lessons. Similarly, other FOCUS students reflected on the challenges of effectively engaging their students in science. However, during most group discussions and journal writings, the majority of FOCUS students chose to reflect on other topics, seemingly not explicitly related to science. For the most part, the ongoing struggle to understand their role within the classroom milieu seemed to overshadow FOCUS students' consideration of explicit aspects of science teaching and learning except for the pedagogical challenges described by some and the focus on accuracy and appropriateness of science content, emphasized by nearly all the FOCUS students. While an examination of FOCUS students' understanding of the nature of science and their epistemological beliefs with respect to teaching and learning was beyond the scope of this study, further research could shed light on the epistemological and pedagogical stances of FOCUS students. FOCUS students described and discussed the mentorship role they had in the classroom- one they felt was very important. In this

sense, FOCUS students at times saw their role in the classroom as being that of a mentor and conveyor of life skills.

Theme 4: FOCUS students believed they took on mentorship roles in their partner classrooms

FOCUS students believed they took on mentorship roles in their classrooms and described it as their most important contribution to the classroom and their students' lives. They shared many reflections on the unanticipated moments in which they took advantage of a situation to emphasize life skills they believed were critical to student growth. Parker summarized his developing role as a mentor for students in his eleventh journal entry, *"I hope I have given more than I have taken by really connecting to my students and passing on to them the inspiration for them to know they can do whatever interests them and that they are all capable to far exceed their realized capability. For that is the most important lesson that can be taught, it is not photosynthesis nor electric currents, but the inspiration that every one of them has the power to control their own futures, but it is up to them to rise up and use their potential to its fullest."* Like Parker, other FOCUS students attempted to take advantage of the opportunities they observed in their classrooms to convey life skills and beliefs to their students. In this first impressionistic tale, Keisha described discussing cultural norms with her kindergartners:

"As far back as my memory goes, I remember my mother being very open with me about what social norms were and telling me that I never needed to feel like I fit perfectly into those boxes. This is seemingly not the case for several of my students. Several of my FOCUS students are also my students at work and therefore have known me for years. Over the past year, I

decided to refrain from putting heat on my hair to foster its health. Tuesday was my students' first day seeing my hair straight since 2014. Not surprisingly, they noticed! All their comments centered on the idea they were glad that I ditched the curly hair that "was poufy" or they "didn't like". I know better than to get offended by the comments of 5-year-olds. Instead, I was offended by their lack of knowledge about the differences between different people and the strong presence of social norms in our society. I've found that the best way to handle these types of issues with children is to turn it into a teachable moment and that's exactly what I did. I responded to each individual comment and question by talking the students through some of the differences that different demographics have, from gender and race to socioeconomic status, and showing them that differences between us are what strengthens us. On a level that 5-year-olds could understand easily, I explained that saying that you dislike something about someone is not okay, even if it's not what you and your peers perceive as "normal". This experience strengthened my belief that kids should not be hidden from tough topics. The conversations surrounding those tough topics should just be adapted to be more appropriate for their age group. That is one thing that my mother always stuck to in every aspect, and I truly appreciate it. Although it may not seem like children should be concerned with issues as heavy as social norms, it can come into a larger effect than expected. Just imagine the reaction that a 5-year-old black student with naturally curly hair would have had if those comments been directed to her rather than adult. Such situations of exclusion can stick with a young girl for a long time. I know this from personal experience."

In the above impressionistic tale, Keisha emphasized the importance of sharing her belief that diversity strengthens a community with her students. While the beliefs that she discussed with students were not explicitly related to the scientific content she was supposed to teach,

Keisha felt that the opportunity to discuss acceptance and tolerance of all should not be missed. Keisha dubbed this experience a "teachable moment" and emphasized her mother's influence on her thinking. Another of the "teachable moments" mentioned by a FOCUS student in his reflections illustrated parental influence. In an excerpt from his fourth journal entry, Todd discussed his parents' influence on his ability to think critically and how he tried to pass that lesson along to a student in his partner classroom:

"I was helping my teacher with her math review for an upcoming test. Upon reaching the math portion of the practice test one of the students called me to his desk and asked for clarification with one of the geometry questions. Almost immediately I tripped over myself as I realized I couldn't be sure of the answer, a fact that was picked up shockingly quickly by the student. Rather than allowing the moment to linger I quickly had the student open a search tab on his laptop and determine the correct answer for himself.

I also firmly believe that the avenue I took to rectify the situation was satisfactory in that it inadvertently conveyed one of my favorite philosophies of education: the idea that no one individual can ever really have all the answers. Similarly, I am proud that the student could see how quickly most problems can be solved with even a minimal amount of effort. When I was growing up the answer I inevitably received after a good round of questioning my parents involved me spending time with a dictionary or encyclopedia set to obtain the answers for myself, a process that has taught me to look for answers rather than simply pose question after question. I believe that the way that I addressed the student's problem was both satisfactory and educational in nature."

In addition to the teachable moments FOCUS students did take advantage of, many similar moments were reflected on as missed opportunities. Both Sarah and Kelsey mentioned

experiences where they believed that they should have taken advantage of a teachable moment, but were unable to reflect in the moment to capitalize on the event. Sarah was helping with a social studies unit on the Presidents of the United States when she missed the opportunity to delve deeper into societal issues with a student. This experience was recounted several times in journals, classroom conversations, and interviews. In Journal 5, she wrote:

"On Tuesday, they learned about Jimmy Carter, the former president from Georgia. After the lesson, the students were given a worksheet to complete as a class to solidify what they had just learned. One of the activities on the worksheet was to write a sentence about how you were similar to Jimmy Carter and how you were different. I went around the room to help students think of ideas. One student said that they both were boys, and when I asked how he thought they were different, he responded with "I'm brown." I was shocked at his reply and simply responded by telling him to go ahead and write that down.

Thinking back to the event, I think I should have responded differently. His answer was entirely correct, and it was clear he understood the question. However, I could have prompted him more by asking him to think about what we had just learned rather than focusing on what Jimmy Carter looked like. One of the reasons I was so shocked at the student's answer was because of the stigma associated with racial discrimination that discourages people from distinguishing others based on race. The student's full acknowledgement of this difference made me question whether he was just making a surface-level observation or whether he thought more deeply into that difference. Does he associate a certain race with success, such as the ability to become president? This may be unlikely since the only president he knows well is Barack Obama, but one exception doesn't discount an entire ideology. While kids are young, race is

equivalent to hair or eye color, but as they get older, race becomes an identity. By not taking advantage of that opportunity to talk to the student about his beliefs, I missed the opportunity to reinforce the idea that students can be anything—even Presidents."

Like Sarah, Kelsey also missed an opportunity that she felt would have been a valuable teachable moment for a student during a social studies unit. In her eighth journal entry, Kelsey reflected on a situation in which she allowed a student to purchase something that he did not have the currency for because she was overcome with compassion for him. However, in reflecting on her behavior during this event, she decided she should not have given him the toy because it would have been more beneficial for the student to learn a life lesson:

"This week, the students finished their social studies unit on historical figures and basic economic principles. They learned about goods, services, consumers, and producers. To celebrate the end of the unit and practice consumers and producers, the students had a program called FirstOpoly. Each of the first-grade teachers divided their rooms into a dance party room, a movie room, and an iPad room. The reading teacher and I set up a store in the hallway. The students had been earning and saving tickets all week in preparation for the FirstOpoly. It cost a different amount of tickets to enter each room or buy a toy from the market in the hallway. V, a special needs student, approached me at the market and told me how he wanted to "buy" a toy because it was his little sister's birthday. I thought he was being sweet, thoughtful, and compassionate, four very important traits for first graders to develop. As he reached for his toy and handed me his tickets, I realized he was three tickets short from actually being able to purchase the yo-yo he had picked out. I felt that I was stuck in the situation because he was being so genuinely thoughtful but was unaware that he didn't have enough tickets. Instead of telling

him he couldn't have the yo-yo, I simply told him that after buying the toy, he was officially done and could not buy anything else.

When I got home, I kept thinking about the situation with V and wondering if I had done the right thing by letting him buy the toy. On one hand, the excitement and smile V had after getting his yo-yo were priceless especially because he bought it for his little sister. On the other hand, I knew that if it had been any other student I would have told them that they, unfortunately, did not have enough tickets and would not be able to buy the toy. I thought about how most other students would not have been terribly distraught by being unable to buy a toy, but that with V, I was unsure of how he would have handled the news given to him. If I could go back in the situation, I think that I would change my action. Instead of letting him have the toy, I would have taken the opportunity to explain the value of money and that although the money may not be there, his sister would have been delighted he thought of her on her birthday, and ultimately, I would not give him the toy. I think this is a better decision because the students in special needs included classrooms are meant to be "included" with as little extra help as necessary. By quietly turning my head the other way when I realized he didn't have enough money, I wronged both V and myself. I wronged myself because as a teacher, it is my responsibility to be fair and balanced. I wronged V more so because I missed out on a great opportunity to teach him an important life skill: you can't always get exactly what you want."

FOCUS students took their perceived mentorship roles in the classroom very seriously. In their final journal entries, students emphasized that of all their roles in the classroom, this one was the most important, and perhaps the one they had learned the most from. Kelsey summed up the importance of mentorship by both FOCUS students and classroom teachers, *"It did not take me long to realize how important teachers are in the lives of their students, especially elementary*

school teachers. It is in the classroom that many young students will experience many real-world issues like death or divorce for the first time. Students look to their teachers for understanding and explanation." Caleb described his mentor role in this way, *"When I began this class, I wanted to be able to inspire at least one student to understand that education does not have to be a chore. I want to help these children see that furthering your education does not make you a nerd or uncool. Rather, furthering your education can open many doors for a more rewarding future."* Keisha discussed recruiting students to take Project FOCUS by using the mentorship role as a selling point, *"The aspect of this class that seems to sell undergraduates more than anything on the course is the relationships that you can form with the students. A close second to that is the personal growth obtained throughout the course."*

Reflective Disequilibria Summary

Project FOCUS students reported experiencing many different reflective disequilibria over the course of the semester. They discussed struggling to find their place in the classroom, observed students missing out on valuable learning experiences due to situations and structural barriers beyond their control, were concerned about the accuracy, appropriateness, and methods of how content was delivered in the classroom, and agonized over whether they were making appropriate decisions in mentoring students. One of the topics that the researcher expected to find, but did not, was more reflection on issues surrounding science teaching and learning. FOCUS students were asked to discuss issues of science teaching and learning during class and it was the focus of many different class periods. However, journals and classroom discussions often circled back to individual students, issues of classroom management, or other topics such as those discussed above. In the previous section, the specific disequilibria experienced by

FOCUS students were discussed. In the next section, the reflective actions students considered during the class discussions and in the writing of the journal entries are examined.

FOCUS Students' Reflective Responses to Experienced Disequilibria

In this section, the reflective responses that FOCUS students generated in relation to the disequilibria they described are examined. Students' words are represented by italicized font, with researcher explanation and interpretation following. The discussion of FOCUS student reflection is discussed with respect to four main themes, generated from the data:

1. FOCUS students offered suggestions and solutions of varying degrees of practicality.
2. FOCUS students were unable to identify with disequilibria scenarios unless they had experienced a similar situation.
3. FOCUS students' classroom experiences often necessitated that they confront their privilege.
4. FOCUS students believed that structured reflection was useful in aiding their learning.

Theme 1: FOCUS students offered suggestions and solutions of varying degrees of practicality.

During their group discussions and in their journals, FOCUS students were asked to respond to their disequilibria by suggesting solutions to the issues raised. In both the group discussions and the journal entries, the solutions posed seemed to fall into two different categories, either they were practical and could be implemented by FOCUS students themselves

or the solutions they suggested argued for a larger scale structural change, beyond the scope of what a single FOCUS student could enact in the classroom.

Within the practical category, students often made suggestions about new experiments or lessons to use in the classroom, ways to improve their classroom management or teaching, or solutions that eased some of the tensions felt in a disequilibrium scenario. In the discussion of scenario #5, Kelsey mentioned to her group that because she is not a confrontational person, she would not want to be put in the position of explaining to her partner teacher that some of the content had been taught inaccurately. Kelsey and Sarah came up with a plan that they could use to reinforce the correct content without confronting the teacher:

SARAH: *What would you do in this situation?*

KELSEY: *I don't know, I'm not a very confrontational person, so I'm not sure.*

SARAH: *Me neither!*

KELSEY: *I think what I would do is that if I had another plan that week, I would go back and try to highlight what the teacher didn't. But I don't think I would talk to the teacher about how I think that they were wrong.*

SARAH: *Yeah.*

KELSEY: *I think I would just try to incorporate into my own lesson.*

SARAH: *I think maybe in another lesson I'd say something like 'So you remember how we drew stars like this, well actually they look like this, they are balls of fire, you know, balls of gas.' Whatever. Whatever stars are.*

KELSEY: *They look like that from far away, but up close...*

TAMIKA: *It's how they really look.*

SARAH: *Yeah. How does this scenario influence your experience in the classroom?*

KELSEY: *That your teacher isn't always right, you know what I'm saying? That's important to know because they don't know everything, they are human too. Students are pretty much dependent on the teacher, you know that's their only source of information so that's a pretty important thing to be reminded of.*

SARAH: *And also, I guess, be skeptical of where you get your lessons from. Did it say he got it from someone else?*

KELSEY: *Yeah, another teacher gave it to him. So when you're looking online make sure it aligns with what you're actually trying to teach.*

Other practical solutions involved giving each other suggestions for lesson ideas when they were struggling. For example, during the first group discussion of the semester, Tyler told his group that he needed to find a chemical change experiment to show his class. Justin suggested that he make elephant toothpaste.

TYLER: *That's what we're doing this week, physical and chemical changes. I have to have something for tomorrow, so I don't really know. I went in yesterday and it was just my observation day, and I was just observing and then she asked, "So you'll have something for me on Thursday?" I said, "Okay, sure." But I don't really know what I'm going to do.*

CALEB: *My class is working on magnets right now.*

JUSTIN: *A good chemical change would be elephant toothpaste.*

TYLER: *What is that?*

JUSTIN: *It's peroxide, soap, and food coloring and dry yeast. You can get all the supplies at the grocery store. You mix it all together and it gets big and foamy and comes out of the container and looks like you are squeezing a giant tube of toothpaste.*

Students offered practical solutions to classroom issues in their journals, too. In response to an impromptu lesson his teacher asked him to give, Tyler reflected on the situation by writing in his sixth journal entry, *"Upon reflection of this afternoon I still find myself substantially frustrated by the outcome of the lesson but with the emphasis on myself more than the behavior of the kids. As I reflect I recognize that the disorder that developed in the classroom was largely of my own creation and due entirely to what was an overall lack of direction from me. I believe that if I had approached the activity with more of a 'game plan' and had hard copy directions to hand to the students then the majority would have been able to complete the exercise rather than lose focus, allowing for actual learning to take place."* Sarah devised a similar solution when the groups of students that she had divided up evenly became uneven because her students wanted to work with their friends, *"If I were to repeat this, I would hand out numbers or different colored squares of paper rather than having them count out loud. This would prevent students from switching their number after discovering who is in their group or seeing another group that they would rather be in. I considered putting them into groups ahead of time, but I felt that I did not know enough about the students to pair them with people they would work best with. Additionally, I feel that the students need to learn how to get along with others because you won't always get to choose who you work with, and sometimes it's better to not work with your friends."* When reflecting on struggles related to their lessons, FOCUS students came up with practical solutions that they could implement the next time they taught. They offered reasonable solutions to their classmates and to the scenarios they were presented with as well.

However, FOCUS students struggled to formulate reasonable solutions when they reflected on issues of socio-economic discrepancies or administrative decisions. For Jewel, this

kind of solution meant taking on more responsibility than was required of her when her teacher was feeling distressed:

"Today was the day that I was supposed to be doing an experiment but I could tell by the looks of things that wouldn't be happening. During writer's workshop, Ms. B and I discussed the challenges she was having. On Monday, her paraprofessional, whom she had worked with for 5 years, quit out of nowhere. Then last night, the school board met and decided to switch up many things within the classroom. And finally, today, her student teacher who had been helping out since August, found out she had been reassigned to another classroom. Within the span of a week, Ms. B had lost all her classroom help. Now it would only be her in the classroom with her kindergartners. I told her I would try to help out a little more and come in as often as possible."

In the moment, Jewel was trying to help her teacher out in the best way she knew how—by volunteering her time and filling the void left by several other people. However, this solution, appreciated by the teacher, was neither a long-term nor sustainable solution. The situation of Ms. B losing all her help was not within the scope of what a FOCUS student could handle. However, Jewel attempted to help. Caleb also offered a solution to a situation beyond his control, by suggesting that the teaching schedule be changed to have science earlier in the day. In the current climate, teachers typically do not have control of their day to day schedule—the school or county administration controls scheduling. Instead, he could have suggested that the method of teaching be changed to accommodate for students who are less engaged because of the time of the day that science is taught. Another example of this was when Todd discovered that one of the students in his classroom was having trouble seeing the paper:

"Perhaps the biggest challenge that I faced this week while working with students involved one of our newer students, Y, and a small health problem that seemed to develop throughout the week. On the Monday, I was walking around the classroom as the students worked and noticed that he was having to lean substantially closer to the paper than the other students. Upon further questioning he revealed to me that "some of the numbers were just a little fuzzy" when he sat up straight in his desk. I did not want to him to feel embarrassed about his eyesight so I told him to keep up the good work, all the answers were on track, but I advised him to mention his trouble seeing to his parents. However, having previously learned about Y's home situation I am unsure what resources are at his family's disposal, leaving me with an empty feeling because of my helplessness within the situation.

When returning to the experience for further reflection I can only reach one conclusion: I really shouldn't have said anything at all, because I knew there was very little I could do to help. After some research on my own I have discovered several excellent services that provide vision care to underserved communities and I intend to pass this information on to the teacher, with the intention of that knowledge eventually reaching the student's parents. While not a significant interaction at the surface the implications of our conversation really shook me. It is extremely frustrating for me to see firsthand what I believe to be a basic lack of health-related services as the product of what is purely socio-economic status. Similarly, it is frustrating to know that these already disadvantaged students can be further hampered by problems that are so simply fixed. Yet again I am struck with the feeling that with the right funding and resources these seemingly struggling kids could perform just as well as any others."

Todd approached this situation from a perspective of helplessness. He could have found ways to help the student see his paper better or read some of the questions to him and address the issue

with his teacher quickly. However, often the big problems the FOCUS students encountered seemed insurmountable and they forgot that they could address the problems in smaller, more manageable ways. Similarly, FOCUS students also had trouble suggesting practical solutions to situations that they did not feel were plausible. In the next section, the behavior of FOCUS students when they were presented with what they believed to be implausible situations is discussed.

Theme 2: FOCUS students were unable to identify with disequilibria scenarios unless they had experienced a similar situation.

Group discussion scenarios were designed as plausible situations that FOCUS students might encounter in their classrooms. The impressionistic tales that the participants in this study discussed were derived from journal entries of FOCUS students. However, FOCUS students seemed to have trouble relating to the scenarios, particularly in the beginning of the semester. FOCUS students often were very critical of the hypothetical FOCUS student in the scenario or dismissed the situation as implausible. For example, when discussing the first scenario, in which a FOCUS student developed a lesson they had not fully thought out, Caroline, Parker, and Travis engaged in the following discussion:

> CAROLINE: *How would the teacher feel if the FOCUS student interrupted her to ask what the answer was?*
>
> PARKER: *Or, how would she feel if you can't answer the question? You know, you brought this lesson plan and then you can't handle it, I guess?*
>
> TRAVIS: *I feel like she'll think you'll useless because you are in there teaching some twelve-year-olds and you can't handle it.*
>
> PARKER: *What's the point of having you if the kid has a question and then you're just*

going to ask me the same question?

TRAVIS: *It still boils down to preparation.*

PARKER: *And Erin probably feels terrible, inadequate.*

CAROLINE: *Useless.*

Caroline, Travis, and Parker were all first-time participants in Project FOCUS. In this first scenario discussion, they concluded that they would each be more prepared than the hypothetical FOCUS student the next time they entered the classroom. Their discussion suggests that they had not yet developed an appreciation of the "messiness" and unpredictability of teaching and learning. By contrast, the group discussion containing two Project FOCUS repeaters, Justin and Aaron, as well as two first-time FOCUS students, Caleb and Tyler, was much less critical of the hypothetical student. Instead, Justin and Aaron shared their experiences with Caleb and Tyler:

CALEB: *Well the teacher doesn't know, or the student doesn't know...*

AARON: *The student didn't review ahead of time and doesn't have the teacher to be like a safety net.*

TYLER: *Yeah.*

AARON: *Last Friday, I did an experiment with my class where they're learning about physical and chemical changes. I gave them all a penny and I gave them a cup of vinegar and salt in it to take the oxidation off the penny. After that, they were supposed to take the penny out and put a paperclip in after that. The paperclip was supposed to attract all the copper that had come off, so the paperclip was supposed to turn brown. Well the other class left their pennies in the cup and the vinegar solution like turned blue/green, which I read it was supposed to happen, but I didn't anticipate the second class to do that. I thought that they would take the penny out so that didn't happen. When I came in*

on Monday, my teacher asked," Well, what happened here? What is that?" And I had to basically tell her that I didn't know, but I would look it up. She was mainly concerned because she didn't know if it was part of the experiment or not. So I looked it up, and thankfully, on the same thing where I found the lesson online it had said if you leave the penny in solution, it's going to create malachite, which is what the blue/green stuff was. Then we taught them about another chemical change that happened during the experiment.

JUSTIN: *I've had that happen before, too, a student asked me a question I didn't know the answer to and my teacher just looked up when she heard me say, "I don't know let me ask Mrs. P." so she looked up the answer for me.*

The two discussions presented above are very different. Caroline, Parker, and Travis were very critical of the hypothetical student, stating that the teacher might feel that there is no point to having the FOCUS student in the classroom. Aaron, Caleb, Justin, and Tyler had a much different conversation, especially when Aaron and Justin told stories of experiences they had in their classrooms where they were not prepared to answer a student or a teacher's question. Another example of a discussion in which FOCUS students were critical of the scenario and dismissed it as implausible was during the second group discussion. Students were discussing a scenario in which there was a new kindergartner in a classroom who did not speak English, but the FOCUS student was unaware of that issue and became frustrated during the lesson. Todd, Travis, Tyler, and Wade began their discussion of the scenario in this way:

TRAVIS: *First off, I think this guy is dumb.*

TYLER: *Probably would have caught on a little bit quicker than an entire activity.*

TRAVIS: *But, why not just ask her? Ask her why are you not doing this?*

TYLER: *Or say Habla espanol?*

TODD: *I had a kid in my class I had this happen with. I asked the kid how old his siblings were and he just looked at me like I was nuts. I repeated the question in Spanish and he told me.*

The dismissiveness with which Todd, Travis, Tyler, and Wade approached this scenario permeated their discussion. Despite Todd claiming that he had a similar experience, the students in this group did not seem to think that an event like this could happen in their classroom. In the beginning of their group discussion, Jasmine, Jewel, Keisha, and Tamika also seemed a little dismissive of the situation. However, Keisha shared an experience she had in a previous semester of Project FOCUS, which helped Jasmine compare the situation to experiences she was having in her placement classroom:

JASMINE: *Discuss similar experiences. I've never dealt with that.*

JEWEL: *All the students in my class are pretty proficient in English.*

KEISHA: *Last time I did FOCUS, there was a student who he could kind of speak English but you could tell sometimes if somebody said some big words or was talking fast that he would get confused. He would act like he knew what was going on but I could tell that he didn't. It wasn't like he couldn't understand at all, but he would just like pretend that he knew what was going on in some circumstance when he didn't.*

JASMINE: *Do Ebonics count? A lot of my sixth graders speak Ebonics. It's so funny.*

KEISHA: *Is it ever a situation where someone can't understand them?*

JASMINE: *I mean, they're pretty loud with it. I feel like the teacher can understand it because she used to it, and I'm used to it, so I can understand it. But I just noticed they speak a lot of Ebonics. Like it's so funny, whenever one kid, whenever he gets a question*

right, he'll dab or he'll do other gestures...he'll stand up and do it and she'll get so angry, but it's funny. It's hilarious.

Similarly, in the group of Aaron, Caleb, Kelsey, and Sarah, both Aaron and Kelsey discussed having an experience they could relate to the scenario. This really seemed to help their group focus on the communication difficulties a student might face in the classroom:

CALEB: *I'm not sure why she wouldn't consider that to be a, like, I feel like if I was in that situation, I would be like, oh she doesn't speak English.*

SARAH: *Yeah, I don't know what took so long.*

KELSEY: *I mean it's good that Lorenzo's translating, but it might be also good to like make her immersed.*

SARAH: *Not like take him away completely but like she's not going to bother learning if he keeps just telling her.*

CALEB: *It's a bigger problem than like your science classroom. She needs to learn English. That's a completely different thing.*

KELSEY: *It's bigger than what the FOCUS student can take on by themselves.*

AARON*: I had a student that could not speak any English in my first Project FOCUS class. And she was exactly like that, where basically if we did something, the teacher had to get it translated for her on a piece of paper for her to be able to do...she took her tests in Spanish and everything and she had like a second language teacher come in the class every day, that specifically worked with her doing her assignments. My situation is similar though because the kids in the class a lot of them were English as a Second Language, so they translated for her too, just like Lorenzo did in that.*

CALEB: *But I'm sure you didn't yell at them for doing it.*

SARAH: *But then the student in this scenario didn't know also.*

AARON: *Well, my teacher told me before we started. Yeah, I knew when we started and the kids let me know too. They were like, she doesn't speak English.*

KELSEY: *Did she learn it really fast?*

AARON: *No.*

KELSEY: *Really?*

AARON: *The whole semester I was in there, she was still learning.*

KELSEY: *That's unusual. They usually pick it up so fast.*

AARON: *She could sort of understand what I was saying, but she couldn't speak back to me in English.*

KELSEY: *When I was walking in today, there was a dad in the main office, picking up two kids and they had to get a special woman to come speak to him because he didn't speak any English. I bet it's hard too, because they don't have any practice at home.*

Other scenario discussions were not as divisive as Scenario Discussion #1 and Scenario Discussion #2, possibly because every student had had more experience in the classroom and could relate to the situations presented by that time. For example, in response to the reading of scenario five, Todd said, "*That's pretty realistic."* This statement, along with the other immediate reactions of the students to the various scenarios emphasized the idea that FOCUS students needed to be able to relate to the scenario presented to them, either themselves or through another group member. If no one in the group could relate to the situation in a meaningful way, the conversation was brief and students would begin discussing other issues. Often, one of the issues that students confronted in their journals, but not in group discussions, was the idea of their own personal privilege.

Theme 3: FOCUS students' classroom experiences often necessitated that they confront their privilege.

When FOCUS students were confronted with situations that were different from their own, they were often forced to acknowledge their privilege in their journal entries. The FOCUS students often discussed how helpless they felt when encountering a student whose life experience had been less-privileged than theirs. For example, when Tamika realized one of her students did not have an internet connection at home to do his homework, she scolded herself for never even considering that was a possibility and making assumptions about students. Sarah also confronted her privilege several times throughout her journals. In one memorable example, she wrote:

"Before teaching my lesson this week, I had each of the students tell me about what they did for spring break, thinking that some students probably spent some time at the beach or in the mountains. However, none of the students who answered had gone anywhere. In fact, every single student who answered just stayed at home playing with video games or playing with the kids next door. It was somewhat surprising to me yet also not all that surprising at all. When the students first began answering, I was happy that they seemed to have a restful and fun break; however, as I noticed the trend of students who stayed at home, I felt a little sad for them and feigned excitement for their spring break because I didn't want them to feel bad that they didn't get to go anywhere exciting.

I don't think I would have reacted differently because I don't think that my students had any inclination that I was surprised or upset about their answers. However, I probably would not have shared what I did over spring break (a trip to Florida) so that they wouldn't feel like their

spring break was not as enjoyable. This experience made me realize how privileged I was to grow up with a family who could afford weeklong vacations at the beach and to live in a community where almost everyone travelled somewhere for spring break. This experience has taught me to continue to be mindful of the economic level of the students I teach and to not make assumptions about others based on my own experiences. One of the rewards of teaching in a school system very different than my own is that it helps me to constantly remember that no two people are the same; no two people share the same experience."

In another example, Sarah mentioned that the challenging behaviors she witnessed in her classroom were due to differences between her upbringing and that of her students'. During his final interview, Justin was asked to discuss what prompted him to write about a fight he witnessed between a male and female student. He responded, *"It was way against the way that I was raised. A boy striking a girl would have never happened where I was raised. But, at the same time, I know I need to be aware that this isn't the same type of school that I grew up in. These kids come from different backgrounds. I don't know how their parents raised them. They might have told them that if someone strikes you, you can strike them back, no matter who it is. But that's not how I was raised."* Kelsey also mentioned confronting her differences with students by recounting a conversation she had with one of her students about family names:

"C is an eager, dedicated student in Ms. C's first grade class. She is always raising her hand to answer my questions and is always actively participating in whatever activity I have planned. After our science lesson this week, the students were working on a math worksheet. C asked me to come check her work and sit with her. I walked over, checked her work and helped her with a few problems. She saw my visitor name tag and asked "Miss Kelsey, are you named after your dad?" I thought for a moment, not exactly sure what she meant, and replied "Do you mean my

middle name or my last name?" She instantaneously responded "your last name" and seemed shocked I didn't immediately understand her question. I told her my last name was the same as my dad's and she continued to explain to me how her and her two brothers were named after their dads, but all had different last names. She added that her mother's last name was different from all of her children's. I simply nodded my head and let her finish her explanation. I don't think I let it show, but I was really taken aback by this experience with C. By the end of the conversation, C seemed just as shocked that my sister, father, and mother all had the same last name, as I was that she and her siblings and her mother did not.

This event really sparked my thinking. I was surprised by how different C's and my family experiences were. Not to say that either is better or more wholesome, but it reminded me to be conscious of how different my background and a student's can be. Although this was not directly associated with a classroom activity, I think it was a learning experience for the both of us about knowing people different than ourselves. It is just as important for me to realize that my students are diverse as it is for C to realize that other family structures exist besides her own.

C asked her question very frankly and did not hesitate at all to tell me about her family. She was not making assumptions or insinuations about my family. She did not judge me and I did not judge her. It reminded me that stereotypes are taught rather than ingrained subconsciously. It made me think about how important it was for both C and me to understand where each other came from in a positive manner. If I could have this conversation again, I would approach it less hesitant than the first time because I think that our conversation helped C understand me better and in return, allowed me to understand C better."

These journal entries were typically respectful of students' experiences and differences. Often FOCUS students emphasized how much they had learned from their students, their

personal growth, and how acknowledging different perspectives had made an impact on their lives. Kelsey illustrated this in her final journal, *"When I first began this semester in Project FOCUS, I had not once stepped into a public school; therefore, I had zero expectations. When I went to Argon Elementary every week, I was forced to only focus on my students for an hour and a half. I think the most valuable lesson I learned from them was the perspective I gained from them as I took a step back from whatever was going on in my life and focused on them. It allowed me to realize that a test was just a test whether I failed it or not, but more importantly, it allowed me to realize that I cared way more about spending time with my students than I did about any test grade. They made me feel like I had a purpose."* A tonal difference was apparent when FOCUS students discussed privilege in a group setting compared to writing about it in their journals. Instead of acknowledging privilege, thinking of a student's perspective, or discussing uncomfortable ideas in depth, FOCUS students often attempted quipped remarks in conversations with peers. In the following conversation, Caleb, Todd, Tyler, and Wade were discussing scenario #3:

TODD: *In this scenario, what assumptions are you making about students, teaching and learning?*

TYLER: *That they haven't seen what you're going to do before.*

TODD: *You're also assuming that they want to learn, because some of these kids don't really.*

CALEB: *Like a large percentage don't want to learn.*

TODD: *A striking number of kids.*

CALEB: *Close to a majority.*

TYLER: *A student whined to me the other day, "Oh my god, we have to read these two*

pages, fifth grade is so hard." I was like "Yeah man, it's rough."

TODD: *Fifth grade is a tough one.*

Never in their discussion did these FOCUS students consider other options for making the activity more interesting to students, demonstrating why it was important to learn about the water cycle, or engaging the students who did want to learn. This is contrasted by Caleb's journal entries in which he insisted that he wanted nothing more than to inspire at least one of the students in his class to love learning and view it as a means to success: *"The first week or two I spent trying to get to know the personalities of the children in the classroom. I found out many of them came from broken homes. I remember one specific instance when I found out that one of the students in my classroom was homeless. He had to miss out on an incredibly fun activity because his caretakers had to get him early. Apparently, this happens very often and he was clearly heartbroken. This semester contained many moments like this that made me realize how incredibly lucky I was to have the education and upbringing that I had. These children do not deserve a subpar education, but are not given many choices in terms of their future. I truly hope that there is something that can be done to better the public school system in our state."* Todd also reflected in his final journal with a tone markedly different than the one that he brought to the group discussions, *"My time with the students at Gallium Elementary has impacted me far more than I ever thought possible. As a scientist, I was struck by the sheer mass of variables at play within the classroom while my human side could not ignore the personal realities that each student faced. If I was to start the semester anew, I believe that I would change only the outlook that I first brought to the program. While I had initially hoped to perform crazy experiments that wowed the class, I realize now that helping the students succeed is much more important."*

This difference in tone between the journal entries and group discussions, particularly around discussions of privilege and cultural differences, suggests that students might not be comfortable unpacking their privilege in groups. It also could mean that the prompts included in the group discussion did not help facilitate those discussions, while a more open prompt (as given in the journals) allowed students to examine their privilege to the extent that they were comfortable in sharing their struggles. In the next section, FOCUS students' reactions to their experiences with reflection are discussed.

Theme 4: FOCUS students believed that structured reflection was useful in aiding their learning.

One of the purposes of this study was to examine the process FOCUS students used in reflecting on their service-learning experiences. Using Jay and Johnson's (2002) Typology of Reflection, the researcher explored the FOCUS students' levels of reflection in their written journal entries and through interviews with three primary participants, Justin, Sarah, and Tyler. In this section, FOCUS students' levels of reflection in terms of Jay and Johnson's (2002) Typology of Reflection are explored. In addition, FOCUS students explicitly stated that they preferred structured reflection over the semi-structured format of the journal entries. This idea is also explored within this theme.

The examination of FOCUS students' levels of reflection consisted of an in-depth exploration of each primary participants' journal entries and interviews. First, each FOCUS student is considered individually and then they are considered as a group. All three primary participants, Justin, Sarah, and Tyler, submitted all thirteen written journal entries. For the purposes of an examination of the FOCUS students' reflection in-depth, this study primarily

examined journal entries 4-13, which were the entries written after FOCUS students had begun working in their classrooms.

Justin. For the most part, Justin, enrolled in Project FOCUS for his third semester, achieved only a descriptive level of reflection in his written journal entries. Throughout these entries, Justin settled into a pattern of responding to the journal that felt limiting, as if he were writing the journal not to learn from the experience, but to fulfill a course goal. In each entry, he would describe a situation, then write out the questions of the prompt and respond to them. In four out of the ten journal entries examined, Justin chose to reflect on situations that happened in prior semesters or during his own childhood. Because this study focused on the experiences happening in Spring 2016, this left only five of Justin's journals to examine.

Table 4.1 is a summary of Justin's journal entries and their level of reflection according to Jay and Johnson's (2002) Typology of Reflection. All five of Justin's journal entries followed his established pattern of describing a situation and then answering the questions posed in the prompt. Justin's journal entry 6, in which he described an experiment that did not go as planned due to an error, encompassed many of the same features that were visible in the other five journal entries, but also somewhat demonstrated the beginnings of a comparative level of reflection:

Table 4.1 A visual depiction of Justin's levels of reflection according to Jay and Johnson's (2002) Typology of Reflection by journal number.

	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Descriptive	X		X			X		X	X	X
Comparative			X						X	
Critical										
Reflection on Experience Prior to Spring 2016		X		X	X		X			

"This past week I did an experiment showing how a surfactant can break down water surface tension. During the experiment, I used a foam boat, dish soap and water. The boat is supposed to move when it encounters the water. During the second group, my boat did not move after I told the students it would and this made me uncomfortable. I scrambled to demonstrate it again before the students got upset. When it didn't work again, I felt flustered and annoyed. I quickly explained to the students that the water already had soap in it so I will need fresh water. I explained this to them so they would not get confused on why it did not work. After changing the water, the boat propelled across the water.

Looking back to the event, how would I respond to the event now? First, I should have not assumed that the experiment would work every time. Second, I should have taken more time to prepare between each group. Third, I would not get flustered or annoyed; because I need to remember it is science and nothing in science works perfectly all the time. Fourth, I would have a backup plan for just in case the experiment messed up. For example, act like it happened on purpose and have the students explain to me why it did not work. Lastly, I could replace the water before the experiment that way I could avoid a failed attempt. How did this event challenge my beliefs or values? It showed that just because you have done an experiment before doesn't mean it will always go as planned. It also showed me that I should be more prepared for times that the experiment does not go according to plan and have an answer prepared for why it did not work. This event just showed me that just because I have done something before does not mean that I should assume that it will work for me every time."

This journal entry was primarily descriptive because Justin spent most of his time discussing what happened and how he felt about the event that occurred. However, this journal entry also encompassed the beginnings of comparative reflection because Justin discussed how the students

might be feeling - he anticipated that the students might become upset by the failed experiment and that they may be confused as to why the experiment did not work – and also that he focused heavily on how he could improve his lessons in the future, going as far as to list four potential reactions or solutions to the disequilibria that he experienced. Justin never reached a level of critical reflection in his journal entries. While he discussed how his beliefs were challenged in each journal entry, for the most part, he simply reiterated a point he had made earlier in the journal, as he did in journal entry 6. Justin seemed to enter the comparative reflection level again in his twelfth journal entry.

The final interview with Justin revealed insights that could have contributed to his low levels of reflection, as well as the four journal entries in which he reflected on experiences from prior semesters. In that interview, Justin revealed that the student teacher had performed four of the experiments he had planned to do with his students throughout the semester. This could explain why Justin did not feel that he had new experiences to examine each week, because he was not teaching as regularly as he had in prior semesters. In fact, when asked if he felt there were other experiences he could have journaled about during week four, when he wrote about a student getting in a fight, Justin said, *"No, that week was pretty normal. The student teacher hadn't arrived yet, and we weren't teaching science that week. There was nothing else to reflect on."* In addition, when asked what he remembered reflecting on in his journals over the semester, Justin recalled several topics, including a magnet lesson and a social studies lesson about cotton, both of which he had experienced and journaled about in the semester prior to Spring 2016.

Additionally, Justin was asked during the final interview to review the dimensions of Jay and Johnson's (2002) Typology of Reflection for journal entries 4, 7, and 12. Justin's fourth journal entry retold an experience in which he had witnessed a scuffle between a male and

female student while the classroom teacher was out of the room. Justin's fourth journal entry is included below:

"This past week a male and female student got into a fight. The male student did not like the female student playing the same game as him so he decided to get out of his seat and try to slam her computer shut. The female student reacted by scratching the male student's hand. Once in the lunch line the male student decided to push the female student into the wall causing her head to hit the coat rack. During the event, I was filled with mixed emotions. The man in me was angry at the boy for striking the girl, but the teacher in me was mad that the girl decided to take matters in her own hands and scratch the boy's hand. I went to the female student to ask if she was ok as the student teacher dealt with the male student.

Looking back on the fight that took place between the two students, I would change how I reacted by being more prepared and observant. Dealing with the male student can be difficult because he seems to always be in a foul mood. However, there are ways to prevent the student from having meltdowns. The other students have been told not retaliate or encourage his behavior, but to stay neutral when he has episodes. There are ways to tell when the male student is getting angry, but since I was busy with my lesson I did not notice his behavior. This is something I need to change. I need to become more aware of the class around me when teaching in small groups. This event challenged the lessons my grandfather taught me when I was young. He always said never to hit a girl no matter how mad she makes me. After seeing this male student for the second time hit a girl, I felt my blood boil. I was raised in a private school where students are paddled for breaking the rules and if a male teacher observed a male student strike a female student, he would have paddled the student instantly. Even though the female student scratched him, the male student was out of line when he decided to get up and shut the female's

computer. This event really challenged the values I grew up with and I hope both students learn from the situation and move on."

When reviewing journal 4, Justin felt that his reflection fell into all three categories: descriptive, comparative, and critical. In his words,

"I think it fits in all three: descriptive, comparative, and critical because descriptive I told exactly what happened in detail with her, striking against the coat rack and then I told how I was feeling. As a man, I was feeling very angry because I was told never to strike a girl as a boy and then when he did it again, I felt my blood boil because of that. I didn't really talk about how it would be from the teacher's perspective or the students' perspectives but I said how can I improve? I said I needed to be more observant. I know the kid; the teacher has told me that he has problems with anger. I can tell whenever he's having anger problems, so I should have been more observant instead of only concentrating on the kids I was teaching. I should have still been watching him more and maybe diffuse the fight before it happened. For critical, it was just my morals and ethics. It went against what was deep-rooted in me for how I was raised. So, I would guess that parts of this journal would fit into all three."

While Justin was correct in noting that he mentioned his initial reaction, ways to fix the problem, and some moral/ethical issues that he felt surrounding the situation, the researcher assessed his level of reflection on this journal entry as descriptive (Table 4.1). Justin's reflection in journal entry 4 was not comparative because, while he did offer some alternative solutions, his solutions did not encompass multiple perspectives. He did not consider how this event was disruptive to the rest of the class, the ramifications a fight like this could have on the learning environment, or the perspectives of the students involved. Instead, Justin was only concerned about his response to the situation. In addition, while he did mention his beliefs and morals

related to violence against women, Justin did not consider it in a way that renewed his own perspective or explored the implications of the event further than what was going on in the moment. When Justin was asked if he felt he could have reflected more on this event, he simply stated that he could have included that he left the classroom to alert his partner teacher to the events that had transpired. This is an additional descriptive detail that did not add to his reflection on the events, but informed the reader that he took another step. Similarly, when assessing his levels of reflection on his twelfth journal entry, Justin decided that his reflective level was descriptive and critical, while the researcher assessed that the journal entry was descriptive and comparative. She felt that he had considered the student's perspective, while Justin mentioned that he had not done that. It seemed that after reviewing the Typology of Reflection, Justin felt that mentioning his own morals and beliefs was enough to qualify as a critical level of reflection. These responses suggested that perhaps students need more than to be provided with a structure for reflection. In just a cursory glance at the Typology of Reflection, Justin picked out a few words, like moral and ethical, and attributed them to a deeper level of reflection. However, it is not enough as a reflector to simply mention those categories; the reflection must also include some ramifications on the implications of holding those ethics or morals and how it effects the situation.

Sarah. Like Justin, Sarah also fell into a pattern in her journal writing. Starting in journal entry 4, each entry began with Sarah writing, *"This week I taught a lesson on…"* and then going on to give a brief description of the activity her students did and the challenge she faced. Also like Justin, Sarah mostly reflected on a descriptive level. However, on some topics, Sarah incorporated some comparative and critical reflection in her journal. Table 4.2 depicts Sarah's levels of reflection throughout her journal entries. In journal entries 7 and 13, Sarah engaged in

some comparative reflection. In journal entries 4, 8, and 13, Sarah engaged in some critical reflection. Sarah's written descriptions of the disequilibria she faced in her classroom were typically very thorough. She addressed the particulars of what was going on in her classroom, as well as what she felt she should have done to address the issue. In journal entry 7, she went beyond descriptive reflection to a level of comparative reflection, by really considering how students felt when she realized that misbehavior during teaching effected the students who behaved as well as what she could do to address the challenging behaviors. In journal entry 4, Sarah discussed the ramifications of a student who discussed race as a difference between President Jimmy Carter and himself. She lamented not discussing the issue more in-depth with him and discussed her renewed perspective of how race could affect classroom teaching of topics like politics. In addition, she met all three of these levels in her thirteenth journal entry. Journal entry 13, which was required to be three times as long as a normal journal entry, was intended to be a summary reflection that surveyed a FOCUS student's perspective on the entire semester. In this journal entry, Sarah determined that the three themes that she had reflected on most throughout the semester were student behavior, learning environment, and how a student's environment effects his/her behavior. In the journal, Sarah discussed not only her own biases related to Carbon County, as she grew up nearby, but also what she saw as the educational ramifications of challenging student behaviors and the culture surrounding her school.

Table 4.2. A visual depiction of Sarah's levels of reflection according to Jay and Johnson's (2002) Typology of Reflection by journal number.

	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Descriptive	X	X	X	X	X	X	X	X	X	X
Comparative				X						X
Critical	X				X					X

In her final interview, when reflecting on journal entry 4, Sarah explained that her reflective level was *"somewhere between comparative and critical. I could have gone into a more worldview perspective to be more critical."* When asked to give examples of each of those components in her journal, she stated, *"When I tried to understand his views on race and then compared those views to mine, that was comparative. I guess critical was when I tried to assess if his view encompasses what my view does."* Talking to Sarah about her journal entries seemed to help her think more deeply about her reflection on the issues. When asked whether she fully reflected in her seventh journal entry, she immediately said, *"I could have thought more about the socio-economic components or compared Carbon County to other places in the state."* It seemed as if Sarah was thinking more about the issues she had brought up in her journals just by seeing the Typology of Reflection. She compared journal entry 7 to journal entry 4 saying, *"I feel that this one is more comparative than critical because I didn't elaborate as much as I could have."* About journal entry 12 in the final interview, Sarah discussed how she felt she could have done more reflecting: "*At the end of writing this, I was still not sure what I should have done about the bullying. Even now I still don't know what to do about preventing bullying in the classroom. I don't even know if my partner teacher notice that it's going on. You only see it when another student needs to sit by the student being bullied. The rest of the class is super crazy so I wouldn't even blame her if she didn't notice."* Sarah judged journal entry 12 to also fall between comparative and critical on the Typology of Reflection. She believed that the entry was comparative because it incorporated multiple different avenues she could take to solve the problem and critical because it explored some of the implications of bullying. The researcher only judged this entry to be descriptive, because Sarah did not describe in detail what she would

do or explore the implications of bullying. Mostly Sarah described what she saw in the classroom and expressed her helplessness and uncertainty in handling the issue:

"When we got out to the table in the hall, the students all found their chairs except one student. This student refused to sit next to one of the girls at the table, and eager to keep them quiet, I asked another student to sit next to this girl so that the first student wouldn't have to. However, this student also refused and it became obvious that many of the students did not like this girl. At the time, I was slightly panicked because I didn't want them making noise, so I just allowed them to bunch up on one side of the table.

Thinking back to the event, I'm still not sure how I would have responded differently. On one hand, I want to make that first student sit next to the girl or risk getting sent back to the class without participating, but I know that would have caused loud outbursts from the student, which would in turn embarrass the girl and also really highlight the fact that no one wanted to sit next to her. Without knowing the reason behind why they don't like this student, I don't know that I could make the right decision on what to do in this situation. I am stuck with the question of whether it would be better to bring the issue to everyone's attention and single the girl out or to just ignore what was happening so that she doesn't have to face the reactions of others. This really challenged me to think about how bullying can start at such a young age and how I don't really know how to react to it. Is it preferential to address the issue head on or one-on-one with each student? I know that ignoring the issue altogether is not beneficial, but I don't exactly know which way is yet."

Sarah's journal entry 12 did not seem to make comparisons or embrace multiple perspectives as she did in journal entry 7 or incorporate larger societal dimensions like she did in journal entry 4. During her final interview, Sarah noted that she had never encountered bullying

in her own childhood, so she felt ill-equipped to handle it with her second graders. This suggests that students might have an easier time reflecting more deeply on situations that they have previously considered, experienced, or that they hold strong beliefs about.

Tyler. While Tyler did not have an established writing style in his journal entries as Justin and Sarah did, he showed progress in his reflections as the semester proceeded. Tyler started out the semester discussing preparation and communication with his teacher as the most important and biggest problems that he encountered. He often discussed how he needed to be more prepared when teaching his lessons. Tyler's journal entries read more like a description of what happened and how he should have prepared more for the lesson. However, in journal entries 11 and 12, Tyler began to discuss students' perspectives on what was going on in the classroom and challenges that he had in teaching outside of being prepared. Tyler's levels of reflection by journal entry are represented in Table 4.3.

Table 4.3. A visual depiction of Tyler's levels of reflection according to Jay and Johnson's (2002) Typology of Reflection by journal number.

	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Descriptive	X	X	X	X	X	X	X	X	X	X
Comparative								X	X	
Critical										

While the prompt instructed students to reflect on any event that made them feel uncomfortable, surprised, or stuck out to them, Tyler focused on the word "uncomfortable" and used it 17 times over all 13 of his journal entries. Perhaps that explained why his journal entries were related to his perceived unpreparedness, rather than other issues he saw in the classroom. Another explanation could be that he did not experience some of the same challenges that other

FOCUS students did. However, during his final interview, he said, *"My biggest challenge this semester was motivating students to learn. There were a lot of students who were there doing the work, but I could tell they didn't really enjoy it. So, that was probably my biggest challenge this semester was trying to present the material in a way that makes it fun for them and makes them want to learn it."* However, in his journal entries, Tyler did not mention student motivation being something he struggled with until journal entry 11. Up until that point, Tyler focused his reflection on his own perspectives in the classroom. However, in his interview, Tyler said, *"I started noticing students struggling with motivation to learn science a few days after my first lesson on circuits. I could tell they didn't understand the material, but didn't want to ask me questions about it."* It appears, at least retrospectively, Tyler was aware of other issues in his classroom, but chose to focus on needing to be more prepared in the classroom to answer questions he did not know the answer to or situations in which he messed up an experiment.

When using the Typology of Reflection to assess his levels of reflection, Tyler felt that his fourth journal entry was both descriptive and comparative: *"For descriptive, I stated what was wrong, how I felt. For comparative, I was maybe looking into the future to see what would happen if I didn't use all of my time and I also answered how I could improve in the classroom to solve the problem of showing up to teach a lesson that the teacher didn't have time for that day."* Tyler's perspective on his level of reflection differed from the researcher's, as she felt that he achieved only a descriptive level of reflection on journal 4 (Table 4.3). Similarly, Tyler also felt that his seventh journal entry also fulfilled the descriptive and comparative levels of reflection. For the comparative level, Tyler felt that by offering some solutions to being more prepared and communicating with his teacher he had offered options of improving what was not working. However, since he had not truly incorporated multiple perspectives, the researcher did not assess

him at the comparative level. During the interview, the researcher asked Tyler if he thought he could have reflected on a critical level on the issues presented in his seventh journal entry. In his reply, he discussed an issue that never came up in his journals, *"I don't think I could have met the critical level of reflection with this topic. One issue I did encounter was a student asked a question about God and religion while I was teaching and that could have been reflected on critically I think, but I never wrote about that in my journals."* This statement suggests that Tyler encountered issues that he could have reflected on more deeply than issues like teacher preparation, that were so often the focus of his reflections.

Reflective responses of all participants. For the most part, it seemed that the depth of reflection depended on the issues that students chose to write about. Whereas Tyler seemed to gain deeper perspective over the course of the semester, incorporating more comparative issues toward the end of the semester, Jake and Sarah's levels of reflection depended on the topic on which they wrote. All three students seemed to benefit from discussing their reflections in terms of the Typology of Reflection, even if they over-estimated their levels of reflection in comparison to where the researcher placed them on the typology.

In their final journal entries, group discussions, and interviews, FOCUS students explicitly stated that they had an easier time reflecting on their classroom experiences with specific prompts and structures in place to help them. About the journals, Caleb wrote, *"I think that making the journal prompt different for each week would improve the course. It is easy to get complacent or forget the journal if the prompt remains the same each week."* Similarly, students expressed these feelings in the final group discussion of the semester. Tamika claimed she struggled to find interesting topics to discuss on weeks that simply seemed normal. The journal prompt was left open-ended for research purposes so that no assumptions were made

about what disequilibria students experienced in the classroom. However, it seems that students wanted more specific and structured journal prompts.

Chapter Conclusion

In this chapter, the data generated in this study was presented in context of the research questions. Four themes were identified related to the common reflective disequilibria FOCUS students experienced in their classrooms. The themes included:

1. FOCUS students experienced barriers to teaching.
2. FOCUS students identified several structural barriers that they believed hindered student learning.
3. FOCUS students were concerned about content accuracy and appropriateness.
4. FOCUS students believed they took on mentorship roles in their partner classrooms.

One of the research questions for this study considered the extent to which the disequilibria students experienced embodied issues of science teaching and learning. Overall, only Theme 3, which included students' reflection on pedagogical challenges and content accuracy and appropriateness addressed issues related explicitly to science teaching and learning. However, these concerns were not exclusive to science. When students taught social studies content, they were similarly concerned about the presentation of the material in a way that was accurate and appropriate.

Four themes related to FOCUS students' reflection were also examined in this chapter. These themes were related to the ways in which students reflected best. The four themes included:

1. FOCUS students offered suggestions and solutions of varying degrees of practicality.

2. FOCUS students struggled to identify with disequilibria scenarios unless they had experienced a similar situation.

3. FOCUS students' classroom experiences often necessitated that they confront their privilege while reflecting.

4. FOCUS students believed that structured reflection was useful in aiding their learning.

These themes will be explored in more detail in the next chapter. Chapter Five will present the findings of this study in the context of the literature, including implications for practice and future studies.

CHAPTER 5

DISCUSSION, IMPLICATIONS, AND CONCLUSIONS

This case study was an exploration of the reflective disequilibria that undergraduates experienced in Project FOCUS, a service-learning course for students majoring in science. Through weekly written journal entries, in-class group discussions around impressionistic tales, and semi-structured interviews, FOCUS students shared their experiences in their partner classrooms, which provided insights into the disequilibria they felt. The purpose of this study was to examine how undergraduate students in science service-learning courses reflect on their experiences, by identifying reflective disequilibria and how they reconcile their disequilibria and experience. This purpose led to the development of four research questions: (1) How do students describe feelings of disequilibrium in weekly written reflections and in-classroom dialogues? (1a) To what extent do students' feelings of disequilibria embody issues of science teaching and learning? (2) Using Dewey's notion that disequilibrium is required for reflection, how do students describe attempts to reconcile feelings of disequilibria emerging from their FOCUS experience? (2a) How do students' attempts to reconcile feelings of disequilibria change over the semester? The theoretical framework used to frame the study was Dewey's (1933) notions of reflection, which states that reflection must be a conscious effort and a person must experience disequilibrium (a feeling of tension, disbelief, discomfort, or surprise) to initiate a reflective response.

In this chapter, the findings of this case study are discussed more in-depth. In the first section, researcher interpretations of the themes related to reflective disequilibria are discussed

and related to relevant literature. In the second section, themes related to FOCUS students' reflective process are examined and related to relevant literature. The status of the FOCUS program, implications and suggestions for improvements derived from this case study are discussed in the third section of this chapter, followed by implications of this case study for other science service-learning courses. The chapter concludes with a researcher reflection on the case study.

Discussion of FOCUS Students' Reflective Disequilibria

In this section, a discussion and interpretation of the findings, detailed in the previous chapter, is presented. Each theme related to disequilibrium is presented with a discussion and interpretations, and an analysis of the extent to which each embodied issues of science teaching and learning. Within each theme, related literature is included for a robust examination of the theme.

Theme 1: FOCUS students described experiencing barriers to teaching

In their journal entries, classroom discussions, and interviews, FOCUS students described experiencing several constraints that they felt prevented them from fulfilling their obligation to teach in the classroom or that kept them from being an effective teacher. The two primary barriers mentioned by the FOCUS students were confusion they experienced around their classroom role and disappointment with not being able to teach science lessons for a variety of reasons. In this section, each of these variations of the theme are considered separately for their discussion and implications.

Classroom Role. The FOCUS students' role within their partner classroom varied widely because of the highly contextual nature of education. Each partner teacher chose to utilize their FOCUS student in a different way, based on the personal teacher preference, grade level,

classroom schedule, and various other factors. For this reason, it was difficult to communicate to each student about the environment they could expect to face in their classrooms. Some FOCUS students took on more of a teaching assistant role in the classroom, never had complete "control" of the lesson or the classroom; they only taught the lessons given to them by their partner teacher. Other FOCUS students were given complete control of the lesson plans and classroom instruction. The contextual nuances provided each student with a different experience, making it difficult for the course instructor and teaching assistant to design the reflection course, discussion, and assignments around a shared understanding. For the most part, when FOCUS students experienced a sense of disequilibria regarding their classroom role, they did not entertain a different disequilibrium in their discussion and writing until they had sorted out their place in the classroom.

In their research on biology micro-teaching experiences, Sezen-Barrie et al. (2014) found similar results related to tensions with undergraduate pre-service teachers. Undergraduates who participated in the microteaching experiences reflected, not on scientific practices or pedagogy, but on their physical position in the classroom or the role they were fulfilling. One undergraduate reflected on the struggle of trying to stand in the front of the classroom to keep students' attention, while balancing the need to move around the classroom to provide children with help on their computers (Sezen-Barrie et al., 2014). According to the authors, reflecting on the minutia of where to stand in the classroom or whether to take on the role of a disciplinarian takes up reflection time that could be used to reflect on pedagogy or evaluate student learning. In the present study, it seemed that FOCUS students spent a great deal of time focusing on the tiny details of teaching rather than a larger picture. This often lead to FOCUS students' professing that the education profession was much more difficult than they had previously thought.

Returning FOCUS students, like Aaron, Justin, and Keisha, felt less disequilibria around classroom role than their peers. Aaron and Justin returned to their same classrooms from prior semesters, but Keisha was placed in a different classroom in a different school than she had been in previously. This suggested that, with time, FOCUS students can become acclimated to the changing roles they might encounter day to day and can resolve their disequilibria about classroom role, even when they change classrooms or schools in future semesters. It seemed that some disequilibria, like tensions around classroom role, simply take multiple repeated experiences to work through on the reflective cycle.

Opportunity to Teach. Similarly, FOCUS students spent time reflecting on their teaching opportunities in their partner classrooms, which were often hindered by teacher or administrative decisions. Often, a scheduling conflict occurred between social studies and science. Sometimes, science was scheduled for the last period of the day and the teacher ran out of time to include the science that the FOCUS student came to teach. When this occurred, FOCUS students often chose to write about the tension associated with this experience. They discussed their perceived need to be more flexible, more prepared, and communicate better with their teachers. While this disequilibrium experience does not speak to a FOCUS student's preparedness, it does speak to the need for the FOCUS program to convey to students the need to be flexible and the importance with which the program should embrace the "messiness" of teaching. In part, understanding that a classroom cannot run like a well-oiled machine should be one of the foci for reflection in Project FOCUS. Both teaching and the very nature of science can be tenuous and uncertain. A few FOCUS students came to the program with a more nuanced understanding of the reality of classroom teaching, but most students entered the program with only the knowledge that they carried with them as a student. FOCUS students who were

returning to the program, like Keisha, chose to reflect on disequilibria like student learning or their pedagogical choices. FOCUS students who were surprised by the chaos of the classroom or who were involved in classrooms that they felt were poorly managed, reflected on student behavior or their lack of teaching opportunities.

Theme 2: FOCUS students identified several structural barriers that they believed hindered student learning.

Overall, FOCUS students were more concerned, as expressed in their journals or class discussion, about their students' opportunities to learn rather than their own. FOCUS students believed that the students in their classrooms were faced with multiple structural barriers that hindered their learning. The first two of these barriers to student learning, socio-economic dilemmas and administrative decisions, seemed to cause FOCUS students to exhibit behavior related to learned helplessness and lack of agency. The other category, challenging behaviors, was a disequilibrium experienced, which in contrast to a sense of defeat or powerlessness, the FOCUS students described in terms of a sense of frustration and the expectation that they should know what to do to fix the issues.

Socio-economic dilemmas. In their journals and during class discussions, FOCUS students often discussed the socio-economic disparities that they saw in the Carbon County Schools. FOCUS students noted lack of adequate services as barriers that students needed to overcome to learn properly, including healthcare (Todd), internet at home (Tamika), and homelessness (Caleb). Often, the FOCUS students felt that these barriers were beyond their control and expressed a sense of defeat, powerlessness, and sadness. They expressed the belief that there was nothing they could do for the student and discussed how they wished there was something that they personally could do to help.

In a sense, FOCUS students approached challenging issues in their classrooms, such as socio-economic dilemmas, from a perspective of learned helplessness. Learned helplessness is a psychological theory in which people who do not feel they can achieve a task, attribute their failure to a lack of ability instead of effort (Dweck, 1975; Qian & Alvermann, 1995). Because FOCUS students did not believe that they could help their struggling students, they did not even attempt to think of ways to improve their students' school experiences by solving the problems that they could. The feelings that FOCUS students expressed, of defeat and powerlessness, were similar to those witnessed by researchers in examining teacher burnout (Neves de Jesus & Lens, 2005). While it is obvious that FOCUS students were not experiencing burnout, the emotions expressed when feeling burnout are similar. Both teachers experiencing burnout and FOCUS students felt a lack of control over the challenges with their students, either due to a personal factor (as in burnout teachers) or external factors (as in FOCUS students). Because FOCUS students anticipated failure in helping their students with socio-economic problems, they felt no control over the situation, and thus, simply were helpless in the situation. While some of the challenges faced by the FOCUS students related to socio-economic issues were difficult, students could have tried to help in the classroom. Instead, the FOCUS students who experienced these types of disequilibria, determined there was nothing for them to do and simply reported in their journal entries on the events that unfolded.

For the most part, upon observing these disparities, FOCUS students were not called to action, but felt that they lacked the agency to help students. While this behavior could be related to learned helplessness, it is also related to agency. Researchers have been working to understand agency in science classrooms, connecting it to representing the learning of science as a complex social activity (Arnold & Clarke, 2014). Agency has not been clearly defined within

science education, but is used to mean different things by researchers. However, Arnold and Clarke (2014) "contend that any social context…needs to be understood as a site within which student agency can be validated or denied" (p. 737). Student agency is associated with many different factors, including but not limited to choice, initiative, and motivation (Arnold & Clarke, 2014). For this study, student agency was considered specifically to mean that FOCUS students felt it necessary to act in response to a disequilibrium that they experienced. While one of the implicit goals of the course teaching assistant was to help FOCUS students understand that science learning is more complex, the complexities seemed to discourage the students from acting rather than empowering them. Though the FOCUS students reflected on the socio-economic struggles of their students, they often believed they were not able to help in any way, demonstrating a lack of agency.

However, witnessing these struggles in their students' lives helped FOCUS students feel more appreciative of their own education, as well as make a commitment to be more understanding and make fewer assumptions about their students. This outcome of the study was expected, as increasing understandings of diversity and increased awareness of poverty are typical outcomes of service-learning courses (Astin et al., 2000; Jones & Hill, 2001; Hughes et al., 2009). While this outcome is typically expressed as a desired outcome of service-learning programs, cited as contributing to students' identity development (Jones & Hill, 2001), it has also been part of a critique of service-learning programs (Eby, 1998). Eby (1998) argued that service-learning programs are "often based on simplistic understanding of service" and "teach a false sense of need" (p. 3). Without careful consideration of the presentation of the community, its needs, and the service provided, service-learning programs can perpetuate deficit models. This can lead to supporting "ineffective and sometimes harmful kinds of service" (Eby, 1998, p.

3). While this researcher does not believe that the FOCUS program is harmful to the community in which it serves, it is prudent to examine whether the FOCUS students view their classrooms from a deficit perspective. The scope of this research was not to identify or evaluate deficit perspectives and thinking of FOCUS students, but the data of this study suggests that the program may not be doing enough to implicitly address bias or deficit perspectives. Eby (1998) wrote that improperly created service-learning programs can "exaggerate the importance of the person who serves, demean the person served and ignore resources in the community such as peers, families and community leaders. It fails to recognize the political, social and economic factors which create the need" (p. 4). From the FOCUS students' reflective responses to their classroom disequilibrium experiences, it appeared that they sometimes exaggerated their own importance in the teaching and learning process and ignored community resources. For example, when Todd lamented that there was nothing he could do for his student who was struggling to do a worksheet because he could not see, Todd assumed that he was the only person who wanted to provide the student with help. Todd conducted research to try and find community resources for the student, but never passed those along to the teacher or the student because he assumed that it was futile. In this way, Todd assumed he was the only person trying to help his student correct his eyesight. Another example of the reinforcement of deficit perspectives was when Sarah discussed how "bad" her students were and how she assumed they were poorly supported because of their behavior in school. Experiences such as these could reinforce deficit perspectives in FOCUS students when not adequately addressed in reflection classes.

In fact, as Eby (1998) suggested, Project FOCUS might have implicitly perpetuated deficit perspectives. While the goal of the program is to increase K-8 students' understanding of science with the use of hands-on, inquiry oriented science lessons delivered by science content

experts, FOCUS students sometimes assumed that their students were not taught any science when they were not present. Those assumptions, which may or may not have been true, were harmful to the representation of elementary teachers. It is necessary to remind students that their classroom experience is not a complete picture of what goes on in a classroom in Carbon County on a daily basis.

Administrative Decisions. FOCUS students also felt that administrative decisions were similarly causing barriers to student learning. Whether it was holding students accountable for their behavior in ways FOCUS students did not agree with or creating a schedule that minimized science time, FOCUS students believed that the administration helped to create an environment that did not foster a love for learning. FOCUS students' recognition of the systemic problems that exist within the educational system they were working in, is an illustration of reflective growth. They moved from descriptive reflection to comparative, sometimes even critical reflective thought. Being able to witness firsthand teachers' lack of control over classroom time or curriculum, helped FOCUS students gain perspective on the educational system. FOCUS students who believed that teachers were primarily to blame for students not learning, were able, by the end of the semester, to make connections between the complexities of education. For example, Jewel discussed several of these issues that had occurred within her classroom. Not only did she witness a time when the administration prevented the teaching of science, but she also experienced when her partner teacher lost all her classroom aides in one week. The realities of education seemed to drive some reflective thought for some students, helping them to see a larger picture, including difficulties of teaching. This reflection took time; most of the critical reflection was evident in the last journal entry of the semester. In addition, it seemed easier for students to experience critical reflection when they were only reflecting on experiences they had

witnessed, but were not truly involved in firsthand. When Todd reflected critically in his last journal entry of the semester, he mentioned structural educational problems that he witnessed, and discussed how they effected the students and the classroom teacher, but failed to consider how they effected his own teaching in the classroom.

Challenging Behaviors. Even though they were not pre-service teachers, FOCUS students often felt as if they should be able to manage challenging student behaviors, despite receiving very little training to do so. Many of the disequilibria FOCUS students experienced centered around student behavior or the consequences of that behavior. FOCUS students often lamented that they felt uncaring when holding students accountable for their behavior and preferred to let the teacher take care of it. From classroom discussions and journal entries, it seemed that FOCUS students believed that using classroom management strategies was being "mean" to their students. Similarly, Weinstein (1998) surveyed pre-service teachers and found that they did not equate having an orderly classroom with caring for their students. Instead, pre-service teachers felt that demonstrating care for their students and maintaining order in the classroom was a dichotomous relationship. Similarly, when FOCUS students considered their own classroom management strategies, maintaining order seemed to demonstrate a lack of care for their students. However, they seemed to let go of the false dichotomy when examining their partner teachers' classroom management, as evidenced when Kelsey stated during a group discussion, "*I was shocked by how mean the teacher is. But teachers just must act like that so that the kids listen. She really loves them, but she can't be nice for a long time.*" Kelsey recognized that her partner teacher cared about the students, but that she exerted her power over the class to help students achieve their learning goals.

Simultaneously, however, FOCUS students also felt that a few students' challenging behaviors hindered other students' learning and desired to do more to help all students learn. Nearly all FOCUS students reflected on challenging behaviors at some point during the semester. It seemed to be a constant source of frustration that prevented FOCUS students from thinking reflectively on science content and pedagogy. Attitudes such as these have been represented in the science education literature. King, Shumow, and Lietz (2001) interviewed elementary science teachers who stated that they felt they could teach more science if it were not for the behavior problems in their classrooms. Therefore, helping FOCUS students to acclimate to and manage challenging behaviors faster should be a goal of future teaching assistants.

Because student behavior overshadowed other teaching and learning goals, it seemed to limit the depth of reflection for some FOCUS students. The tension surrounding challenging behaviors seemed to prevent some FOCUS students from moving beyond a descriptive level of reflection. They focused on what was going on, from their own perspective. While students were encouraged to look at situations from multiple perspectives, which is a hallmark of comparative reflection (Jay & Johnson, 2002), they often did not do that when reflecting on student behaviors. However, once FOCUS students began to examine challenging behaviors as a lack of engagement, they seemed to begin to be able to reflect on the ways in which they were teaching science. When FOCUS students began considering behavior challenges as being related to a lack of engagement, they began also to think about the perspective of the student. In Parker's journal entry about his failed lesson on dolphins and whales, he considered the first graders' short attention spans and the need to do something, instead of simply talking about a subject. These considerations demonstrated that he was thinking about his students' perspectives. When Sarah realized the challenging behaviors in her classroom were harmful to the students who were

paying attention, she began to consider the perspective of those students. This echoed what Jay and Johnson (2002) said about comparative reflection, "when we consider alternate perspectives or varying ways to approach a problem, we discover meaning we might otherwise miss" (p. 78). When she realized how a few students' challenging behaviors impacted the rest of her students, Sarah incorporated her students' perspectives into her reflection. She moved beyond thinking about how she was impacted by challenging behaviors and considered how her students' felt. This allowed her to evaluate her teaching from her students' perspective and helped her see that she needed to change her teaching strategies to minimize disruptive behaviors.

Theme 3: FOCUS students were concerned about content accuracy and appropriateness.

While FOCUS students focused very little on the nature of science in their reflections, most reflected at least once in their journals or during class on science content accuracy and appropriateness. FOCUS students, regardless of the subject they were teaching, wanted to ensure that their students were learning the correct material in meaningful, engaging ways. Glover et al. (2014) noted a similar situation in the service-learning project they studied. Students involved in peer teaching took the learning of their students seriously. In the undergraduates' reflections, they expressed concern that they did not know the material well enough to teach it to their secondary students (Glover et al., 2014). In this study, FOCUS students sometimes expressed concern that they might not remember a topic well enough to teach it or they reflected on experiences in which students asked them a question they could not answer.

Accuracy. FOCUS students frequently reflected on the importance of ensuring that information presented to their students was accurate. Many of them stated that it was the teacher's responsibility to provide accurate information because, in contrast to more constructivist views of personal and social knowledge construction, they viewed the teacher as

the main source of knowledge within the classroom. However, when they encountered situations where the teacher was conveying incorrect information to students, whether real or hypothetical, FOCUS students were often hesitant to speak up to correct the information. Initiating a conversation with the teacher became uncomfortable for many of the FOCUS students and they discussed ways to get the accurate facts to students while avoiding a conversation or direct confrontation with their teacher. However, when their partner teacher initiated the conversation by asking the FOCUS student a question about the science content, they would enter into a dialogue with the teacher about the correct information. Disequilibria centered around accuracy of information seemed to revolve around FOCUS students' roles within the classroom and the inherent power structures that might accompany a service-learning program. Two returners, Aaron and Justin, felt comfortable talking to their teachers about information presented inaccurately because their partner teachers often initiated conversations. However, other FOCUS students discussed how uncomfortable they felt with respect to initiating a conversation or addressing their teacher directly about issues of content and planned to add accurate information into their next classroom lesson to avoid speaking to the teacher about it. Tang (2003) suggested that different field experiences offered different opportunities for growth in a study of student teachers in their field experience placements. Student teacher field experience contexts are somewhat comparable to the Project FOCUS partnerships between a partner teacher and FOCUS student. The evidence in this study and Tang (2003) seems to suggest that the opportunities for professional and personal growth are mediated by the Project FOCUS placements as well. In Tang's (2003) study, it was apparent that the supervising teacher had a great deal to do with the growth of the student teacher. Each supervising teacher offered different amounts of challenge and support to their partnered students. While not within the scope of this study, it stands to

reason that teachers partnering with Project FOCUS students would similarly offer differing amounts of feedback, support, and encouragement. Closely related to this assumption is the idea that due to varying amounts of encouragement and support, FOCUS students would have wide-ranging levels of comfort in approaching their teachers to enter into a dialogue about accurate content. Additionally, the partner teacher is in the "privileged position" in the relationship. This creates a power dynamic that both the partner teacher and the student can feel. In a study of mentor and student teacher pairs, Stanulis and Russell (2002) found that sometimes mentor teachers can "unconsciously engage in behaviors that safeguard [their] privileged positions" (p. 78). The data in this study suggested that some Project FOCUS students felt that they did not have any power in their relationship with their teacher.

The ways in which FOCUS students discussed accuracy of science content with respect to their teaching was reminiscent of students simply discussing a list of facts. FOCUS students did not bring the nature of science into their discussions. They did not consider whether they were representing science in ways similar to how scientists perform their work. They were more pre-occupied with the standards and facts they felt their students needed to learn when they discussed the accuracy of information. In fact, many FOCUS students wanted to insure students did well on formal assessments. Several researchers have suggested that undergraduate science majors sometimes hold naïve views of the nature of science (Miller et al., 2010; Parker et al, 2008). This could account for why most FOCUS students did not consider whether the nature of science was accurately represented in their classrooms or during group discussions. Similarly, FOCUS students reflected on whether the material presented to their students was developmentally or age-appropriate.

Appropriateness and pedagogy. On several occasions, FOCUS students questioned the age and developmentally-appropriate nature of the material presented to students in their classrooms. Sometimes, FOCUS students expressed a belief that the science topics teachers introduced to students were not appropriate for the classroom and could be better taught by students' parents at home, as Jewel suggested when discussing a time when the guidance counselor came to teach her preschoolers about their bodies. In most cases, however, when FOCUS students questioned the appropriateness of material, it was because their students were struggling to understand or grasp a concept as quickly as the FOCUS student thought they should. The FOCUS students tended to question the content appropriateness particularly after teaching a lesson which they perceived as challenging or difficult for students. For many FOCUS students, this was where the reflection ended. If their students struggled, they believed it was the result of the content being too difficult and did not consider other factors that might be impacting student understanding. However, in some cases, a few of the FOCUS students looked beyond the question of difficult content to consider whether such factors as the activity or teaching style was to blame for students' difficulties with the course material. Once again, these naïve conceptions and surface level reflections could be attributed to not considering their students' perspectives in their reflections. FOCUS students may have also held a deficit perspective of their students. When FOCUS students appeared to hold deficit assumptions, they rarely considered alternative perspectives or solutions. It appeared that they struggled to consider other factors at play when thinking about their students' learning of the lesson. Additionally, the data from this study implies that some FOCUS students held student-based student learning theories, in which traits of the student were the primary factor that affects student learning (Biggs, 1994). For the most part, those FOCUS students who held the belief that a student's lack of understanding stemmed

from a deficit in the student did not reflect on or consider ways in which to improve their own teaching. A student-based theory of learning is one possible explanation for why some FOCUS students tended to equate and even blame learning difficulties on a student's characteristics, including ability, motivation or other factors (Biggs, 1998).

For the FOCUS students who looked beyond a failed lesson, they turned to reflecting on the methods they were using in their classrooms. They considered whether their lesson had been engaging for students, whether students had an active role in the lesson, or whether the tasks assigned to the students were too challenging or developmentally difficult. After considering the different ways an activity or lesson had failed, these FOCUS students then began suggesting solutions or strategies they could use for their next lesson. In this way, it appeared that when FOCUS students began considering their own shortcomings, especially related to pedagogy, their actions were more consistent with a teacher-based, process-based, or classroom-based theory of learning. A teacher-based theory of student learning assumes that the teaching context is to blame when students are not learning (Biggs, 1998). When FOCUS students began questioning their pedagogical strategies, their actions reflected a more teacher-based learning theory. While an investigation of student beliefs about learning was not within the scope of this study, FOCUS students did express beliefs about student learning in their journal entries and group discussions. Through their reflection on these lessons, FOCUS students began to grow in their understanding of science pedagogy and ways to improve their teaching. While FOCUS students' understandings of the classroom nuances and the teaching and learning of science seemed to be increasing, it was not this aspect of their service-learning experience they most valued.

Theme 4: FOCUS students believed they took on mentorship roles in their partner classrooms.

Of all their many roles in the classroom, FOCUS students believed that their role as a mentor was the most important one. They valued their relationships with their students above all their other classroom roles. Perhaps this was because they felt most comfortable in this role, as it did not put them in the role of a teacher. As a result of this focus on mentorship, FOCUS students continually sought out ways to guide their students, wishing to impart on them life skills they found valuable. Among these skills was the love of learning, diverse perspectives, and critical thinking skills. Without realizing it, FOCUS students were fostering a "hidden curriculum" with their students. That is not to say that the lessons FOCUS students wanted to teach could be construed as positive or negative, but it seemed as if FOCUS students were implicitly attempting to pass along their own morals and beliefs to benefit their students. This implied that, though FOCUS students believed they were taking on a mentoring role in their classroom, they were most likely embodying the role of an arbiter of success. The difference between being a mentor and being an arbiter is how the knowledge or information is being perceived by the individual receiving it. A mentee chooses his/her mentor, hoping to emulate his/her mentor's professional or personal choices (Bozeman & Feeney, 2007). A mentorship relationship assumes that both the mentor and mentee are on similar career paths and that the mentee has similar values and beliefs as the mentor. However, the FOCUS students did not seem concerned about their students' future career goals. Instead, they seemed to assume that their students would want to emulate them. FOCUS students perceived themselves as success stories, as college science students, and wanted to inspire their students to go to college, whether that experience was perceived as valuable to their students. Because it is unknown whether the

Carbon County students were willing to be mentored by the FOCUS students, it is assumed that the FOCUS students were taking on the role of an arbiter of success. An arbiter is an expert who makes judgements and settles disputes in their discipline. FOCUS students viewed themselves as successes. In their interactions with students, FOCUS students attempted to impart the behaviors and characteristics that contributed to their own success, in hopes that they would inspire their students to becomes successful as well. Being an arbiter of success could be a one-sided relationship, where FOCUS students were passing along a morals and beliefs that the Carbon County students did not value. FOCUS students made the judgement that their way of defining success (as a college student) should be shared by the Carbon County students and tried to instill those values in their students. This is contrary to a mentorship relationship, in which Carbon County students would expressly seek the advice and knowledge that FOCUS students had to offer, and share FOCUS students' views of success. However, in this position of arbiter of success, FOCUS students disseminated a hidden curriculum.

Alsubaie (2015) defined a hidden curriculum as "the unspoken or implicit values, behaviors, procedures, and norms that exist in the educational setting" (p. 125). Though well-intentioned, FOCUS students were not always aware that they were perpetuating a hidden curriculum in their classrooms. FOCUS students recognized that they had the ability to be good role models in addition to teaching science. When the opportunities arose, they took advantage of them to help the students in their classroom develop life skills that the FOCUS students themselves felt were necessary to becoming good citizens. In their interactions with students, they imparted a social curriculum that, for the most part, they seemed to not be aware of. Keisha and Todd mentioned specifically that they were teaching their students lessons that their parents had taught them. However, it was evident that the majority of FOCUS students were not aware

that they were invoking a hidden curriculum; they did not question whether they should be teaching students these life skills or question the norms that they themselves had assimilated over their lifetimes. Rather, they accepted those norms as facts and skills that students must learn to succeed in life. The data suggests that FOCUS students implicitly understood and embraced the idea that teaching is more than simply conveying a body of knowledge. When FOCUS students missed opportunities to teach life lessons that they felt would have been valuable, they reflected on those events at length. They considered those missed opportunities to be serious shortcomings of their time in the classroom. In this way, FOCUS students seemed to value the social and cultural lessons they passed along to students more than the science content itself.

By their very nature, service-learning courses are likely to pass along a hidden curriculum to the students who participate in them. Each service-learning course takes on the perspectives of the institution that it represents and embeds those perspectives into the experiences of the service-learning program (Boyle-Baise, 1998; Eby, 1998). As discussed earlier, service-learning courses are particularly vulnerable to passing along deficit models. During Spring 2016 in Project FOCUS, at least, a hidden curriculum was not explicitly discussed with students, but it would be valuable to consider helping students identify and question the curriculum that is implicit in the service being provided to elementary schools and their teachers. Alsubaie (2015) found that when teachers failed to understand the hidden curriculum implicit in their teaching, it negatively impacted their students. However, when teachers understood and questioned the implicit ideas within their teaching, they could better help their students bring about social change (Alsubaie, 2015). If Project FOCUS students were provided with an opportunity to reflect on the hidden curriculum that they were teaching, perhaps they could also question the implicit values that they themselves had received or were receiving in their classrooms.

Discussion of FOCUS Students' Reflective Responses

FOCUS students' reflective responses to the disequilibria they felt throughout their service-learning experiences were varied. Primarily, the FOCUS students processed these disequilibria using weekly written journal entries, but also by discussing in-class disequilibria scenarios. Four themes emerged from the data related to students' reflective responses to the disequilibria they experienced. In this section, each theme related to reflective response is presented with a discussion and interpretations, and a consideration of the extent to which each changed over the course of the semester.

Theme 1: FOCUS students offered suggestions and solutions of varying degrees of practicality.

In reflecting on the disequilibria FOCUS students were faced with in their service-learning experiences, they offered a variety of solutions to their struggles. These solutions ranged in degree of practicality from suggestions of actions that they themselves could take to impractical solutions that would necessitate structural, cultural, or societal changes. When students were unable to come up with practical solutions, their reflections were fatalistic in that they seemed to only sit and observe the inequities that they witnessed in their classrooms. When the solutions were practical, students tended to be called to action and felt that they contained the agency to solve the challenge they were facing. Dewey (1933) emphasized the importance of focusing on multiple solutions and reserving judgement on those solutions before drawing any conclusions. For the FOCUS student to move forward and continue to identify reflective practices, it may be valuable to include experiences that emphasize the identification and evaluation of multiple solutions before drawing conclusions. In addition, a guiding question from Jay and Johnson's (2002) Typology of Reflection could be useful in directing FOCUS students

to reflect on the larger structural issues that they identify as being too big for them to handle themselves. On the Critical Reflection level, the question: "How does this reflective process inform and renew my perspective?" could be helpful in re-directing FOCUS students to reflect more deeply on situations they feel ill-equipped to handle, instead of simply recounting the experience. Perhaps considering how reflection on an issue impacts their perspective would help Project FOCUS students put their experiences into context.

Theme 2: FOCUS students struggled to identify with disequilibria scenarios unless they had experienced a similar situation.

As mentioned in Chapter 4, FOCUS students struggled to recognize disequilibria scenarios as legitimate unless they or a classmate shared a similar experience. The group discussions took on a lack of seriousness when FOCUS students believed that a scenario was not plausible. This suggests that the scenarios need to be strongly rooted in a real story or portrayed as such. Students responded to the scenarios better when the researcher prefaced the scenario with a story about a prior student or teacher who had experienced a similar situation. However, having a student in the group who could directly relate to the scenario was one of the most important factors in gaining students' buy-in. If the FOCUS students related a scenario to their current (or past) classrooms, they were better able to discuss it, identify problems associated with the situation, and discuss solutions. Dewey (1933) wrote that reflection in community was a crucial part of the reflection process, particularly in the realm of professional development. Even when most FOCUS students in the group could not relate to the scenario, having just one group member give a similar first-hand account helped. The FOCUS students were more likely to respond positively and productively and give helpful solutions to the scenario if someone else in their group could relate to the issue at hand.

Theme 3: FOCUS students' classroom experiences often necessitated that they confront their privilege while reflecting.

Many of the disequilibria students chose to reflect on in their journal entries caused the FOCUS students to confront their privileged perspective. They often admitted to being saddened, shocked, or surprised by an event in their classroom because they had never encountered similar situations before. They discussed socio-cultural differences between themselves and the students in their classrooms, pledging to be more understanding and not be as quick to judge. Jones and Hill (2011) discussed how service-learning can lead undergraduates to "come to a more complex understanding of diversity…including awareness of stereotypes and assumptions, understanding of life situations of which they were previously unfamiliar, and new knowledge of social issues" (p. 213). FOCUS students seemed to have some of these same new understandings because of their classroom placements, which they wrote about in their reflective journal entries. A striking difference, however, is how FOCUS students handled their privilege in their writing and in their classroom discussions. The FOCUS students never acknowledged their privilege in their discussions with their classmates, instead they echoed each other's dismay that the students in their classrooms did not want to learn or that their children's behavior was bad. They used "othering language," expressing their concern for the children in their classrooms, setting themselves apart from what they witnessed in the classroom by emphasizing that their upbringing had been different. By contrast, in their journals, FOCUS students explored the reasons for the students in their classrooms struggling to learn or exhibiting challenging behaviors. It may be that FOCUS students were not comfortable admitting to their peers that they were forced to confront their own privilege when juxtaposed with their classroom experiences. It could also be that since FOCUS discussion groups were varied on a weekly basis, a group of

students was not stable enough from week to week to form trusting relationships that were strong enough to make them comfortable with sharing uncomfortable topics. The researcher must also consider the fact that conversations were being audiotaped could have potentially introduced a source of bias. It seems that the topic of privilege and underlying assumptions related to it may need to be more explicitly emphasized in the FOCUS course to help students explore their own privilege (racial, socio-economic, etc.) and the difficulties facing some of the students in their classrooms.

Only once was the concept of race explicitly mentioned in FOCUS students' written reflections. When helping with a social studies lesson on Jimmy Carter, one of Sarah's students told her that a difference between him and the former President was that he was brown, whereas Carter was not. In the moment, Sarah remembered not knowing what to do, but later she reflected on the experience and wondered whether the student's statement implied anything about his perception of his own abilities. However, as the racial composition of the Project FOCUS class in this case study and the composition of Carbon County varied so widely, it is naïve to assume that no one else experienced any sort of disequilibria around race in their classrooms. Seider and Hillman (2011) suggested that college students, particularly those of color, involved in a service-learning course did not want to seem "overly sensitive about racial issues" (p. 2). Those same students also expressed a desire not to represent the voices of all minorities by speaking up in their discussion sections during their service-learning course. Of the sixteen FOCUS students in this case study, half were students of color. Perhaps FOCUS students also did not want to bring attention to themselves or have their voices misconstrued by their peers or their instructors and chose to avoid issues of race in their reflections.

Unlike issues of race, issues of poverty and socio-economic differences between the FOCUS students and their students was a frequent topic of discussion in the written reflections. FOCUS students often compared the advantages they had (stable family life, having internet at home, private schooling, etc.) to the challenges their students faced (homelessness, inadequate health care, etc.). Some FOCUS students, like Caleb, expressed the belief that if the Carbon County students could simply do well enough in school, then they would break the cycle of poverty. FOCUS students also discussed in their written journal entries their attempts to mask their surprise when differences emerged in the classroom. Jones and Abes (2004) suggested that when undergraduate students encountered first-hand experiences with poverty for the first time during service-learning experiences, they felt guilt associated with their privileged economic positions. They also posited that this guilt helped students move from acknowledgement to action, many students developed a sense of responsibility to help the impoverished by continuing to volunteer in their service-learning placements after the course had ended. For FOCUS students enrolled in Spring 2016, nearly one-third (5 of the 15 who completed the course) either were returning for a second or third semester or have participated in the course two or more times in the semesters since. Jewel participated in a second semester in the Fall of 2016 and Kelsey went onto participate in both the Fall of 2016 and the Spring of 2017. Other students who participated in this study have since committed to mentorship opportunities, have applied for Teach for America, or other teaching opportunities in the semesters since. Unlike the undergraduates in Jones and Abes' (2004) study, FOCUS students never explicitly acknowledged differences in social class, instead they compared their differing experiences and advantages to those of their students'. This difference could be attributed to the context of the service-learning experiences; Jones and Abes (2001) placed undergraduate students at a food pantry and an AIDS service

organization, where "witnessing the impact of poverty is unavoidable" (p. 161). For some FOCUS students, issues of poverty and social might have been harder to recognize.

Theme 4: FOCUS students believed that structured reflection was useful in supporting their learning.

The reflective assignments for the Project FOCUS class in the Spring 2016 were semi-structured for the purpose of research. The researcher wanted the FOCUS students to determine for themselves the specific disequilibria they considered important. However, in discussions and in their journals, some FOCUS students mentioned that they struggled to come up with topics to discuss in their journals because they admitted they had not felt any disequilibria for some weeks. If students were having to contrive disequilibria because they were not sure which direction to take in their writing, they may have been reflecting superficially. Perhaps a better direction would be to provide FOCUS students with a list of topics (science pedagogy, the nature of science, classroom management, etc.) that they could consider in their reflections, at least in their initial writing attempts.

One of the goals of this research project was to understand how FOCUS students' reflection developed over the course of the semester. The implication of this question was to observe whether the depth of reflection was related to repeated reflection experiences, the topic of the reflection, or various other factors. Higher levels of reflection could contribute to development of deeper understandings about service-learning experiences and improve FOCUS students' lesson planning and teaching (Jay & Johnson, 2002). Among the three primary participants, the context and depth of reflection ranged widely. Tyler seemed to develop more comparative reflection in his journal entries toward the end of the semester, while Sarah achieved levels of comparative and critical reflection on topics she felt more comfortable

discussing. Justin seemed to exhibit lower levels of reflection and a tendency to reflect on prior experiences due to his limited experiences with teaching in Spring 2016. This demonstrated that depth of reflection could relate to both the topic and repeated reflective experiences. However, all three primary participants were able to utilize a reflective taxonomy to examine previous journal entries and expand on how they could have deepened their levels of reflection.

In the final interview of the study, primary participants reviewed three of their journal entries and used Jay and Johnson's (2002) Typology of Reflection to assess their own levels of reflection. Through this process, they were able to reflect on the content of their journals, judge their reflective level, and discuss with the researcher how they could have improved their reflecting. All three of the FOCUS students who participated in the final interviews judged their reflective levels to be between Descriptive and Comparative. Two of the three students made suggestions of ways they could have reached the level of Critical Reflection. By simply showing the students the Typology of Reflection, it was apparent that they improved on their level of reflection and began to think more deeply about situations they had previously written about. This supports the idea that reflection should be explicitly taught to students to help them improve their reflective skills (Jay & Johnson, 2002; Sezen-Barrie et al., 2013).

Implications of Findings

In this section, the implications of the findings of this case study are discussed in terms of future directions of the Project FOCUS program, and for science teaching practice in both service-learning and teaching preparation contexts. In the first section, an update on the current status of the Project FOCUS program, at the time that this chapter is being written in the Spring semester of 2017 is presented. In the second section, recommendations for improvements to the course stemming from the findings of this study are detailed. The implications of findings for

practice, both in science service-learning and science teacher preparation are presented in the third section. Finally, the implication of the findings for future research are detailed in the fourth section.

Status of Project FOCUS

In its fifteenth year since the inception of the program, Project FOCUS has seen a decrease in course enrollment, falling from 80 students in the Spring of 2014 to only 31 in the Spring of 2017. Many different stimuli for this decline were suggested and explored by the course instructor and the researcher. Included in this discussion were an increase of experiential learning courses offered by the university, decrease in the availability of Carbon County science teachers, increase in FOCUS student accountability measures, and a lack of interest from current students. As a result, as Spring Semester 2017 began, the future of the Project FOCUS program looked bleak and the course instructor was intending to end the program. The application was removed from the course website and the intention to end the program was announced, citing a lack of student interest as one of the primary reasons for its termination. However, in February 2017, the course instructor was approached by several academic advisors in the Biology Department, advocating for continuation of the program to support a university-wide initiative to include experiential learning in all students' programs of study (Knauft, personal communication, February 15, 2017). With the expected increase in enrollment, the findings of this study are of great importance to encourage the longevity of this program.

Recommendations for Course Improvements

The FOCUS program has become a staple in K-8 classrooms in Carbon County. Many teachers in the county expect and look forward to receiving a Project FOCUS student each semester. Several teachers have partnered with the same FOCUS student for multiple

consecutive semesters. One of the benefits that it offers is the immersive environment that FOCUS students enjoy, becoming part of a classroom for an entire semester. However, in this study, it was evident that the course experiences of the 16 FOCUS students varied widely. In this study, there seemed to be a relationship between how well a FOCUS student communicated with his/her teacher and the amount or quality of disequilibria they experienced. If a FOCUS student communicated well with his/her partner teacher and planned, suggested or taught lessons, he/she typically became aware of multiple disequilibria and brought these to group discussions or reflected on them in their journals. However, if a FOCUS student simply showed up to the classroom and did only what the teacher asked, without a lot of initiative, or did not have repeated opportunities to teach or engage with students, he/she often did not reflect on specific disequilibrium experiences in his/her journals. Students, such as Kelsey, Parker, and Todd, who interacted often with their teachers and taught lessons regularly, reflected on topics such as science content accuracy and pedagogy. However, other students who expressed limited experiences with teaching lessons or interacting with students, such as Aaron and Wade, often reflected on the same disequilibrium throughout the semester in their journal entries. In Aaron's case, he spent most of the semester grading papers for his partner teacher or helping with lessons that she had planned. As a result, he often reflected on the grading of papers or situations from previous semesters. Similarly, Wade, who only taught one lesson the entire semester, often did not turn in journal entries and had little to say during group discussions. Wade's teacher reported that Wade never asked to teach more than the one lesson that he taught at the very beginning of the semester. When FOCUS students felt they had nothing to reflect on for that week, they reached outside of the scope of the current Project FOCUS semester to reflect on disequilibria they experienced in other classroom settings (Tamika, chemistry) or reflected on a

disequilibrium they felt during a previous Project FOCUS semester (Jake). Because the experiences of each FOCUS student varied so widely, it becomes incumbent on of the teaching assistant to become a facilitator of each student's personal experience and help students to reflect more deeply about their classroom experience. This sounds like a daunting task, one that might sometimes be viewed as outside of the scope of a teaching assistant. However, this author suggests four fronts for facilitating deeper reflection for future FOCUS students: teaching assistant continuity, structured written reflection, in-class reflection, and the development of explicit learning goals.

Teaching Assistant Continuity. As mentioned above, due to the contextual nature of the course, it became necessary for the teaching assistant to become familiar with each of his/her students' classroom context and to support students as needed. When possible, it would be beneficial for the same teaching assistant to work with Project FOCUS for multiple semesters in a row. In the beginning of working with Project FOCUS, the number of different contexts and ways partner teachers utilize their FOCUS students can be confusing. One suggestion this author has is to check in with each student individually during class time. This could be done in a number of ways, including either informally before or after class or formally, in the style of a "mini-conference" after each teacher evaluation is submitted, but it is beneficial to check in with every student and ask him/her directly how things are going and if there are any specific supports he/she needs several times throughout the semester. In addition to the teacher contexts, each school involved in the Project FOCUS program has slightly different challenges for students to overcome. However, these contextual challenges are similar across semesters, so once a teaching assistant becomes acclimated to them, he/she should be able to handle each more smoothly over the semester. In addition, a teaching assistant can develop a rapport with the administration and

faculty over the course of a few semesters. In the beginning, the administration and faculty were not approaching the researcher with questions or concerns about the Project FOCUS program. This may have been because they did not know who to approach. This caused many problems for the program and left the teaching assistant without valuable information that she could use to help improve her students' performance in the classroom. After a couple of semesters, however, the administration and faculty felt more comfortable approaching her with concerns they had about students and those challenges were quickly handled. Additionally, just like in the FOCUS students, multiple experiences with the program allows the teaching assistant to experience many and varied disequilibria associated with the course. By engaging in reflection on these disequilibria, the teaching assistant can develop reflective exercises to address the tensions students are feeling. It would also allow for teaching assistants to encourage returners to share their experiences with other FOCUS students, by having shared experiences with them.

Structured Written Reflection. Weekly reflective journal entries have been staple assignments for Project FOCUS students since the inception of the course. For this study, the journal prompts were unstructured topically to allow FOCUS students to choose the disequilibria they wanted to focus on for themselves. This seemed to cause more confusion for students than was intended. On several occasions, FOCUS students believed that they did not have anything to write about because it seemed like a normal week in the classroom. This led to the FOCUS students reflecting on experiences they had in other classes or in previous semesters. In the final group discussion of the semester, FOCUS students were asked to make suggestions about the course. Several FOCUS students suggested that the journal prompt be more structured so that they would know what to write about. However, if FOCUS students were given too specific of a topic to reflect on, it could be argued similarly that they could struggle to discuss the topic

because they had not had direct experience with that particular issue. A good journal prompt should direct the students to reflect on their experiences in the classroom, as well as integrate their own prior experiences, help them to consider their biases, embrace multiple perspectives, and construct possible solutions to the disequilibrium they are examining. Following Jay and Johnson's (2002) Taxonomy of Reflection by incorporating several of the different questions at each level could be one way to form a journal prompt that encompasses several levels of reflection and guides students to question their own assumptions in considering different situations.

Overall, deeper reflection was evident in the final journal entry of the semester. While it was not certain whether the deeper reflection was due to students' having more experience with reflecting or that the prompt was well-constructed, it appears it was probably a combination of the two. The final journal entry asked FOCUS students to review all of their journal entries over the entire semester, choose three to four themes that they saw in their writing, and discuss how their beliefs about each of those themes had changed over the course of the semester. This prompt allowed FOCUS students to revisit their reflections and consider the issues that they found most important. The prompt did not direct students to consider flaws in the educational system, but many students did.

Written reflections are an important part of the Project FOCUS experience. Structuring them adequately to guide students' reflection is critical for learning gains to be made. Properly written prompts could help students consider classroom nuances, issues of science teaching and learning, and structural flaws of the United States education system. However, just as important, is creating a classroom in which reflection can also happen during class.

In-Class Reflection. The disequilibrium scenario discussions were a valuable part of class time for the FOCUS students. In the beginning of the semester, the discussions were sometimes short, because FOCUS students had been in their classrooms only for a short time. However, that period of discussion around a hypothetical situation offered students the opportunity to talk about their classrooms. Often, the discussion moved off-topic with a discussion of the struggles of challenging student behavior, teacher communication issues, or of a lesson gone awry. These discussions, while only tangentially related to the scenario, were often more beneficial to the FOCUS students, because they could compare experiences and reflect together on the disequilibria they were experiencing. Dewey (1933) insisted that for reflection to be valuable, it must also happen in community. The students formed small communities during their group discussions in which they discussed their classroom struggles. Even when the groups changed from week to week, students were more comfortable sharing their experiences in small groups than with the entire class. To encourage more reflection during class periods, the findings of this study suggest that a period of group reflection is beneficial for students to share their experiences. It would be beneficial for students to be sorted into small groups that remained the same over the entire course of the semester so that less time is spent explaining classroom contexts and more time is spent unpacking disequilibria.

Learning Goals. Several researchers address the benefits of teaching reflection explicitly to pre-service teachers (Correia & Bleicher, 2008). While Project FOCUS has many stated learning goals for the community, students, and teachers involved with the program, few of the goals are explicitly stated for Project FOCUS students themselves. Up until this point, this was due to the highly-contextualized nature of the course. However, upon noticing with this research that students who do not seem to have high engagement in their classrooms are less reflective, it

is recommended that reflection be explicitly taught throughout the course. This could be done by adopting a reflective taxonomy and teaching it explicitly to students as a way to evaluate their own reflection. In their final interviews, primary participants rated their own reflection level using Jay and Johnson's (2002) Reflective Typology. Through this process, they discussed ways in which they could have been more reflective. The guiding questions in Jay and Johnson's (2002) Reflective Typology could help FOCUS students to unpack their disequilibria and reflect more deeply on their classroom experiences. However, the implications of the findings of this study extends beyond the scope of Project FOCUS. In the next section, the implications of the findings for science service-learning courses and science teacher preparation contexts are examined.

Implications of Findings for Practice

The findings of this case study have implications for practice in both science service-learning courses and science teacher preparation programs. Implications for practice from this study include:

- Explicitly teaching reflection using structured written and oral reflections
- Encouraging students to share their experiences and collaborate to determine solutions to classroom challenges
- Minimizing structural disequilibria (like classroom role) by streamlining service-learning experiences as much as possible
- Extending time spent in service-learning experiences

Science Service-Learning. Reflection has not been widely examined in undergraduate science service-learning courses. Researchers typically mention that some form of reflection has

taken place, but very few of the studies utilized reflection in their data collection. Examining student service-learning experiences using reflections, both written and oral, can be useful in gaining insight to student experiences and learning. Over the course of this study, the examination of FOCUS students' reflections clarified the students' struggles, emphasized topics of discussion, and helped foster meaningful classroom discussions. The findings of this case study suggest that reflection could be similarly useful in other science service-learning courses, particularly ones that are involved with cross-age peer teaching. Reflections can be developed in ways to support the course's learning goals and evaluate students' learning. As the academy pushes for increases in experiential learning components to undergraduates' programs of study, researchers need to evaluate students' performance in new ways. Written and oral reflection aligns with the paradigms of service-learning, while simultaneously providing students with opportunities to grow personally and professionally. If the reflections are an important piece of the learning experience for service-learning courses, as many researchers and course instructors insist, then the attributed value must be communicated to students so that they, too, value the work that they are doing on the reflections and do not view it as busy work.

Science Teacher Preparation. Researchers have supported the idea that science service-learning courses for future science teachers, particularly at the elementary level can help develop positive attitudes toward science (Wilson, Bradbury, and McGlasson, 2015), develop multi-cultural understandings of science (Barton, 2000), and improve their reflective practices (Correia & Bleicher, 2008). This study's findings supported the idea that science service-learning courses would be beneficial to students with little or no experience in classrooms. In reflections on their classroom experiences, FOCUS students began to consider the difficulties of teaching science to elementary students, as well as thinking of new ways to engage students through science.

Science service-learning courses incorporated into science teacher preparation fostered connections between classroom and real world science contexts for future elementary teachers (Wilson et al., 2015). Service-learning experiences in science teacher preparation took many different forms, including planning a Family Science Night at a school in the community (Wilson et al., 2015), teaching science in homeless shelters (Barton, 2000), and working in outdoor spaces at local schools (Wilson et al., 2015).

Science service-learning courses, like Project FOCUS, could be used as a recruitment tool to attempt to inspire interested undergraduates majoring in science to teaching. Additionally, every semester of Project FOCUS prompts some students to consider teaching as a career. As previously mentioned, nearly a third of students involved in this study were engaged in Project FOCUS over multiple semesters. A few students apply for Teach for America or other alternative certification programs after a semester in Project FOCUS. Other students have gotten involved with informal science learning, mentorship, and other opportunities using their teaching skills. In the past few semesters, even a few students who were intending to apply to or were already accepted in the university's teacher preparation programs took the course to gain more classroom experience.

Implications of Findings for Future Science Education Research

This study provided a glimpse at the reflective disequilibria experienced by one group of students through written and oral reflections in one science related context. It contributes to the literature, confirming Dewey's (1933) belief that feeling disequilibria is necessary to begin a reflective process, as well as demonstrating that reflection both individually and collectively is important for students in science service-learning courses. It utilized data generated from student

reflections on a scale that had previously been excluded from studies conducted on science service-learning courses. Possible implications for future research include:

- Cross case analysis of students using reflection in similar cross-age peer tutoring science service-learning contexts
- An analysis of students' beliefs about science, science teaching and learning, and community service before and after engaging in a science-based service-learning course
- An analysis of reflection, both oral and written, in a science content course to evaluate the disequilibria students experience in science courses
- A longitudinal study of students engaging in science service-learning experiences to determine their reflective practices in other courses

This exploratory case study raised additional questions about the reflection of undergraduate science majors enrolled in a science-focused service-learning course. It answered questions of what students in the context of Project FOCUS were prompted to reflect on, but it would be beneficial to explore other science-focused cross-age peer teaching service-learning experiences. To contribute to science service-learning research, these studies could be done at universities in in more suburban or rural community contexts. It could also examine students using different amounts of reflection or at different parts of their studies. A cross case analysis could shed light on additional disequilibria experienced by undergraduates and show different approaches to reflection that students may have.

A different approach for research in science education would be to examine the beliefs of undergraduate students in science service-learning courses, particularly in relation to science, science teaching and learning, and community service. Many different beliefs about science

teaching and learning and community service emerged through the course of this study. This could contribute to science education literature by demonstrating how undergraduates' beliefs evolve over the course of a science-focused service-learning course. As universities push for additional experiential learning experiences in the academic program for undergraduates, researchers need to continue to examine the benefits and challenges of those courses.

Another avenue for science education research could be an exploration of the disequilibria students experience during a science content course. Through this study, it seemed that students expressed beliefs about science teaching and learning that would carry over to science content courses, particularly in the areas of the role of the teacher and student in the classroom. These disequilibria could be explored through a study of oral and written reflection in a science content course and compared to the disequilibria student experience in a science-focused service-learning course.

Further research in science education could also incorporate a longitudinal study of undergraduates involved in a science service-learning course to examine how they utilize their reflective practices and experiences in future courses and their daily lives. It would be beneficial to assess the extent to which reflection persists and continues to develop. For example, some FOCUS students seemed to achieve a critical level of reflection by the final journal entry of the semester. It would be beneficial to examine whether that continues to develop after the course is over.

Conclusion

This research journey began in an attempt to improve Project FOCUS in meaningful ways, by increasing the engagement of the students and improve their perceptions of their partner classrooms. By exploring their disequilibria, FOCUS students seemed to become more

aware of the biases they carried into their classroom. Similarly, the process helped the researcher become more understanding of the nuances of the program, of the benefits of service-learning programs, and strategies for creating a course that was meaningful for all stakeholders, and particularly FOCUS students and their course instructors. Through this study, the researcher was challenged to become a better instructor, to confront students' biases and her own in ways that were constructive. For the researcher, reflection has been a process that she still constantly practices at and will continue to include in all of her future work. We all experience multiple disequilibria in a variety of teaching and learning contexts—recognizing them and capitalizing on them is the hard part.

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APPENDIX A

Reflective Journal Entry Prompts

Journal Entry	Prompt	# of Students Who Submitted
1	This is a three-page double-spaced (at minimum) reflection that should address who you are as a person, a scientist, and a learner. This is a reflection, not a biography. Part One (about one page) - Describe your educational experiences. Discuss the value that your family placed on education. Give a specific example. Describe your favorite and least favorite educational experiences. What factors contributed to these experiences? Then, discuss your learning. What methods best help you to learn? How do you know you when you have truly learned a concept? Part Two (about two pages) - Take a snapshot in your mind of what you think an elementary science classroom is like today. Describe that classroom briefly. How many students do you imagine there are in a class? Describe the types of students that are in that classroom. What should a teacher know about their students? Do all of the children learn science? Why or why not? Which students in the classroom need your help (or the teacher's help) the most? Finally, discuss your expectations of being in the classroom. What do you imagine that you will gain from being in the classroom? What challenges might you face in the classroom?	14
2	What scientific knowledge do you think that people need to have in order to be successful in today's world? Reflect on your scientific preparation from kindergarten until now. Give specific examples of how your past experiences in science connect to what you are learning now and why they are important. If you are a FOCUS returner, discuss either a science topic that was taught exceptionally well or exceptionally poorly in the last semester you were in the classroom. What did you learn about teaching science from that experience?	16
3	*If you have been to the classroom this week:* By the end of this week, you have met with your teacher and observed. Write a letter to a friend explaining your first impressions of your classroom environment. How did you feel upon entering the classroom? How did your feelings change throughout your experience?	15

	Tell your friend about the students in class. In addition, select and describe one student you noticed in particular. Why do you think you noticed this student? Discuss one activity you observed in the classroom: Briefly describe the activity and what students were supposed to learn. How do you think your teaching style will compare to your teacher's (based on this activity as an example)? *If you haven't been to the classroom yet:* Think of a topic in elementary or middle grades science that you find (or found) particularly difficult. What is it about this topic that makes it so hard to understand? Think back to the lesson on electricity we did this week with Dr. P. How would you design a lesson to break down the complicated topic into a fun lesson? Using the five E method: engage, explore, explain, extend (or elaborate), and evaluate, explain the lesson you might do. Justify each step of your lesson with why you think it is important.	
4	In the process of preparing or teaching science this week, think of a time that caught you off guard, made you uncomfortable, or that made you think. As you reflect on this event, answer these questions in 150 words or less: • Describe the event. What happened? When did it happen? • Describe the emotions you had in the moment to the thing that happened. • How did you respond in the moment? Why? Answer these questions in at least 200 words: • Now thinking back to that event, how would you respond to the event now? Why? *If you haven't been to the classroom yet, pretend this was your experience on your first day. Use this scenario to answer the prompt above.* It is your first day in the Kindergarten class you were assigned to for Project FOCUS. You walk in to see 25 tiny faces staring at you from their seats on the carpet. Your teacher greets you warmly and introduces you to the class: "Class, this is Jason. He's going to teach you science this semester." A little girl raises her hand, "What is science?" You are shocked--it's January and these kids haven't done science yet. The teacher responded, "Well class, what do you think it is?" A few kids answer around the classroom. "Dinosaurs," says one little red-haired boy. "Rocks!" yells a dark-haired girl. "Colors," a timid girl in the front answers. "All good answers," says the teacher. "I'm not very good at science, but Jason is, and he is going to bring lots of fun science for you. Jason, could you tell them what science means to you?"	16
5	In the process of preparing or teaching science this week, think of a time that caught you off guard, made you uncomfortable, or that made you think. As you reflect on this event, answer these questions in 150 words or less: Describe the event. What happened? When did it happen?	14

	• Describe the emotions you had in the moment to the thing that happened. • How did you respond in the moment? Why? Answer these questions in at least 200 words: • Now thinking back to that event, how would you respond to the event now? Why? *If you haven't been to the classroom yet*, answer the prompt above by thinking about something that happened this week during the FOCUS reflection section that you felt was puzzling or made you uncomfortable or made you think.	
6	In the process of preparing or teaching science this week, think of a time that caught you off guard, made you uncomfortable, or that made you think. As you reflect on this event, answer these questions in 150 words or less: • Describe the event. What happened? When did it happen? • Describe the emotions you had in the moment to the thing that happened. • How did you respond in the moment? Why? Answer these questions in at least 200 words: • Now thinking back to that event, how would you respond to the event now? Why?	13
7	In the process of preparing or teaching science this week, think of a time that caught you off guard, made you uncomfortable, or that made you think. As you reflect on this event, answer these questions in 150 words or less: • Describe the event. What happened? When did it happen? • Describe the emotions you had in the moment to the thing that happened. • How did you respond in the moment? Why? Answer these questions in at least 200 words: • Now thinking back to that event, how would you respond to the event now? Why?	14
8	In the process of teaching science this week think of a time that caught you off guard, made you uncomfortable, or that made you think. As you reflect on this event, answer these questions in 150 words or less: • Describe the event. What happened? When did it happen? • Describe the emotions you had in the moment to the thing that happened. • How did you respond in the moment? Why? Answer these questions in at least 200 words: • Now thinking back to that event, how would you respond to the event now? Why?	12
9	In the process of teaching science this week, think of a time that caught you off guard, made you uncomfortable, or that made you think As you reflect on this event, answer these questions in 150 words or less: • Describe the event. What happened? When did it happen? • Describe the emotions you had in the moment to the thing that happened. • How did you respond in the moment? Why? Answer these questions in at least 200 words:	15

	• Now thinking back to that event, how would you respond to the event now? Why?	
10	In the process of teaching science this week, think of a time that caught you off guard, made you uncomfortable, or made you think. As you reflect on this event, answer these questions in 150 words or less: • Describe the event. What happened? When did it happen? • Describe the emotions you had in the moment to the thing that happened. • How did you respond in the moment? Why? Answer these questions in at least 200 words: • Now thinking back to that event, how would you respond to the event now? Why?	15
11	In the process of teaching science this week, think of a time that caught you off guard, made you uncomfortable, or made you think. As you reflect on this event, answer these questions in 150 words or less: • Describe the event. What happened? When did it happen? • Describe the emotions you had in the moment to the thing that happened. • How did you respond in the moment? Why? Answer these questions in at least 200 words: • Now thinking back to that event, how would you respond to the event now? Why?	13
12	In the process of teaching science this week, think of a time that caught you off guard, made you uncomfortable, or made you think. As you reflect on this event, answer these questions in 150 words or less: • Describe the event. What happened? When did it happen? • Describe the emotions you had in the moment to the thing that happened. • How did you respond in the moment? Why? Answer these questions in at least 200 words: • Now thinking back to that event, how would you respond to the event now? Why?	14
13	This should be a minimum of three pages, double-spaced. Look back at all of your journals from week 3 to week 14. In looking across all ten of these reflections, what are 3-4 common themes that you notice? If you need inspiration, consider how you talk about teaching, learning, students, and science. How have your beliefs on each of the themes changed over the course of the semester? Use specific examples from your journals to explain. Conclude the reflection with final thoughts about this course. What do you wish you had known when you first started that would have helped you be more successful? What would you do differently if you were to take this course again?	14

APPENDIX B

Disequilibria Scenarios

Week	Disequilibrium Scenario
Week 4	Mrs. Jones' classroom is alive with the sounds of scissors against paper and quiet chatter. The fifth graders are cutting out plant pictures to glue under either vascular or nonvascular in their science journals. This lesson is awesome--I found it online last night and Mrs. Jones loved it when I showed it to her this morning! It is hands-on, doesn't require me to do much talking, and everyone seems to be behaving really well. As I walk around, I check to see how everyone is doing. Anthony seems to be working well and Susie has just managed to cut all of her pictures out. Oh! Penny raised her hand across the classroom. Good! I can help out. "Miss Erin? I don't know where this one belongs!" She hands me a picture of freshly cut grass. Uh oh. "What do you think?" I say, stalling for time, I didn't have time to review before I came in this morning. I look around for Mrs. Jones, but she's busy with Henry. I think the answer is vascular, but the student makes a really good case for non-vascular. I don't want to tell her the wrong answer, but I don't want to look stupid either. The student looks up at me, "Well? What is it?" In your group, discuss the scenario using the questions below as a guide. You do not have to make it through all of the questions, but you should discuss the scenario in detail. Think about what you would do if this had happened in your classroom. • What different issues are being described? • How does Mrs. Jones feel in this scenario? • How does Erin feel in this scenario? • How might the students be feeling in this scenario? Consider multiple students' perspectives. • What assumptions is Erin (the FOCUS student) making about science teaching and learning? What are your thoughts about the assumption she is making? • How will this issue impact the learning of the students? • What beliefs and experiences do you have surrounding issues like this one? How do they impact what you would do in this situation? • How have you seen other teachers handle similar issues? • What steps might others involved (i.e. partner teacher or students) take in order to help handle some of the issues? • How does this scenario influence your own experience in the classroom?
Week 5	This week, I taught a lesson on motion in Ms. Nelson's kindergarten class. The standard for this scenario was "Students will investigate different types of motion: Sort objects into categories according to their motion. (straight, zigzag, round and round, back and forth, fast and slow, and motionless)." I took small groups out to the playground to practice doing different types of motion (zigzag, fast, slow, in circles). After they practiced, we played Simon Says. All the children seemed to really enjoy being able to get outside and get their energy out for a few minutes. There was a new student in the class, Maria, who had just moved to Athens. Unlike the other kids, Maria did not immediately start moving after I

	gave directions. When I said, "Simon says turn in circles!" Maria just stood there, looking around. "Turn in circles, Maria!" I called. She jumped when I called her name, but did not move. Another student, Lorenzo, stopped what he was doing and went over to whisper in her ear. Then, as if by magic, Maria would start performing the motion task. This happened repeatedly. Each time I admonished both of them for talking out of turn. It was like Maria had to watch other students perform each task before participating herself. On the way back to the classroom, I asked Maria if she had a good time. Lorenzo answered for her. It was so strange that Maria needed Lorenzo to prompt her before she did anything. I talked to Ms. Nelson before I left to tell her about this troubling behavior. She whispered, "Maria doesn't speak any English. Lorenzo is her neighbor, and he has been translating for her when we are in class. She will catch on soon. Don't worry." But I am worried-- knowing English is critical for learning science. Put yourself into the FOCUS student's position in this scenario. What would you do? How would you feel? Use the questions below to help guide your discussion. Please be sure that you are all participating in the discussion. • What different issues are being described? Think about issues with classroom management, the way the science is being taught, or the science content. • How might the people in this scenario feel? • In this scenario, what assumptions are you making about students, teaching, or learning? • How will this issue impact Maria and Lorenzo's learning? • Discuss similar experiences you may have had and how you handled them. • How does this scenario challenge what you believe about science teaching? • What would you do in this situation? • How does this scenario influence your own experience in the classroom?
Week 6	This week's topic in my third grade classroom is the water cycle. I found a great lesson on the best lesson website called Cloud In a Jar. Using shaving cream and food coloring, you can simulate rain in a jar. In the lesson, you put water in a jar and top it with shaving cream. Then you have students put drops of food coloring on top of the shaving cream. The drops "rain" down into the jar. I thought it was a great, hands-on way for students to observe how rain occurs. I led the lesson in the hallway with four groups, each group of five students was able to have their own cloud in a jar. The first two groups did the experiment with no trouble. They made predictions about what would happen to the shaving cream (it would turn blue from the food coloring, but the water would still be clear) and were amazed at the "rain." We had a good discussion about how rain occurs and they were able to answer all of the questions I asked them. The third group refused to take turns and fought over the jar and food coloring, spilling water and food coloring all over the table. The fourth group were bored and uninterested. When I introduced the name of the experiment and showed them the materials, Kevin rolled his eyes and said, "I did this last year, I know what's going to happen." I asked him to tell me what he thinks will happen and he replied, "I don't need to tell you that, you're not my teacher. My brother says that he doesn't need to know about the water cycle in high school, so I don't need to learn it." The rest of the group chimed in and said, "Yeah!" I tried to get them on track by telling them that maybe Kevin's brother just hadn't taken the right classes in high school yet, but it didn't work. Where did I go wrong?

	Put yourself into the FOCUS student's position in this scenario. What would you do? How would you feel? Use the questions below to help guide your discussion. Please be sure that you are all participating in the discussion. • What different issues are being described? Think about issues with classroom management, the way the science is being taught, or the science content. • How might the people in this scenario feel? • In this scenario, what assumptions are you making about students, teaching, or learning? • How will this issue impact each group's learning? • Discuss similar experiences you may have had and how you handled them. • How does this scenario challenge what you believe about science teaching? • What would you do in this situation? • How does this scenario influence your own experience in the classroom?
Week 8	When I went to the classroom on Monday, Mr. Higgins, the first grade teacher I'm partnered with, wanted to teach an introductory lesson on stars. Another teacher had given him the lesson plan and he just wanted my assistance with the activity. So he read a picture book about stars to the class and then they did an activity where he taught them to draw stars (the five pointed kind). The students enjoyed the activity, but I'm worried they didn't actually learn any science. The little drawings of stars are like the drawings of hearts--they are a symbol that represents an object, but does not accurately portray the actual shape. Stars are balls of gas--like the sun. I didn't interrupt Mr. Higgins while he taught the lesson because I didn't want to embarrass him or myself. Now that the lesson is over, it's important that I address this issue so that we can be sure the students learn the correct material, but I'm not sure where to start. Put yourself into the FOCUS student's position in this scenario. How would you feel? Use the questions below to help guide your discussion. Please be sure that you are all participating in the discussion. • What different issues are being described? (Think about issues with the way the science is being taught or the science content.) • What assumptions are being made about teaching and learning science? • In what other ways might have the teacher/FOCUS student taught this information? • What other scientific topics might this happen with? • Discuss similar experiences you have had and how you handled them. • How does this affect what you believe about teaching science? • What would you do in this situation? • How does this scenario influence your experience in the classroom?
Week 10	This week, I planned a two part lesson, Freddy the Fish followed by the water filtration activity. On the first day, the students really enjoyed Freddy. They used great adjectives to describe Freddy's condition and I was so excited for the second part of the lesson: building the water filter. I bought all the supplies and divided them up ahead of time for each group so there wouldn't be any excess time. I introduced the topic to the students by asking them, "Do you think we can make Freddy's water clean again?" They all shouted, "No!" I

	showed them the clean water in the bottom of the water filter that I had made. The filter was covered in black paper so they couldn't see how I created it. They seemed really curious to learn how I had cleaned the water. I gave them instructions and let them start working. It didn't even take 5 minutes for things to go very wrong! Frustrated because the particles kept spilling through the bottle opening, one group gave up and played in the materials instead. Another group complained loudly that it would never work and played on their netbooks. Not one group was able to create a filter! Instead, sand and rocks were scattered all over the classroom floor. I was certain that my students would be able to do this activity--what did I miss? Put yourself into the FOCUS student's position in this scenario. How would you feel? Use the questions below to help guide your discussion. Please be sure that you are all participating in the discussion. • Discuss similar experiences you have had and how you handled them. • What would you do in this situation? • What problems do you see in this scenario? • What assumptions are you making about teaching and learning science? • How does this change what you believe about teaching science? • How might you plan or teach differently as a result of your discussion today?
Week 11	This week, I taught a lesson on the layers of the Earth. I used a hands-on activity that modelled the different layers and we talked about each one. Everything was going well, until Sam raised his hand and said, "B.o.B (a famous rap artist) said the world is flat and I believe him, not you." I had heard of this controversy, but did not know much about it. I asked him, "Why do you think that? We looked at pictures of the Earth today--it is a sphere." He shook his head and said, "That's a picture, it's not real. Everything I see is flat. I turned to the rest of the class, "Do any of the rest of you think the Earth is flat?" Five more students raised their hands. Oh brother, I'm in trouble now. Science was over and I had to leave, but I can't let the students continue believing the Earth is flat. What can I do? Put yourself into the FOCUS student's position in this scenario. Use the questions below to help guide your discussion. Please be sure that you are all participating in the discussion. • Discuss similar experiences you have had and how you handled them. • What would you do in this situation? • What problems do you see in this scenario? • What assumptions are you making about teaching and learning science? • How does this change what you believe about teaching science? • How might you plan or teach differently as a result of your discussion today?
Week 12	1. Think back to your first day in this class, what were your expectations and how were they met? 2. What do you wish you would have known before taking Project FOCUS? 3. How have you changed as a teacher since your first day in the classroom? 4. How have you changed as a person since your first day in the classroom? 5. How have you changed as a learner since your first day in the classroom?

	6. Think of one thing you have learned in class that you can apply in another class or another part of your life. What is it, and how can you apply it? 7. What was the biggest challenge you had to overcome in Project FOCUS? 8. What is one of your best memories from Project FOCUS this semester? 9. What is one thing you hope your students learned from you this semester? 10. What is something you learned about science that you did not know before? 11. Would you take Project FOCUS again? Why or why not? 12. Would you consider being a science teacher after this experience? Why or why not? 13. What is one thing you would change about this class if you could and why? 14. What aspect of this class helped you the most and why? 15. What is one goal you had for Project FOCUS this semester? How did you meet it?

APPENDIX C

Semi-Structured Interview Guides

Interview One: Experiences in Science Education

- Please tell me a little about how you decided on your major.
    - What is it?
    - How did you decide?
    - When did you decide?
    - Did any particular event/person prompt you to make that choice?
- What does the word 'science' mean to you?
    - How would you explain the word science to a child who has never heard of that word before?
- We are going to go on a journey through your science education, starting with the earliest and moving toward the most recent.
    - Elementary School
        - What else do you remember about learning science in elementary school?
        - What was your favorite experience with science in elementary school?
        - What was your least favorite experience with science in elementary school?
    - Middle School
        - What do you remember about learning science in middle school?
        - What was your favorite or best remembered experience with middle school science?
        - What was your least favorite experience with middle school science?
    - High School
        - What do you remember about learning science in high school?
        - What was your favorite experience with science in high school?
        - What was your least favorite experience with science in high school?
    - University
        - What does science learning look like for you at a university level?
        - Tell me about your favorite science experience thus far.
        - Tell me about your least favorite experience with science thus far.
- We are going to talk now about Project FOCUS as a course. Project FOCUS is a service-learning course. Most of the learning that you do in the course is in a placement classroom and we only meet once a week to reflect on what you have done in your placement. Have you taken any other courses similar to Project FOCUS, either in your high school or college career?
    - For returners, how many times have you taken FOCUS?
    - If yes, when did you take them and what are they?
    - If no, why did you choose to take this one?

- Project FOCUS requires a lot of reflection both in class and through the weekly journals. What, if any, other experiences do you have with reflection?
    - Do you or have you ever kept a personal journal?
    - How comfortable do you feel writing in the FOCUS journal each week?
    - To what extent do you find journaling helpful?
- What other experiences do you have working with children?
- What other experiences do you have working with science and children?

Interview Two: Initial Reflections on Placement Classroom

- Please tell me about your placement classroom.
    - What is the atmosphere like?
    - How much time are you able to spend on science?
- Describe your function in your placement classroom.
    - Where do you feel you fit in?
    - Are you more of an assistant to the teacher or are you teaching with very little assistance from the teacher?
- Think back to the lesson that you taught that you think went the best.
    - What was the topic? What was the activity? How long did it take? Did you teach the whole class or small groups?
    - What were the goals of the lesson?
    - Did the students learn what you wanted them to? How did you know?
    - What challenges did you face in preparing the lesson?
    - What challenges did you face in teaching the lesson?
    - How did you approach those challenges in the classroom?
    - What could you do to improve this lesson?
- Tell me about the lesson you taught that you feel went the most poorly.
    - What was the topic? What was the activity? How long did it take? Did you teach the whole class or small groups?
    - What were the goals of the lesson?
    - What makes you think students didn't learn what you planned for them to?
    - What challenges did you face in either preparing or teaching this lesson.
    - What could you do to improve this lesson?
- How do you reflect each week on your time in the classroom?
    - When do you start reflecting?
    - How do you choose which event to talk about?
    - How do you put the event in perspective for yourself?
- Each week, do you find yourself thinking about similar issues or different issues when you leave the classroom?
    - Give me an example of one of these issues.
    - Why do you think it is important?
    - How does it impact learning?
- What is one thing that has stuck out the most in your mind from your classroom?
    - What is it about that event that you find puzzling or interesting?
    - Have you drawn any conclusions about the event?

- Thank you for coming to talk to me today. Is there anything that you think I should know about your reflective process and your partner classroom?

Interview Three: Journals and Levels of Reflection

- Let's start with an update on your placement classroom. Since last we talked, has anything changed in your classroom?
    - What new challenges did you face in the second half of the semester?
- Pick the biggest challenge that you feel you had during the semester. Walk me through the event (or events) that made you realize that challenge and what you did after realizing it.
- What are some of the issues that you remember talking about in your journals?
- Let's look at journal 4 in particular. I will give you a minute to look over it.
    - Do you remember writing this journal?
    - How did you decide on the topic for this particular week?
    - What about this topic made you feel uncomfortable or made it stick out for you?
    - Besides the journal prompt, what prompted you to write about this journal?
    - Do you think you fully reflected on this topic? Why or why not?
    - Have you thought about this issue again since you wrote about it?
- Here are some guidelines for rating a piece of writing's reflectiveness (using the Jay and Johnson chart). Take a moment and look over both of these things.
    - At what level do you think that you were reflective in this journal?
    - Why do you think it qualifies for that level?
    - Do you think you could have reflected at a deeper level on this issue?
- Let's look at journal 7, in particular.
    - Do you remember writing this journal?
    - How did you decide on the topic for this particular week?
    - Besides the journal prompt, what prompted you to write about this journal?
    - What about this topic made you feel uncomfortable or made it stick out for you?
    - Do you think you fully reflected on this topic? Why or why not?
    - Have you thought about this issue again since you wrote about it?
- Here are some guidelines for rating a piece of writing's reflectiveness (using the Jay and Johnson chart). Take a moment and look over both of these things.
    - At what level do you think that you were reflective in this journal?
    - Why do you think it qualifies for that level?
    - Do you think you could have reflected at a deeper level on this issue?
- Let's look at journal 12, in particular.
    - Do you remember writing this journal?
    - How did you decide on the topic for this particular week?
    - Besides the journal prompt, what prompted you to write about this journal?
    - What about this topic made you feel uncomfortable or made it stick out for you?
    - Do you think you fully reflected on this topic? Why or why not?
    - Have you thought about this issue again since you wrote about it?
- Here are some guidelines for rating a piece of writing's reflectiveness (using the Jay and Johnson chart). Take a moment and look over both of these things.
    - At what level do you think that you were reflective in this journal?

    - Why do you think it qualifies for that level?
    - Do you think you could have reflected at a deeper level on this issue?
- Let's now talk about the gains you might have had in this course. What, if anything, did you learn this semester about science teaching?
- What, if anything, did you learn this semester about learning in science?
- What, if anything, did you learn about science this semester?
- What, if anything, did you learn about yourself?
- What, if anything, did you learn about education?
- What does the word science mean to you?
    - How would you explain science to your students?
    - Has this changed for you since the start of the semester?
- What has been the most rewarding part of Project FOCUS?
- Is there anything that I didn't ask about your placement classroom, your learning or your reflection that you would like me to know?