

Summer 2014

Professional Identity and Pedagogical Discontentment in High School Science Teachers Participating in a Professional Development Institute

Stephanie J. Hathcock
Old Dominion University

Follow this and additional works at: https://digitalcommons.odu.edu/teachinglearning_etds

Part of the [Educational Psychology Commons](#), [Science and Mathematics Education Commons](#), and the [Teacher Education and Professional Development Commons](#)

Recommended Citation

Hathcock, Stephanie J.. "Professional Identity and Pedagogical Discontentment in High School Science Teachers Participating in a Professional Development Institute" (2014). Doctor of Philosophy (PhD), dissertation, Teaching and Learning, Old Dominion University, DOI: 10.25777/rka7-8575
https://digitalcommons.odu.edu/teachinglearning_etds/26

This Dissertation is brought to you for free and open access by the Teaching & Learning at ODU Digital Commons. It has been accepted for inclusion in Teaching & Learning Theses & Dissertations by an authorized administrator of ODU Digital Commons. For more information, please contact digitalcommons@odu.edu.

**PROFESSIONAL IDENTITY AND PEDAGOGICAL DISCONTENTMENT IN
HIGH SCHOOL SCIENCE TEACHERS PARTICIPATING IN A
PROFESSIONAL DEVELOPMENT INSTITUTE**

by

Stephanie J. Hathcock
B.S.E. December 2002, John Brown University
M.S.E. May 2006, University of Arkansas

A Dissertation Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirements of the Degree of

DOCTOR OF PHILOSOPHY

CURRICULUM AND INSTRUCTION

OLD DOMINION UNIVERSITY
August 2014

~~Approved By:~~

~~Daniel Dickerson~~ (Director)

~~Joanna Garner~~ (Member)

~~Ávi Kaplan~~ (Member)

~~Petros Katsioleoudis~~ (Member)

ABSTRACT

PROFESSIONAL IDENTITY AND PEDAGOGICAL DISCONTENTMENT IN HIGH SCHOOL SCIENCE TEACHERS PARTICIPATING IN A PROFESSIONAL DEVELOPMENT INSTITUTE

Stephanie J. Hathcock
Old Dominion University, 2014
Director: Dr. Daniel Dickerson

Although science teachers regularly participate in PD experiences involving reform-based practices, even our best teachers struggle to change their teaching practices to coincide with these pedagogies, and when they do change, it occurs at differential rates. The aim of this study was to better understand teachers' self-systems by analyzing their experiences in a PD institute program through the lens of professional identity. This multiple case study involved five high school science teachers participating in a summer PD initiative. Data were collected through interviews, written reflections and exploration and commitment cards, and a scale designed to capture participants' perceived level of pedagogical discontentment, or unease with teaching practices (Southerland, et al., 2012). Data were analyzed using the Theoretical Model of Professional Identity (Kaplan, et al., 2012), which highlights the dynamic interplay of teachers' self-perceptions, beliefs, purposes, and practices. Data were also analyzed for pedagogical discontentment, and the two were compared. Analysis led to patterns of change in professional identities, triggers for changes to professional identities, insights into perceptions of pedagogical discontentment, and ultimately, the potential relationship between professional identity and pedagogical discontentment. The model of professional identity served to capture

teachers' experience of the PD, including tensions that arose as they began to explore portions of their professional identity. Pedagogical discontentment served to assist in better problematizing portions of the participants' professional identities, and assisted in identifying tensions and potential changes in less elaborative interviewees. However, the professional identity model was better able to capture the underlying causes of discontentment and planning associated with alleviating discontent. These emergent models can provide conceptual tools for future use, as well as guide evaluating and designing PD experiences for teachers.

©2014, by Stephanie J. Hathcock, All Rights Reserved.

Dedication Page

This work is dedicated to my family. I could not have done this without their support. To my parents, who treated higher education as the best choice I could make while keeping me grounded – you never cease to amaze me. To my husband, who made this little venture possible and kept me sane while I did it. Cheers to our new start! And to all of the wonderful teachers I've been blessed to be acquainted with over the years. I hope to build upon the great foundation you left for me.

ACKNOWLEDGEMENTS

Many thanks go out to all of the ODU faculty and staff who assisted me along this journey. My committee provided me with such helpful expertise and advice. I am particularly indebted to Daniel Dickerson. I am so thankful to have had him as my advisor. His advice, work ethic, and general good will toward me made my time at ODU valuable and my future bright. Many thanks also to Joanna Garner, who was a guiding light throughout this process. Linda Bol's course work, feedback and support during my time at ODU was an incredible asset. If she offers a class, take it! And finally, to Barbara Webb, who makes PhD students' lives better through her calm, helpful nature and willingness to answer all my questions.

TABLE OF CONTENTS

LIST OF TABLES.....	viii
LIST OF FIGURES.....	ix
CHAPTER 1: INTRODUCTION.....	1
IDENTITY & PROFESSIONAL IDENTITY.....	2
THEORETICAL FRAMEWORK.....	5
OVERVIEW OF STUDY.....	11
CHAPTER 2: LITERATURE REVIEW.....	13
STATE OF SCIENCE EDUCATION.....	13
TEACHERS' PERSONAL BELIEFS.....	16
TEACHER PROFESSIONAL IDENTITY.....	20
CHAPTER 3: METHODS.....	30
PURPOSE & RESEARCH QUESTIONS.....	30
RESEARCH DESIGN.....	30
DATA ANALYSIS.....	40
STRATEGIES FOR ESTABLISHING TRUSTWORTHINESS.....	63
CHAPTER 4: RESULTS & DISCUSSION.....	65
PROFESSIONAL IDENTITY CASE OVERVIEWS.....	65
RQ1: PATTERNS OF CHANGE IN PROFESSIONAL IDENTITIES.....	69
RQ2: TRIGGERS FOR CHANGE.....	98
RQ3: PERCEIVED PEDAGOGICAL DISCONTENTMENT.....	101
RQ4: RELATIONSHIP BETWEEN PROFESSIONAL IDENTITY & PEDAGOGICAL DISCONTENTMENT.....	124
CHAPTER 5: CONCLUSIONS.....	132
SUMMARY OF FINDINGS.....	132
THEORETICAL IMPLICATIONS.....	138
IMPLICATIONS FOR PRACTICE & FUTURE RESEARCH.....	142
LIMITATIONS.....	144
BIBLIOGRAPHY.....	149
APPENDICES	
SCIENCE TEACHERS' PEDAGOGICAL DISCONTENTMENT SCALE.....	162
PD INSTITUTE PARTICIPANT INTERVIEW PROTOCOL.....	164
PROFESSIONAL IDENTITY CASE SUMMARIES.....	167
VITA.....	299

LIST OF TABLES

Table	Page
1. Demographic Data for Study Participants.....	35
2. Semi-Structured Interview Protocol Table of Specifications.....	36
3. Measures Employed.....	39
4. STPD Scale Pre/Post Scores.....	107
5. STPD Scale by Level Score.....	108
6. Questions for Southerland et al.'s Interview Protocol.....	109
7. Contextual Discontentment for Each Interview.....	118

LIST OF FIGURES

Figure	Page
1. Theoretical Model of Professional Identity System.....	8
2. Science Teacher Pedagogical Discontentment.....	10
3. STPD Subscale Means for Barbara.....	103
4. STPD Subscale Means for Bill.....	104
5. STPD Subscale Means for Lisa.....	105
6. STPD Subscale Means for Penny.....	106
7. STPD Subscale Means for Tony.....	107

Chapter 1: Introduction

Each year, millions of dollars are spent on science inquiry and nature of science (NOS)-based professional development (PD) programming. Despite the money being allocated, evidence of the teachers' use of inquiry and NOS principles in their classroom practices is scant (Borko, 2004; Capps & Crawford, 2013; Wilson & Berne, 1999). These PD experiences attempt to change teachers' practices to be more in line with inquiry and NOS (collectively referred to as reform-based practices), which promotes an active style of teaching involving students learning in ways similar to how scientists work. Although science teachers regularly participate in PD experiences involving reform-based practices, research has shown that even our best teachers struggle to change their teaching practices to coincide with these pedagogies (Capps & Crawford, 2013; Gregoire, 2003), and when they do change, it occurs at an individual rate of progression (Jeanpierre, Oberhauser, & Freeman, 2005; Johnson 2007).

Traditional PD offerings typically focus on increasing content knowledge and improving instructional practices (Borko, Jacobs, & Koellner, 2010; Darling-Hammond & McLaughlin, 1995; Luehmann, 2007). These types of PD programs fail to acknowledge and attempt to understand teachers as individuals and as adult learners. Teachers have a professional identity that is influenced by life experiences, knowledge, and beliefs. Effective science teachers have a strong professional identity consisting of a sophisticated self-understanding of science, a self-definition as a science teacher, and a commitment to facilitating students' identification with and motivation toward science (Enyedy, Goldberg, & Welsh, 2006; Helms, 1998). Thus, science PD should focus on promoting teachers' consideration of their professional identity in relation to their science

teaching and gaining insight into what motivates teachers to take particular actions or make changes in their teaching (Garner, Whittecar, Kaplan, Loney, & Frank, et al., 2012).

Research has shown that teacher change is facilitated by an unhappiness, or discontent, with current practices (Feldman, 2002). The concept of *pedagogical discontentment*, or unease with teaching practices, was recently introduced as a means to better understand why teachers struggle with and change at different rates (Southerland, Nadelson, Sowell, Saka, Kahveci, & Granger, 2012). Pedagogical discontentment is only one facet of teachers' affective states, but it has the potential to help researchers understand teachers' idiosyncratic responses to reform.

The purpose of this study was to investigate teacher professional identity and pedagogical discontentment of high school science teachers involved in a summer PD institute. The study was situated under the premise that meaningful PD experiences encourage and support teachers' explorations of science and science learning in relation to their identity as a teacher (Garner, et al., 2012; Borko, et al., 2010). I employed the concept of pedagogical discontentment (Southerland, et al., 2012) and an emerging model of teachers' motivation and professional identity (Kaplan, Gunersel, Vorndran, Etienne, Heath, & Barnett, 2012a) to investigate the role of PD in teachers' professional identities. Before describing the study in further detail, more expansive descriptions of identity and professional identity are presented.

Identity & Professional Identity

Definition of Identity

Identity has been conceptualized in many different ways. Contemporary perspectives are based on the work of Erikson (1963, 1968, 1982), who described identity as a lifelong developmental process toward optimal functioning within the social environment (Kaplan & Flum, 2010). Many researchers have built upon Erikson's notions of identity (cf. Adams, 1992; Berzonsky, 1992; Marcia, 1966, 1980; Waterman, 1984). These conceptions have focused on varying aspects of Erikson's ideas, however Kaplan and Flum (2010) have noted similarities among them. The shared characteristics include (1) an integrated configuration of personal attributes, values, and goals; (2) a self-constructed system established through agency in determining beliefs, abilities, and goals; (3) the importance of socio-cultural environment and social interactions to identity construction; and (4) that unification and consistency of identity structures lead to more adjusted individuals.

Identity Formation

Identity formation is a dynamic, open, and lifelong process that must be viewed in context (Erikson, 1968). Forming an identity entails exploration and commitment (Marcia, 1966, 1980, 1993). Exploration is the process of information gathering, experimentation, and reflection about beliefs and roles. Commitment is the choosing and synthesizing of those beliefs and roles to formulate an identity. Commitment indicates "the degree of personal investment the individual exhibits" (Marcia, 1966, p. 551) toward beliefs and behaviors. The idea of personal investment has been elaborated by Maehr (1984), who posited that identity is tied to motivation through meaning making; as people go through life, they continually strive to make meaning of experiences. Meaning making

serves as a gateway to action when individuals are motivated to continue with an experience because they perceive that it fits into their identity (Maehr, 1984).

Identity exploration can be aided by providing triggers to exploration, a sense of safety to explore, and scaffolds to support the exploration (Flum & Kaplan, 2003; Kaplan & Flum, 2006; Sinai, Kaplan, & Flum, 2012). Exploration triggers are experiences that are discrepant from current identifications (Sinai, et al., 2012). These subjective experiences can serve to trigger ambiguity or confusion, which in turn, may provide motivation for exploration (Flum & Kaplan, 2003). Triggers can produce anxiety, so it is important to provide a sense of safety for identity exploration. This can involve acknowledging and legitimizing perceptions and feelings, promoting mutual respect, and exercising unconditional affection (Sinai, et al., 2012). Finally, scaffolding identity exploration through reflection and modeling is needed to assist in turning identity exploration into action possibilities (Flum & Kaplan, 2003). Effectively using these constructive identity exploration techniques requires knowledge of participants' backgrounds, subject matter, and the learning context (Sinai, et al., 2012).

Teacher Professional Identity Definition

Teacher professional identity emerged as an area of research over the course of the last two decades. Like identity itself, teacher professional identity has been conceptualized in many different ways. Beauchamp and Thomas (2009) synthesized current literature (cf. Beijaard, Meijer & Verloop, 2004; Gec, 2001; Olsen, 2008; Sfarid & Prusak, 2005) to identify common characteristics among them. They determined that teacher professional identity incorporates: (1) self, including self-concept and identity;

(2) is influenced by emotion; (3) reflection serves as a key means of exploration; (4) involves agency; and (5) can be examined through narratives and discourse.

Teachers' Professional Identity Formation

Most of the research concerning teachers' professional identity has focused on its development in pre-service and beginning teachers (cf. Beauchamp & Thomas, 2006; Bullough, 1997; Thomas & Beauchamp, 2007; Volkmann & Anderson, 1998). In these studies, researchers posit that teacher professional identity forms within the context of the teacher education program, but is also influenced by prior experiences and beliefs. There is a gap in the literature regarding professional identity of practicing teachers. Since identity is dynamic and lifelong, teachers continue to develop and realign their professional identities throughout their careers.

All teachers must participate in PD, which, if properly designed, could serve as a means for exploration of teacher professional identity. Some researchers have promoted the act of provoking tensions in pre-service teachers to encourage professional identity exploration (Smagorinsky, Cook, Moore, Jackson, & Fry, 2004). Meaningful PD that serves to provoke tensions in practicing teachers may serve as a catalyst for teachers to explore their professional identity and may help researchers better understand the differential rates at which teachers adopt new practices. This research seeks to study teacher professional identity within the context of such a PD experience.

Theoretical Framework

Theory of Professional Identity

The theoretical approach adopted for this research on professional identity is based on conceptions of humans, identity, and identity formation as complex, dynamic

systems. The majority of educational intervention research rests on methodological assumptions that humans are simple systems, and that outcomes are calculable, linear, and reducible to the sum of their parts (Davis & Sumara, 2007; McMurtry, 2008). However, we know that humans are complex, inconsistent, and subject to various outside influences (Donald, 2001; Johnson, 2003). Thinking of people as complex systems assumes that "...there are various dynamics at work in social behavior and these interact and combine in different ways such that even the simplest decisions can have multiple causal pathways" (Opfer & Pedder, 2011, pg. 378).

The following characteristics are important to complex systems: nestedness, networked structure, self-organization, adaptive nature, and disequilibrium. Complex systems are not composed of individual parts, but rather are nested, meaning that they are systems within systems (Davis & Sumara, 2005). This nestedness implies that complex systems cannot be reduced to discrete parts, but rather, they should be studied within the context of larger systems at play. Second, complex systems are networked rather than hierarchically structured, meaning that they are difficult to control and that direction of development is difficult to predict (Clarke & Collins, 2007). Third, the self-organizing nature of complex systems indicates that they organize from the bottom up, cannot be exactly predicted, and change according to their own nature and nonlinear pattern of organization (Davis & Simmt, 2003; McMurtry, 2008). Fourth, complex systems adapt their own structure in response to the environment, which is also a complex system (McMurtry, 2008). Lastly, complex systems contain disequilibrium, which is regarded as a positive, creative tension needed for capacity to change (Clarke & Collins, 2007; Prigogine, 1977).

In thinking of teachers as complex systems, the characteristics might look as follows: (1) nestedness can be demonstrated when thinking of teachers (complex systems) working within a particular school (which is a complex system), or participating in a PD (also a complex system). We have to consider the various layers of systems that make up teachers' individual experiences. (2) The networked structure of a teacher is evident because they are difficult to predict or control, including resistance to curriculum reform or decision to go against their principal's mandate. (3) The self-organizing nature of teachers is evident in their ability to come together to achieve more than the sum of each individual's parts. (4) Teachers adapt to their environment based on the norms of their school, leadership styles, pressures from standardized testing, and if they do not adapt, they often leave the profession. (5) Finally, teachers experience disequilibrium when they become dissatisfied with a lesson or teaching style, which may cause them to seek change.

Complex systems experience perturbations to the system from outside sources. These perturbations cause fluctuations within the system when an event prompts the system to respond differently (Davis & Sumara, 2007). Research on complex systems has shown that there is a critical fluctuation point that evokes a qualitatively different organization or behavior (output) due to reorganization (Guastello & Gregson, 2011). This research will apply the complex systems approach to studying teachers participating in a reform-based PD designed to perturb their professional identity system.

Most of the research focusing on teacher change has not been done from a complexity science perspective. To get a better understanding of teachers as complex systems, their professional identity should be studied using a model that also

conceptualizes their identity formation as a dynamic system. The Theoretical Model of Professional Identity System (Figure 1) (Kaplan, et al., 2012a) conceptualizes teachers' professional identity system as dynamic because it acknowledges professional identity as an iterative process, and all of the variables in the model are related (Kunnen & Bosma, 2000). This model merges the dynamic, iterative, and contextual nature of identity (Lichtwarch-Aschoff, et al, 2008) with Maehr's Theory of Personal Investment (1984), which states that meaning leads to motivation, which leads to action.

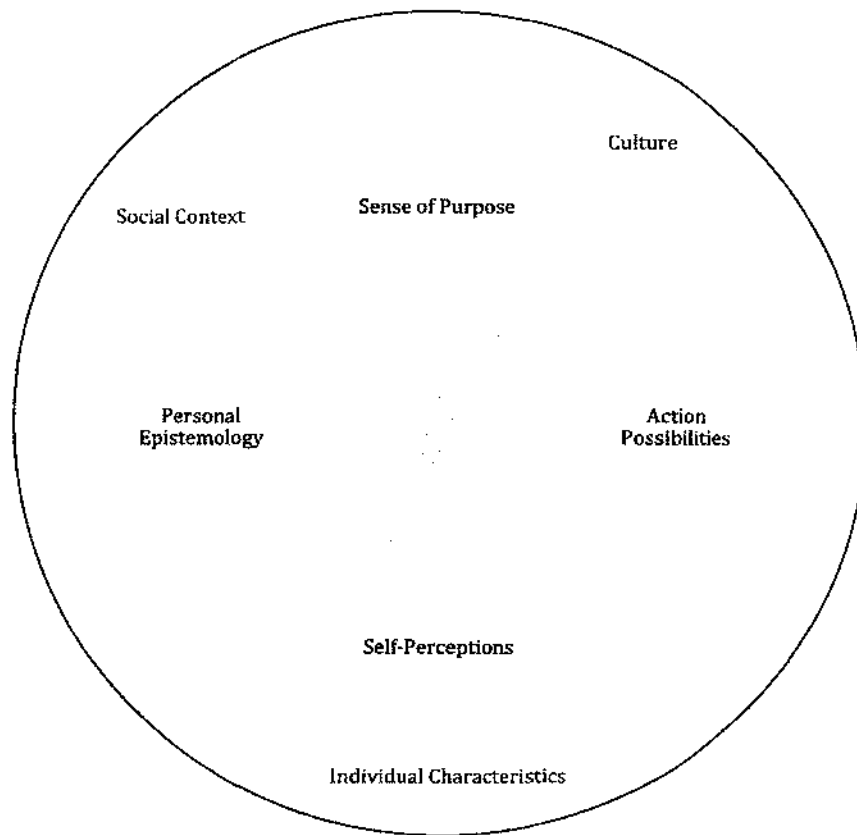


Figure 1. Theoretical Model of Professional Identity System. From “Teacher Professional Identity in Higher Education: An Emerging Conceptual Model,” by Kaplan, Baris-Gunersel, Vorndran, Etienne, Heath, & Barnett, 2012, Presented at the *Annual Meeting of the Eastern Educational Research Association*, Hilton Head, SC.

The model contains four overlapping factors: self-perceptions, personal epistemology, sense of purpose, and action possibilities. Self-perceptions are a collection

of thoughts about self, including perceptions, beliefs, feelings, and identifications (Maehr & Braskamp, 1986). Personal epistemology encompasses beliefs regarding knowledge, teaching, and learning (Kaplan, et al., 2012a). Sense of purpose encompasses pursuits and expected gains from a specific context (Maehr, 1984). Lastly, action possibilities encompass plans and possible concrete actions for the future (Maehr, 1984). Each of these components refers to respective concepts that are deemed by the teacher as relevant to their role. Other factors including social context, culture, and individual characteristics contribute to the dynamic construction of the model (Maehr & Braskamp, 1986), thus each person's particular experience, available information, and sociocultural context combine with the PD context to influence the individual experience.

The model is used to study the changing configurations of professional identity experienced over a course of time. As contextual experiences occur, new relational alignments and tensions arise within the professional identity system (Kaplan, et al., 2012a). The dynamic nature of the model also acknowledges that meaningful change is not typically proportional to inputs, making it nonlinear (Guastello & Gregson, 2011). This allows for the possibility that “small inputs at the right time can produce a dramatic impact, large inputs at the wrong time can produce nothing at all, and that there are many possible patterns of change” (Guastello & Gregson, 2011, pg. 3).

Pedagogical Discontentment

I compare the model of teacher professional identity with the concept of pedagogical discontentment, which is described as unease with teaching practices experienced by teachers who are ready for change in their practices (Southerland, et al., 2012). This affective state encompasses six categories (see Figure 2): (1) ability to teach

all students science, (2) science content knowledge, (3) balancing depth versus breadth of instruction, (4) implementing inquiry instruction, (5) assessing science learning, and (6) teaching nature of science (Southerland, et al., 2011b).

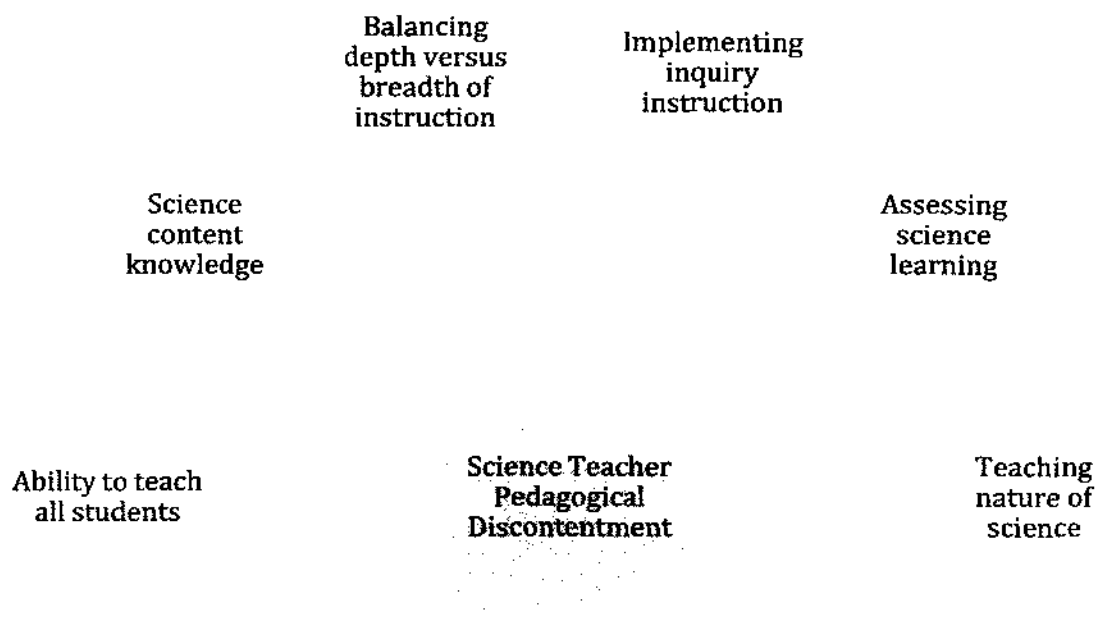


Figure 2. Science Teacher Pedagogical Discontentment. From “Measuring One Aspect of Teachers’ Affective States: Development of the Science Teachers’ Pedagogical Discontentment Scale,” by Southerland, Nadelson, Sowell, Kahveci, Saka, & Granger, 2012, *School Science and Mathematics*, 112(8), 483-494.

Teachers may be discontent overall, or in only some of the categories.

Implementing inquiry instruction and teaching nature of science are categories of particular interest in this research due to the PD’s focus on both. Southerland, et al. (2012) posit that an understanding of pedagogical discontentment can assist teachers in finding PD opportunities targeted to their concerns. Alternately, they suggest that measuring pedagogical discontentment prior to PD allows tailoring and engendering discontentment in order to accelerate change. Finally, they point to the scale as a tool for designing and evaluating PD (Southerland, et al., 2012).

The study looked at the contextual, dynamic experiences and interactions that teachers experienced during an 8-day summer PD institute. This included measuring teachers' pedagogical discontentment prior to and after the PD to determine their potential for openness to change. I also looked for experiences that may have perturbed teachers' professional identity systems, causing fluctuations and realignments in their professional identity system. Finally, I sought to determine the relationship between the concepts of pedagogical discontentment and professional identity. The research questions associated with the study were:

- (1) What were the patterns of change in science teachers' professional identities who participated in the professional development institute?
- (2) What aspects of the professional development institute were perceived to serve as triggers for change in teachers' professional identity systems?
- (3) How did science teachers' perceptions of pedagogical discontentment change as they progressed through the professional development institute?
- (4) What is the relationship between pedagogical discontentment and professional identity?

Overview of Study

This study incorporated the concept of pedagogical discontentment (Southerland, et al., 2012) with Kaplan et al.'s (2012a) Theoretical Model of Professional Identity. The research is a case study of five teachers who participated in an 8-day science PD institute designed to challenge teachers' professional identities and capitalize on or trigger pedagogical discontent as they learn about and engage in experiences with their subject matter, inquiry teaching, assessment, and nature of science principles (Garner, et al., 2012). Data were collected in August, 2013 through the Science Teacher Pedagogical Discontentment Scale, pre-, mid-, and post-institute interviews, daily reflections, and

exploration and commitment statements. Analysis involved determining pedagogical discontentment prior to and after the PD as well as the creation of case summaries of the professional identity system of individual teachers at each stage of the institute. Pre-, mid-, and post-case summaries of individuals were compared to identify themes based on the configuration of the professional identity system, including consistencies, changes, and emergent possibilities. Each case was analyzed to determine which experiences were perceived as meaningful to participants as well as experiences that seemed to facilitate perturbations in their system, which could lead to changes in teacher pedagogical discontentment and professional identity.

Chapter 2: Literature Review

This chapter begins with a discussion of the current state of science education and science teacher professional development. It then explores teachers' personal beliefs, including a discussion of pedagogical discontentment and professional identity. It ends with a justification for the study.

State of Science Education

A Focus on Reform

In the past two decades, science education has undergone a major shift toward placing a greater emphasis on inquiry-based and NOS instruction (American Association for the Advancement of Science [AAAS] 1989, 1993; National Research Council [NRC] 1996, 2000; National Science Teachers' Association Position-Statement 1998). The National Science Education Standards (NSES) define scientific inquiry as, "...the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (NRC, 1996, p. 23). Authentic scientific inquiry can be modeled to students in the form of classroom inquiry, which is a kind of pedagogy that includes doing science and a knowledge of how scientists do their work (NRC, 1996). Classroom inquiry is considered to be especially influential to students' learning because it exposes them to learning that is similar to that of practicing scientists (NRC, 1996, 2000).

Inquiry-based instruction requires both the teacher and students to take on new roles within the classroom. Anderson (1996) explains the changing roles through a Traditional—Reform Pedagogy Continuum. The continuum describes teachers' roles as shifting from knowledge dispensers to coaches or facilitators. Students become more

active, self-directed learners, rather than passive knowledge receivers. Students' work also becomes more self-directed, rather than teacher-prescribed (Anderson, 1996).

Nature of science (NOS) is an understanding of science as a way of knowing, including how scientific knowledge is developed (Lederman, 1992). NOS instruction has been an important goal for science education for almost a century (Lederman, 2007). NOS instruction includes the ideas that (1) scientific theories and scientific laws are different, and that scientific knowledge is (2) tentative, (3) empirically based, (4) subjective, (5) creative, (6) socially and culturally embedded, and (7) created from observations and inferences (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; McComas, Almazroa, & Clough, 1998). Research suggests that these aspects of NOS be explicitly taught to students as they come up in the science classroom (Lederman, 2007; Schwartz, Lederman, & Crawford, 2004).

Although inquiry-based and NOS instruction have both been recommended by science education reform efforts, research has found that most teachers have not adopted these instructional practices in their classroom practices (Anderson, 1996; Capps & Crawford, 2013; Roerhig, Kruse, & Kern, 2007). This lack of adoption could be due to a myriad of reasons, but one of the most important seems to be the teacher's prior experiences with reform-based instruction. In a study of science education reform efforts at a middle school, Davis (2002) found that many of the teachers were either unable or unwilling to adopt reform-based science instructional methods. The majority of teachers were not taught using reform-based methods when they were in school (Crawford, 2000). In addition, most teachers are not taught reform-based teaching practices in their preparation programs (Helms, 1998; Volkmann & Anderson, 1998). This translates into

asking teachers to teach in a way that goes against their experiences, both as students, and with teaching. In order to adopt reform-based practices, teachers must actually go through an “unlearning” process regarding their knowledge and beliefs about appropriate teaching (Woodbury & Gess-Newsome, 2002). This presents quite a challenge to the field of science education that has proven to be difficult to overcome.

Science Professional Development

Many efforts and millions of dollars have been focused on changing science education, however researchers have seen little evidence of differences in classroom practices. Woodbury and Gess-Newsome (2002) have termed this, “change without difference”. Reform-based instruction is very complex, and requires professional development (PD) in order to implement it properly (Crawford, 2000, 2007). There is a disconnect between typical science PD and the outcomes being sought from reform-based PD. Typical science PD programming focuses on science content and pedagogical content knowledge, ignoring teachers as individuals who have knowledge, beliefs, and prior experiences (Darling-Hammond & McLaughlin, 1995). In recent years, as PD has begun to focus on trying to change teachers’ practices to better align with reform-based instruction, there has been very little evidence linked to PD as being beneficial (Borko, 2004; Wilson & Berne, 1999).

What, then, makes for an effective PD program? Capps, Crawford, and Constas (2012) analyzed characteristics of effective general PD by synthesizing empirical studies of PD (Darling-Hammond & McLaughlin, 1995; Garet, Porter, Desimone, Birman, & Yoon, 2001; & Penuel, Fishman, Yamaguchi, & Gallagher, 2007) and effective science PD (Loucks-Horsley, Hewson, Love, & Stiles, 2003) to identify common features among

them. Capps, et al. (2012) then combined the effective characteristics with the National Science Education Standards reform documents (NRC, 2000) to develop a definition of inquiry-based science PD, which states that inquiry-based science teacher PD should assist teachers in creating a classroom that supports inquiry, which should involve students learning about what science is and what scientists do by acting as scientists in their schoolwork.

Finally, they used this definition, combined with the common features of effective PD to generate a list of nine common features of effective inquiry PD. These include: (1) total time, (2) extended support, (3) authentic experience, (4) coherency with standards, (5) developed lessons, (6) modeled inquiry, (7) reflection, (8) transference, and (9) content knowledge (Capps, et al., 2012). They used these common features to perform a synthesis of 17 empirical studies of inquiry-based PDs. While none of the studies they reviewed contained all of the features of effective inquiry-based PD they had identified, many of the studies incorporated most of the features. Capps, et al. (2012) also reviewed the PD programs for robustness of findings. They found that the programs reported findings such as enhanced teacher knowledge and practices as well as changes in teacher beliefs and practices. They point to teacher beliefs as an important filter for PD experiences, suggesting that an understanding of teachers' practices and choices begins with an understanding of their beliefs (Capps, et al., 2012).

Teachers' Personal Beliefs

The personal beliefs held by teachers have been shown to influence their classroom decisions (Crawford, 2007; Smith & Southerland, 2007). This section will give an overview of teacher beliefs in response to science education reform. It will then

discuss pedagogical discontentment, an affective construct that may help explain teachers' differential responses to reform.

In Response to Reform

Teachers' personal beliefs have been identified as a key component in their response to reform-based initiatives. Crawford's (2007) case studies of five pre-service teachers found that their personal beliefs were critical to their aspirations and ultimate abilities to teach inquiry-based science. A case study of practicing teachers experiencing whole-school reform PD (Johnson, 2007) found teacher change to be a very personal experience that teachers progressed through at different rates. These findings were echoed by Jeanpierre, Oberhauser, and Freeman (2005), who did a mixed-methods study of an inquiry PD. They found that teachers began the PD in different stages of teaching inquiry. While many teachers progressed in their inquiry-teaching practices, others did not alter their practices. Smith and Southerland (2007) used comparative case studies to show that some teachers' beliefs can serve as a barrier to reform, while other teachers' beliefs align more closely with reform tenets, allowing them to embrace reform. Similarly, Roehrig and Kruse (2005) conducted a mixed-methods study of 12 high school chemistry teachers experiencing a reform-based curriculum change. They found that teacher beliefs, specifically, their beliefs about teaching and learning, had a significant impact on their adoption of the new curriculum. These and other studies have contributed to our understanding of science teachers' affective states as an emerging research area linked to responses to reform.

Pedagogical Discontentment

A facet of teachers' affective states recently identified as an important catalyst to change is the theoretical construct of *pedagogical discontentment* (Southerland, Sowell, Blanchard, & Granger, 2011a). Southerland, Sowell, & Enderle (2011b) define pedagogical discontentment as "...the unease one experiences when the results of teaching actions fail to meet with teaching goals" (pg. 439). They trace the construct of pedagogical discontentment to conceptual change models suggesting that teachers have to be dissatisfied with an aspect of their teaching before they are willing to engage in reform (Dole & Sinatra, 1998; Feldman, 2002; & Gregoire, 2003). Feldman (2002), in particular, discusses the idea of discontentment as a precursor to finding benefits in new theories. Pedagogical discontentment is also directly related to Settlage, Southerland, Smith, & Ceglie's (2009) case study findings suggesting teachers need to experience doubt and uncertainty as a precursor to change. Southerland, Nadelson, Sowell, Saka, Kahveci, & Granger (2012) suggest that pedagogical discontent should be used to more thoroughly understand teachers' responses to messages of reform.

Southerland, et al. (2011a) tie pedagogical discontentment with self-efficacy, which they describe as the confidence in one's teaching abilities such that they may attempt a new teaching practice. While self-efficacy is associated with new practices, pedagogical discontentment is associated with current practices. They posit that pedagogical discontentment is developed through a combination of sufficient self-efficacy and a propensity for reflection. The moderate pedagogical discontentment that ensues then leads teachers to seek new practices or to engage with PD messages. Lastly, if their self-efficacy is high enough, teachers will then adopt new practices, which may result in the reduction of pedagogical discontentment (Southerland, et al., 2011a).

Research on Pedagogical Discontentment

Southerland, et al. (2011b) began their research on pedagogical discontentment by interviewing 18 practicing science teachers with a wide range of experiences. They employed grounded theory to identify five initial categories of pedagogical discontentment: (1) ability to teach all students science, (2) science content knowledge, (3) balancing depth versus breadth of instruction, (4) implementing inquiry instruction, and (5) assessing science learning (Southerland, et al., 2011b). Southerland, et al. (2012) then used the identified themes to develop the Science Teachers' Pedagogical Discontentment Scale, which was given to 171 practicing teachers. They conducted an exploratory factor analysis that supported the original scales and led to the addition of a sixth category of pedagogical discontentment, teaching nature of science. Finally, Southerland, et al. (2012) administered the amended scale to 462 practicing teachers, which they then used to perform a confirmatory factor analysis. The scale has since been used by Saka (2013), who gave it to 87 teachers enrolling in summer PD courses. She found that teachers who were more pedagogically discontent enrolled in PD programming that focused on providing them with inquiry-based teaching tools rather than PD focusing on other topics such as authentic science experiences (Saka, 2013). Blanchard and Grable (2009) and Golden, Enderle, and Southerland (2010) both found that teachers' who were more pedagogically discontent tended to use more reform-based teaching practices after participating in PD.

At present, studies using the Science Teachers' Pedagogical Discontentment Scale (Southerland et al., 2012) are very limited. Based on initial results, the scale looks to be a promising start for identifying teachers who might be ready to begin changing their

practices. However, it is my assertion that pedagogical discontentment is not enough. Southerland and colleagues (2012) acknowledge that pedagogical discontentment is only one aspect of the affective state of teachers. While they briefly outline the thoughts, beliefs, and attributes as being important to teachers' propensity for change, they focus their efforts solely on identifying pedagogical discontentment, which they acknowledge is only the first condition necessary for change (Southerland, et al., 2011a). This fails to take into account why teachers may be pedagogically discontent, what caused the discontentment, and how they engage with PD, etc. in order to consider new practices. Researchers need to investigate other aspects of individual teachers' affective states, including background experiences, beliefs, goals, teaching practices, the negotiation of discontentment and crises experienced, and ultimately, meanings and motivation with regard to specific contexts. I argue that this can be accomplished more thoroughly through the study of professional identity, a construct that encompasses pedagogical discontentment as well as beliefs, goals, and motivations (Beijaard, Verloop, & Vermunt, 2000; Freese, 2006).

Teacher Professional Identity

Over the last two decades, teacher professional identity has emerged as an area of inquiry. Sachs (2005) describes teacher professional identity by saying that it:

...stands at the core of the teaching profession. It provides a framework for teachers to construct their own ideas of 'how to be', 'how to act' and 'how to understand' their work and their place in society. Importantly, teacher identity is not something that is fixed nor is it imposed; rather it is negotiated through experience and the sense that is made of that experience. (p. 15)

This section gives an overview of existing research on teacher professional identity and then presents an emerging model of teacher professional identity, which has roots in motivation theory and research.

Teacher Professional Identity Studies

Teacher professional identity is a relatively new area of research; however, there have been several studies of teacher professional identity over the last two decades. Beijaard, Meijer, and Verloop (2004) did a literature synthesis of 22 teacher professional identity studies from 1988-2000. They noted the absence of a definition of professional identity in many of the studies, but identified four common features of professional identity: (1) professional identity development is an ongoing process, (2) it involves both person and context, (3) professional identity involves sub-identities, and (4) it includes agency, or the active pursuit of additional learning according to goals (Beijaard, et al., 2004).

Likewise, Beauchamp and Thomas (2009) wrote a paper providing an overview of issues pertaining to teacher identity based on recent literature. They reported variables revealed in several studies, and their findings showcase the need for a more structured conception of professional identity. They found inconsistencies surrounding a definition, the importance of reflection, the influence of context, and the roles of self, emotion, agency, narrative, and discourse (Beauchamp & Thomas, 2009). Both syntheses also showcase the current focus of professional identity on pre-service teachers at the macro-level timeframe (i.e. months, years, and decades).

Science Teacher Professional Identity Studies

Pre-Service Teachers. Professional identity studies of science teachers also tend to concentrate on pre-service teachers at the macro-level timeframe and lack an agreed-upon definition or conceptual framework. Volkmann and Anderson (1998) focused on how a beginning chemistry teacher's professional identity developed in their phenomenological study. They found that the teacher experienced struggle in creating a professional identity that coincided with her personal identity that she negotiated through decisions regarding teaching dilemmas.

Using case study methodology, Varelas, House, and Wenzel (2004) followed ten pre-service teachers participating in summer internships at a science research lab and then after experiencing their first year of teaching. They used a sociocultural perspective on communities of practice to study differences in science and science teacher identities. They found that the pre-service teachers experienced a negotiation of both identities. The pre-service teachers saw the similarities and differences in science and school science, and experienced dilemmas and differences in incorporating their science and science teacher identities. However, Varelas, et al. (2004) noted that since the pre-service teachers' science and science teaching experiences did not overlap in time, they were unable to "reflect in action", meaning that some of the translation was lost.

Another study attempted to create a "designated identity" of pre-service teachers best suited to diverse settings. Settlage, Southerland, Smith, and Ceglie (2009) used mixed-methods to study science instruction in diverse settings. A subsample of six pre-service teachers participated in interviews designed to capture the essence of their identity. Data analysis led to categorizing the teachers as having a collective identity due to their uniformity of answers. However, the interview protocol focused on self-efficacy

and diversity, ignoring affective-cognitive characteristics such as sense of purpose, personal epistemology, and action possibilities.

Practicing Teachers. There are fewer studies of practicing teacher professional identity. These have also tended to concentrate on macro-level timeframes. Woolhouse and Cochrane (2010) focused on the increases in subject knowledge and the value of reflection in their mixed-methods study of general science teachers participating in a course to qualify them as physics or chemistry teachers. They found that as teachers became a part of their specific community of practice, they reconstructed their ideas of conceptions of good teaching. They posited that professional identity pertains to more than just subject and pedagogical knowledge.

Continuing with the theme of subject matter as it pertains to identity, Helms (1998) studied five secondary science teachers over the course of a school year, through whole-group meetings, observations, and interviews. Based on grounded theory analysis, she defined four dimensions of identity: (1) actions, (2) expectations from institutions, culture, and society, (3) future self, and central to each of the three dimensions, (4) values and beliefs. She suggested that subject matter plays an important role in teachers' professional lives and that an understanding of identity could lead to an understanding of career trajectory, including pedagogical and career choices (Helms, 1998).

Case study was used to look at two teachers who differed in their enactment of a PD. Enyedy, Goldberg, and Welsh (2005) researched two teachers who had participated in a curriculum PD and were enacting the curriculum in very different ways. They addressed each teacher's background, beliefs, and goals, and focused on how each teacher negotiated dilemmas. They found that differences in the teachers' identities were

consistent with differences in their teaching practices and that both teachers negotiated dilemmas based on their identity structures.

While the above studies touch on various portions of professional identity, the literature as a whole lacks a conceptual framework with which to understand teacher professional identity and its effects on teacher practices. We need a better understanding of the motivational processes associated with teaching and continuing education, namely, PD. Teachers come into PD with an identity system in place, including various perceptions, beliefs, knowledge, and goals. This identity serves as a lens to their experience of the PD and can enable us to better understand how they negotiate the experience.

Theory of Professional Identity

Personal Investment Theory. My conception of teacher professional identity can be traced back to Maehr and Braskamp's (1986) Personal Investment Theory (PIT) (see also, Maehr, 1983; Maehr & Nicholls, 1980). PIT is based on the assumption that motivation can be inferred from behaviors. Maehr and Braskamp (1986) posit, "[t]he critical antecedent of motivation is the meaning of the situation to the person" (pg. 46). Actions (personal investments) are the result of meaning that has been made of situations. They describe meaning as being made up of thoughts, perceptions, purposes, and goals. These affective-cognitive characteristics make up the three facets of PIT: (1) *sense of purpose*, (2) *self-perceptions*, and (3) *action possibilities* (Maehr & Braskamp, 1986).

Sense of purpose is described as the combination of pursuits and expected gains from a specific context (Maehr, 1984). Sense of purpose represents goals that can be broken down into four categories. (1) Task goals relate to a mastery of skills or

knowledge with a focus on building competence. (2) Ego goals focus on performance relative to others. (3) Social solidarity goals relate to pleasing others for social approval. Lastly, (4) extrinsic rewards goals refer to the receipt of external rewards (Maehr & Braskamp, 1986). *Self-perceptions* are a collection of thoughts about self, including perceptions, beliefs, feelings, and identifications (Maehr & Braskamp, 1986). Lastly, *action possibilities*, refers to the options perceived available to a person (Maehr, 1984). These possibilities are influenced by the sociocultural norms that a person perceives as dictating their choices (Maehr & Braskamp, 1986).

Meaning making indicates that a collection of thoughts is of principal importance to a person, and the process of meaning making is continuous, dynamic, and tied to social cultural contexts. Thus, personal investment is ever changing, and should be studied in context (Maehr & Braskamp, 1986). PIT has been employed in various contexts over the past three decades. Examples of this application include sports medicine (Duda, Smart, & Tappe, 1989), general psychology (Fyans, Salili, Maehr, & Desai, 1983), K-12 students (McInerney, 2008, 2012), and secondary physical education teachers (Lindholm, 1997).

Extension of PIT to Professional Identity. PIT has recently been adapted for use in developing a model of professional identity. Kaplan and his colleagues (2012a) have begun preliminary work on a conceptual model of professional identity that encompasses how a person develops and maintains his professional self. Kaplan, et al. (2012a) used Maehr and Braskamp's (1986) PIT to conceptualize the professional identity of university graduate teaching assistants. Through their coding process, they found that the three facets of PIT were unable to capture beliefs regarding knowledge, teaching, and learning, collectively known as *personal epistemology*. Thus, they added *personal*

epistemology to the PIT and created their model of teacher professional identity. They focused on an individual's professional identity system configuration prior to and after a graduate teacher training certificate program. They then looked for new relational alignments and tensions among the components that may have been triggered by the PD contextual factors (Kaplan, et al., 2012a).

The model was applied by Hathcock, Garner, Kaplan, & Davidson (2013), who did a case study of a physics teacher participating in an eight-day PD. We found that the four components captured the essence of the teacher's professional identity system. The teacher entered the PD with a somewhat unaligned professional identity system. He then experienced tensions in his identity system based on contextual factors associated with the PD. The integration of his personal and social-contextual characteristics triggered a change in professional identity components that left him with further tensions to confront. He left the PD with newly created tensions, indicating that he is exploring an aspect of his professional identity, which may lead to change (Hathcock, et al., 2013).

The vast majority of the current literature is devoted to macro-level timeframe studies. However, research can also be done on a micro-level timeframe (i.e. days, hours, minutes, and seconds). Researching teacher professional identity on a micro-level timeframe would allow researchers to get an in-depth look at PD in action. Specifically, it would enable us to look at how challenges to professional identity, including provocations of tensions, allow for the questioning, exploration, and potential for changes to self and practices (Smagorinsky, et al., 2004). There is a paucity of information regarding how teachers respond to PD experiences, especially on a micro-level timeframe that can capture the specific events triggering and realigning their professional identity

systems. Further, we need studies devoted to practicing teachers, many of whom are being encouraged to alter their practices to be more in line with reform-based instruction and finding that alteration difficult to achieve.

Justification for Study

This chapter began by outlining the current focus of reform-based practices in science education. This has led to the conundrum of understanding why teachers fail to adopt reform-based practices or adopt them at differential rates. Next, the chapter discussed PD as the vehicle for teachers' continuing education regarding reform-based practices and outlined best practices for inquiry-based PD, which includes a focus on teachers as individuals. This led to a discussion of the literature surrounding teachers' affective states, including pedagogical discontentment, which has been purported as a way to assess teachers' readiness for reform. However, I assert that pedagogical discontentment is not enough, and point to professional identity as a lens to study meaning and motivational process in teachers.

Pedagogical discontentment involves identifying dissonance between current and desired practices. The Professional Identity Model showcases this dissonance as tensions between components of the model that arise from triggering events, thus detecting situations leading to pedagogical discontentment. The background literature on pedagogical discontentment briefly discusses teachers' thoughts, beliefs, and backgrounds being important to understanding teacher change, but the concept of pedagogical discontentment focuses solely on discontent with current practices, which the authors consider to be the first condition necessary for change (Southerland, et al., 2011a). The Professional Identity Model, on the other hand, highlights the background

experiences, beliefs, goals, and possibilities of teachers through the four facets of the model: self-perceptions, personal epistemology, sense of purpose, and action possibilities (Kaplan, et al., 2012). Lastly, the literature on pedagogical discontentment indicates that teachers who are moderately pedagogically discontent and have sufficiently high self-efficacy are more likely to seek change (Southerland, et al., 2011a). The Professional Identity Model acknowledges seeking change as exploration that requires active reconstruction of professional identity in a safe context that includes scaffolding and opportunities to reflect (Kaplan, et al., 2012). This research seeks to better understand the relationship between these two constructs.

There are many calls for research that can be linked with teacher professional identity. Southerland, et al. (2011a) called for studies devoted to understanding why reform-based practices are adopted at differential rates. Southerland, et al. (2011b) then called for researchers to capitalize on or even trigger teachers' pedagogical discontentment in order to encourage the adoption of reform-based practices. However, they also contend that pedagogical discontentment is only one of many affective states that should be considered at the outset of PD. Capps, et al. (2012) called for studies investigating connections between PD and teachers' beliefs, knowledge, and actions. Finally, Opfer and Pedder (2011) call for research from a complexity thinking perspective aimed to better understand teachers' response to PD. These calls and gaps combined with the literature above lead me to want to study both pedagogical discontentment and professional identity of practicing teachers in the context of a micro-level timeframe PD setting.

This study sought to expand the current literature on science teacher professional identity by exploring both professional identity and pedagogical discontentment of practicing science teachers. The study addressed inconsistencies in professional identity literature concerning the lack of a consistent definition, influence of context, and the roles that self, emotion, and agency play (Beauchamp & Thomas, 2009). It also combined two fairly new constructs that need additional exploration, pedagogical discontentment and teacher professional identity, and honored teachers as complex systems who are influenced by characteristics such as prior experiences, beliefs, and goals.

Chapter 3: Methodology

This chapter describes the methodology for this study. It begins with a statement of purpose and a description of research design, including a discussion of the role of the researcher and research team. The chapter also provides an in-depth description of the research plan, including the context of the study, measures, data collection, and data analysis procedures. Next, the chapter provides the codebooks used for analyzing the data. Finally, the chapter provides an overview of strategies used to establish trustworthiness of the study.

Purpose Statement & Research Questions

The purpose of this study was to further explore and compare the constructs of pedagogical discontentment and teacher professional identity in practicing teachers participating in a reform-based PD. The research questions for this study were:

- (1) What were the patterns of change in science teachers' professional identities who participated in the professional development institute?
- (2) What aspects of the professional development institute were perceived to serve as triggers for change in teachers' professional identity?
- (3) How did science teachers' perceptions of pedagogical discontentment change as they progressed through the professional development institute?
- (4) What is the relationship between pedagogical discontentment and professional identity?

Research Design

Qualitative research allows for the study of a research topic or phenomenon within a specific context (Hays & Singh, 2012). Emphasis is placed on qualities, processes, and meaning (Lincoln & Guba, 1995), providing for rich descriptions from a small number of

participants. This study employed the case study approach within a social constructivism paradigm.

Case study was appropriate for this research because it incorporates retention of meaningful characteristics of contextual factors, while contributing to our knowledge and understanding of individuals and related phenomena (Yin, 2009). Case studies rely on multiple sources of data, which are then triangulated to form an in-depth description of the phenomenon in question (Yin, 2009). More specifically, this study employed a multiple case study design of five practicing teachers (Yin, 2009). Each teacher represented a holistic case; however, all of the cases were embedded within the context of the PD. This type of design allowed for rich descriptions of each case as well as within- and between-case comparisons.

Social constructivism served as the paradigm, providing an additional foundation based on the perceptions and meaning-making of each participant. In the social constructivist worldview, individuals seek meaning and understanding of the world through experiences. The goal of this research, then, was to capture and interpret participants' views and subjective meanings of situations within the context and boundary of the PD and in relation to their perceptions of actions (Creswell, 2007).

Role of Researcher and Research Team

Research teams are a recommended way of addressing subjectivity, encouraging the use of participant voice, which involves comprehensiveness, accuracy, and emotional content, and increasing trustworthiness in qualitative research (Hays & Singh, 2012). The primary researcher coordinated and conducted the data collection, and led the data analysis. The primary researcher also established and oversaw the research team, which

was composed of three of the members of the dissertation committee. The primary research team participated in data collection and data analysis, including meeting to discuss the data, coding structure, coding iterations, and results.

The primary researcher also chose an auditor to review the research audit trail collected and provided by the primary researcher. The auditor was experienced with qualitative and case study inquiry, but was a disinterested party so as to avoid a conflict of interest (Hays & Singh, 2012). The audit purpose was to “determine the extent to which the researcher completed a comprehensive and rigorous study” (Hays & Singh, 2012, p. 209). To this end, the auditor reviewed all documents included in the inventory list in order to confirm that the researcher actually conducted the research as proposed by comparing IRB, data and other supporting documents to the research methods section.

Context

The context of this study was an eight-day PD institute in August 2013. The institute encompassed a total of 56 hours, or seven hours per day. There were approximately 35 institute participants, consisting of two cohorts. The participants were from a large suburban school system serving 68,500 students. The year one cohort was composed of 17 teachers who previously participated in the 2012 PD institute, during which we conducted a pilot test of the interview protocol. This study involved five members of the year two cohort, who were experiencing the PD institute for the first time. The year two cohort was composed of 10 teachers from five high schools. They came from different subject areas, including biology, chemistry, earth science, and physics.

The focus of the institute was on reform-based teaching, presented to the teachers in the form of science content at the post-secondary level and strategies for incorporating

connections between science content areas using earth science and the nature of science. Science and education faculty from the local university and community college supported teachers as they participated in interdisciplinary field-based science projects and exploration and reflection on the infusion of nature of science and inquiry-based learning throughout the curriculum. A discussion of each experience is presented below.

Field Experiences. The PD included a collaborative, field-based science project, which was centered on a local waterway. Teachers worked in school-based, interdisciplinary groups composed of one teacher from each discipline. Together, they designed and conducted a field study that incorporated each of their subject areas. Facilitators worked with the teachers on a wide variety of data gathering activities in order to analyze the physical, chemical, biological, and earth science related features of the study area.

Field Data Analysis. After each field experience, teachers investigated the meaning of the data collected. They received support from the science facilitators to analyze the following data: physical and chemical properties of soil and water samples, quadrat samples, wells, elevations, latitude and longitude, biomass from organism samples, plankton samples, and characterization of biodiversity.

Inquiry-Based Science Projects. The field experiences culminated in interdisciplinary science projects. Each school-based group of teachers formulated hypotheses, specified methods of data collection and analysis, presented results, explicitly stated connections to nature of science principles, and connected their projects to the state standards of learning for each of the four subject areas. Groups presented their

projects during the last day of the PD institute and participated in walk-around discussions of each project.

Materials

Introductory materials were emailed to participants prior to the start of the PD institute. These included items such as readings on the nature of science as well as a questionnaire to be filled out online. This questionnaire included demographic information as well as the Science Teachers Pedagogical Discontentment (STPD) scale (Southerland et al., 2012). During the course of the PD institute, participants were given handouts pertaining to assessment, inquiry, and nature of science. They were also given cornerstone assessments, which were developed by the year one cohort of teachers.

Sampling Method

Cases were selected using a case study replication approach (Yin, 2009). Replication consists of carefully selected cases that are either a literal replication, in which they predict similar results, or a theoretical replication, in which they predict contrasting results that can be anticipated based on the conceptual framework. The primary researcher emailed each of the 10 cohort two teachers three weeks in advance of the PD institute asking them to participate in the interviews. Follow-up emails were sent to those who did not initially respond. Seven of the ten teachers elected to participate. The other three teachers did not respond to email requests.

Two of the seven cases were removed from the study. One case was removed because she did not complete the pre-institute survey, thus we had no pedagogical discontentment data. The other case was removed because her background and prior experiences were outside of science and high school, leading to a bad fit for the purposes of case

replication. She had several years of prior experience as an elementary and middle school teacher in another subject matter, and had only recently switched to high school science.

The demographic data for the five participants is presented in Table 1.

Pseudonym	Sex	Age	Ethnicity	Undergraduate Degree(s)	Graduate Degree	Teaching Certification	Years Teaching Science	Courses Presently Teaching
Barbara	F	57	Black	Interdisciplinary Studies	Educational Leadership	Earth/Space Science	21	Earth Science & Oceanography
Bill	M	57	White	Geology and Environmental Science	Earth Science	Earth Science & General Science	26	Earth Science & Oceanography
Lisa	F	30	Other	Biology and Geological Sciences	Curriculum & Instruction	Biology & Earth Science	7	Biology & AP Biology
Penny	F	33	White	Biology	Secondary Education	Biology & Chemistry	10	Chemistry
Tony	M	29	White	Chemistry and Music	Education	Chemistry & Physics	2	Chemistry

Table 1. Demographic Data for Study Participants

Measures to Ensure Participant Safety

This study was approved through Old Dominion University's Institutional Review Board prior to implementation. Participants signed an informed consent document that outlined the purpose of the project, uses of the data, confidentiality, risks, benefits, withdrawal, and consent to record the interviews. The data has been kept confidential in the following ways. After collecting, scoring, and transcribing the data, each participant was given a pseudonym and referred by that in all file names, writing, and communication among the research team. The primary researcher stored all files pertaining to this research on a password-protected file server.

Measures

This study employed the use of semi-structured interview protocols, the Science Teachers' Pedagogical Discontentment (STPD) scale (Southerland et al., 2012), daily

reflections, and exploration and commitment cards. These measures are explained in further detail below.

Semi-Structured Interview Protocols. Semi-structured interview protocols were developed by the research team for the pre-institute and mid-/post-institute interviews based on a table of specifications (see Table 2). Tables of specifications serve to increase content validity of an instrument in that questions are easily mapped to a conceptual framework (Leedy & Ormrod, 2010). The table of specifications contained the three constructs of Personal Investment Theory, (1) self-perceptions, (2) sense of purpose, and (3) action possibilities (Maehr & Braskamp, 1986), as well as the additional construct of personal epistemology, which was added by Kaplan, et al. (2012a) in their Theoretical Model of Professional Identity. The questions pertained to the constructs with regard to science teaching and the PD, allowing for an exploration of teaching practices, planning, and the teacher as a learner. Since each of the categories of variables in the Theoretical Model of Professional Identity is related, there was a great deal of overlap in the table of specifications. Reliability and validity of the interview protocol were established through congruence of the model to the questions. The interview protocols are presented in Appendix B.

Construct	Self-Perceptions		Sense of Purpose		Personal Epistemology		Action Possibilities	
	Pre-	Mid- /Post-	Pre-	Mid- /Post-	Pre-	Mid- /Post-	Pre-	Mid- /Post-
Questions Regarding Teaching	2, 3, 4, 5, 6, 7, 9	1, 2, 3, 4, 5, 6	3, 4, 5, 6, 7	1, 2, 3, 4, 5, 6	3, 4, 5, 6, 7	1, 2, 3, 4, 5, 6	3, 4, 5, 6, 7	1, 2, 3, 4, 5, 6
Questions Regarding the PD	1, 8, 9	1, 2, 3, 4, 5, 6	1, 8	1, 2, 3, 4, 5, 6	1, 8	1, 2, 3, 4, 5, 6	1, 8	1, 2, 3, 4, 5, 6

Table 2. Semi-Structured Interview Protocol Table of Specifications

STPD Scale. The STPD scale contains six categories of pedagogical discontentment: (1) ability to teach all students science, (2) science content knowledge, (3) balancing depth versus breadth of instruction, (4) implementing inquiry instruction, (5) assessing science learning, and (6) teaching nature of science (Southerland, et al., 2011b; Southerland, et al., 2012). There are 21 statements in the scale, and teachers are asked to rate their discontentment regarding each statement on a scale from one (no discontentment) to five (very high discontentment).

The categories were established through interviews with 18 practicing science teachers (Southerland, et al., 2011b). Southerland, et al. (2012) then used the identified themes to develop the STPD Scale, which was given to 171 practicing teachers. They used these to perform an exploratory factor analysis, which led to the addition of the sixth category of pedagogical discontentment, that of teaching nature of science. Finally, the amended scale was given to 462 practicing teachers, and a confirmatory factor analysis was subsequently performed using a maximum likelihood method. The results were $\chi^2(173) = 479.54, p < .01, CFI = .95, RMR = .05$, and a 90% confidence interval for the $RMSEA = .05-.07$, which indicated a good to very good fit of the model to the data. A Cronbach's alpha internal consistency reliability analysis was used to determine the reliability of the instrument as a whole as well as for each subscale. The reliability coefficient for the entire instrument was .93. Alpha coefficients on the subscales ranged from .77 (science content knowledge) to .89 (balancing depth versus breadth of instruction), indicating a medium to high level of consistency between the items in the subscales and the items as a whole (Southerland, et al., 2012). The final scale is presented in Appendix A.

Daily Reflections. Participants were asked to reflect on each day of the PD institute in the form of written reflections. Their answers were used to triangulate with their interview data. They received eight copies of the reflection sheet, which contained the following reflection questions:

1. What during today's institute was most relevant to you, how, and why? Please explain.
2. What activities, methods, concepts, or thoughts from today could inform your classroom instruction? Explain.

Exploration and Commitment Cards. On the last day of the PD Institute, participants were asked to identify and write down areas they planned to explore during the school year as well as commitments they made with themselves to do during the school year. Their answers were used to triangulate goals and action possibilities with their interview data. Participants responded to the following prompts:

1. Describe and explain the possibilities for classroom applications that you have considered.
2. Describe and explain any goals for your teaching that you have reflected on or considered.
3. Describe and explain any nature of science concepts of issues that you considered.
4. Describe and explain any roles that you saw yourself in.
5. Describe 1-3 commitments to transfer what you have experienced at the institute into your work this year.

Table 3 provides a description of each measure along with the research questions addressed.

Research Questions Addressed	Instrument	Description	Data Analysis
RQ 1 RQ 2 RQ 3 RQ 4	Semi-Structured Interview Protocol	Transcribed audio recordings of narrative data	Code for professional identity and pedagogical discontentment; triangulate with all
RQ3 RQ4	STPD Scale	Likert-type scale	Subscale and overall scale totals; triangulate with interview data
RQ 1 RQ 2 RQ 4	Daily Reflections	Participant generated written data	Code for professional identity; triangulate with interview data
RQ 1 RQ 2 RQ 4	Exploration and Commitment Cards	Participant generated written data	Code for professional identity; triangulate with interview data

Table 3. Measures Employed

Data Collection Procedures

A link to a survey including the STPD scale as well as demographics information was emailed to participants prior to the start of the PD Institute. Participants completed the survey in the two weeks leading up to the start of the institute. The STPD scale was also given after the PD institute as part of a post-PD institute survey that was emailed to participants.

Pre-, mid-, and post PD Institute interviews were conducted via phone or in person and audio recorded. Pre-institute interviews were conducted during the two weeks prior to the PD Institute. Mid-institute interviews were conducted during the long weekend (Thursday afternoon – Monday morning) in between the first and second weeks of the PD. Post-institute interviews were conducted during the week following the PD Institute.

Daily reflections were written at the end of each day of the PD Institute. Participants were asked to leave their reflections each day. A member of the research team

photographed each reflection and returned them to participants the following day. The exploration and commitment cards were filled out during the afternoon of the second to last day of the PD Institute, photographed, and returned the following day.

Data Analysis

Data was analyzed in three major stages by the research team. Stage one involved transcription and scoring. Stage two included coding for both professional identity and pedagogical discontentment. Stage three involved case analysis, cross analysis, and cross case synthesis. Each stage of the data analysis is further discussed below.

Stage One

Stage one of the data analysis involved assigning pseudonyms to the participants. Next, interviews, daily reflections, and exploration and commitment cards were transcribed and wiped of identifying information such as the school district name. The STPD scale was also scored for both subscale and overall totals.

Stage Two

Stage two of the data analysis involved coding the interviews, daily reflections, and exploration and commitment cards using NVivo software for qualitative research. The research team used an Eclectic Coding procedure that employed two or more coding methods (Saldana, 2013). Provisional Coding (Miles & Huberman, 1994; Saldana, 2013) was established based on the conceptual framework of the professional identity model, categories of pedagogical discontentment, as identified by the STPD scale, and previous findings from our pilot case study (Hathcock, et al., 2013). The research team also used Subcoding to assign second-order tags to some of the primary codes. These “parent” and “child” nodes served to enrich the coding entries as well as allow for greater specificity

within the Provisional Codes (Miles & Huberman, 1994; Gibbs, 2002; Saldana, 2013). The research team used Simultaneous Coding for instances when the components of the professional identity model and pedagogical discontentment overlapped (Glesne, 2011; Saldana, 2013). The research team coded sections separately and then worked toward consensus coding by discussing and establishing a shared operational definition for each code and conducted consensus meetings (Hays & Singh, 2012). The codebooks used for both professional identity and STPD are presented below.

Professional Identity Codebook. First cycle coding for the professional identity model was done using provisional coding. The four main components of the model were used to capture the participants' identity system within interview narratives collected at pre-, mid-, and post-PD Institute, reflective explorations written daily, as well as an Exploration & Commitment assignment completed near the end of the PD. The four components of the model are presented below along with descriptions, markers in the data, and examples of some of the subcategories of each component.

Self-perceptions. Self-perceptions refer to a collection of thoughts about self-related perceptions, beliefs, feelings, and identifications (Maehr & Braskamp, 1986). Examples for markers in the data that precipitated self-perception codes included references that began with phrases such as "I was a", "I just always liked", "I'm a scientist", "I always have been able to", "I'm always teaching", and "I am a specialist". The interview data included a range of self-perceptions based on both current and prior experiences. Examples included perceptions about becoming a teacher, perceptions about self as a learner, and perceptions of the PD experience.

Becoming a teacher. Participants were asked about how they became teachers during their pre-institute interviews. Three of the five participants did not originally set out to be teachers. Penny (see Table 1 for participant demographics and Appendix C for Case Summaries for each participant) perceived that becoming a teacher “just kind of fell into place over the years”. Lisa and Tony both wanted to be doctors. Lisa changed her mind after an experience shadowing a doctor left her feeling that it would not be as “fulfilling” a career as she had thought. Tony realized that biology “didn’t click”, but chemistry and physics did, and felt that experiences with kids were “fulfilling”. Barbara, on the other hand, wanted to teach since grade school, which she attributed to having a teacher who she “really adored”. Bill said that he was “always kind of a teacher”. However, he went into the oil industry after college because he said there were too many teachers. He became a professional teacher after the oil industry began to falter.

Self as learner. Participants also expressed self-perceptions about themselves as learners, particularly during the mid- and post-interviews. Penny and Barbara seemed to see themselves as being similar to high school students during the PD. Penny said that the PD institute reminded her of “what it’s like to be a student again, what it’s like to be in the learning process” (Mid). Similarly, Barbara said that the PD institute allowed her to see things “from a learner perspective” (Mid). Tony and Bill seemed to see themselves as college students during the PD. Tony said that “it was nice to get back into a lab” (Mid), and perceived that the experience was “right in normal life” from a “chemistry perspective” (Mid), referring to the lab work as college level material. Bill said that he felt like he was “going back in time” (Post) and made comparisons to his experiences in college labs.

Perceptions of experiences. Participants discussed various perceptions about their experiences with the PD institute. For example, Barbara said that she did not initially want to attend the PD, but at the mid-interview, she said, “I’m glad that I didn’t miss it, and I think that it’s a good opportunity for me as a learner” (Mid). Bill said that the PD “reminded me what I like to do” (Post). Penny’s experiences with portions of the PD, such as designing and implementing her group’s field study and working with the LabQuests, led her to increased self-efficacy associated with trying those types of activities in her classroom. She said she had “so much more confidence” (Mid) to try those types of activities after having done them during the PD.

Personal epistemology. Personal epistemology refers to beliefs about the nature of knowledge, teaching, and learning (Pajares, 1992). Examples for markers in the data that precipitated personal epistemology codes included references that began with phrases such as “I think”, “I thought”, “I don’t think”, “I realized”, “I know”, “A lot of people don’t realize”, and “The kids usually understand it when I”. Participants expressed a wide array of beliefs about topics such as science and scientists, learning, teaching practices, and students.

Beliefs about science and scientists. Four of the five teachers expressed beliefs about science. For example, Lisa believes that science is “very dynamic, and when we think we’ve got it, it changes, and then we kind of get a new perspective” (Pre). Tony believes that scientific theories often begin in “art or history or philosophy or creativity and imagination” rather than “hard science” (Pre). Barbara believes that oceanography, which she teaches, is different from other sciences because it is composed of so many different sciences. She said:

“I kind of don't think of oceanography as one of the hard sciences because I kind of think of it as a hodge podge; I don't think of it as a specialty. I think I look at it that way because it incorporates so many different sciences” (Mid).

Finally, Bill expressed some beliefs about scientists after having worked with other teachers at the PD institute. He believes that “scientists always like to look at things” (Mid). He also discussed scientists' appearance, which are in keeping with stereotypical views (Chambers, 1983), saying, “...most of us don't care how we look, you know, it's funny that the typical scientist has got messed up hair and glasses and a lab coat but that's typical”(Mid).

Beliefs about learning. Four of the five teachers expressed beliefs about learning. For example, at the end of the PD, Penny expressed the following belief,

“I think process actually leads to a better product. Even if there are still unanswered questions, the process has allowed you to gain so much more than had the teacher said, here these are your supplies, this is the procedure, do it” (Post).

After the first week of the PD, Barbara expressed the belief that having students “develop their own investigation” is “more engaging” and “more relevant” (Mid) to her students. Tony believes that “passing a minimum proficiency test is really not worth celebrating” (Pre). Rather, he believes that it is much more meaningful to be able to “come up with surface answers as well as deeper meaning and the value of being able to understand why you got to those answers” (Pre). Finally, Lisa believes that her students learn best when they “get to put their hands on things” (Pre). She also believes that teachers learn the same way, saying,

“I think teachers are just as bad as the students in that we have really short attention spans. And if it's something we can do, something we can think on our own, something we can collaborate, I think teachers come away with a lot more when they're able to work together versus just being told things through a PowerPoint”(Pre).

Beliefs about practices. Each of the teachers shared a variety of beliefs about their practices during the interviews. For example, Tony believes that science teachers do not let students fail enough. He believes that the problem stems from grades, saying, “[a] final product by the end of a time frame is what forces, you know, failure is good, but not having a product is bad” (Mid). Barbara came to the belief during the first week of the PD institute that the labs she implements are of the cookie-cutter variety. She said, “the objective is already there, they already know what procedures to take, so they’re just kind of basically following somebody else’s structure” (Mid).

Penny believes that the constraints associated with the SOL necessitate her adopting a lecture style of teaching sometimes. She said, “you just have to have some of those days in order to get through so much information before the SOL” (Pre). Bill seemed to believe that he could not do more inquiry-based activities because “normally I don’t have time to waste for them not to get something” (Mid). This coincides with his belief that he has to make all of his classroom activities “canned”. He said, “we have to do the cookbook stuff. We have to make everything canned. We know what the kids are going to get regardless of what we tell them we don’t know, but we know” (Post). Finally, Lisa believes that she is limited in the classroom by budget cuts and SOL testing. She finds that many of the things she would like to do with students are not possible, “because everything is always about money and we don’t have money for that” (Pre). She also believes that teachers are limited by their “fast paced pacing guides”, which causes them to “go at 50 mph all year long” (Mid).

Beliefs about students. Each teacher also shared a variety of beliefs about their students. Most of these pertained to students’ lack of ability or lack of motivation. Lack

of ability presented itself in a few different ways. For example, Barbara believes that many of her students are not prepared for “higher level work” (Pre). She believes that her students should come to oceanography knowing some earth science concepts, but she finds that they do not. Tony believes that there is a “huge difference in just skill set” (Mid) between his students and college level students. He believes that students do not have the “skill set ingrained in them” (Mid) to do lab work similar to what he did at the PD. This includes simple things “that are in science from day one”, such as “if I have a sample, I have to label it. If my sample looks like your sample and we both put it on the desk, we don’t know whose sample it is” (Mid). Penny believes that a “significant” number of her students struggle with algebraic skills such as isolating variables, and reading comprehension, which can “hold back a class” (Pre). Bill believes that his students would “just freeze” (Post) if they had to try to solve large problems, saying that he is “dealing with the lower end” of students, and calling them the “curdled cream of the crop” (Post).

Lack of motivation was also expressed in different ways. For example, Barbara believes that her students seek “instant gratification” (Pre). Because of this, they do not like to “look at things or study things outside of class” (Pre). Rather, they just want her to “tell them the answers” (Pre). Penny believes that her students are “very needy”, saying, “...things they could answer for themselves, they’re calling my name, sometimes 5 times in 30 seconds” (Pre). Lisa believes her students will be frustrated with a more open-ended approach to learning because they do not want to have to think. She said, “this generation of students is very much, just tell me what to do. And if you don’t tell them in 5 minutes, they get angry and then sit out” (Mid). Finally, Bill believes that it is very difficult to get

his students out into field. This is based, in part, on his belief that his students are apathetic toward learning, which causes them to get bored easily and avoid work. He said, "I can't take them out to a mudflat for half a day. They're just not going to be focused. I might get one kid that's focused, but the problem is I have 30" (Mid).

Sense of purpose. Sense of purpose is described as the combination of pursuits and expected gains from a specific context (Maehr, 1984). Examples of markers in the data that precipitated sense of purpose codes included references that began with phrases such as "My goal", "I try to", "I always wanted to", "I can use that to show", "It gives me the opportunity to", "I can actually show them", "I have to find", and "I'm always looking for". Participants discussed a wide range of purposes and goals for their students and for themselves.

Purpose and goals for students. Participants expressed a multitude of goals for their students. For example, Tony, Bill, and Lisa all expressed the goal of students taking more ownership of their learning. Some of Tony's other goals for his students were for them to "think bigger and think deeper", "understand why you got to those answers", and be able to "bring in that next level of thought" (Pre). He left the PD with the goal of having students grapple with "difficult questions that we would never be able to touch otherwise" (Post). One of Bill's goals is for his students to leave his class with an understanding of the science he taught, which to him does not necessarily mean a high grade, but rather, for them to see the relevance of science to their lives. After the first week of the PD, he also expressed the goal of getting students to "figure out a solution on their own" (Mid). Lisa's goals for her students include wanting them to "explore their

own interests”, “do their own research”, “show their creativity”, and to “produce their own products” (Pre).

Penny would like for her students to experience success. She said:

“I think that the kids having opportunities to be successful and then being successful and getting...not only knowing the material, where they've grown in their knowledge, but they're excited about learning also; they feel successful also, like they could do anything. (Pre)”

She was also focused on choice and students “actually doing things instead of just kind of sitting” (Pre). She left the first week of the PD institute with the goal of “allowing kids to design their own experiments” (Mid). Barbara said, “student achievement is basically what I’m interested in” (Pre). Associated goals consist of “helping students understand” (Pre) what she is trying to teach them. She would also like for her students to become “more self-directed learners rather than wait for me to give them the answers” (Pre). Over the course of the PD, she developed additional goals for her students, including wanting them to “construct their own meaning”, “develop those inquiry skills”, and “want to learn things” (Mid).

Purpose and goals for self. Participants also expressed various goals for themselves. For example, Barbara would like to be “more of a facilitator” (Pre), which would involve her “stepping out of the way” (Mid). Her goal for facilitating student experiences includes “guiding them to find their own answers rather than telling them my answers or what they should think” (Mid). Tony’s perceived purpose as a teacher is to prepare his students for their futures. He said, “I’m not teaching to high school; I’m teaching for the future” (Pre). He would also like to have “true interaction[s]” with his students and develop “relationships” (Pre) with them. Penny’s goal for herself is to know that she is making “a difference” (Pre). She left the PD Institute with the goal of developing “better

habits” (Post), including the way she questions students, her assessments, and what students do in her classroom.

One of Bill's goals for teaching is to “bring the real world in” (Pre). He brings photographs and videos of his science-related vacations into the classroom in order to show his students “first-hand” experiences and, “actually show them that I was standing right beside the ones that are mentioned in the textbook” (Pre). One of his goals as a learner at the PD Institute was to find, “...anything that I can see a small change in that ties to something that the kids could see” (Mid). He seemed to leave with the goal of making something to show his students the “real stuff” he had done during the PD, saying, “I’ll create something and use that as a way to get my kids to see the real stuff” (Post). Finally, Lisa's perceived purpose as a teacher is to share her love of science to future generations. She left the PD institute with the goal of examining and altering her assessments to make them more valid. Her associated goal is to “get a better idea of what the students really understand” (Post).

Action possibilities. Action possibilities refer to the options perceived available to a person in a given situation (Maehr, 1984). Examples of markers in the data that precipitated action possibilities codes included references that began with phrases such as “I tell the students”, “I usually”, “I came up with”, “I can bring some of that back in”, “I do”, “I started explaining”, “I keep telling the kids”, and “I don’t plan on”. Participants discussed their current practices, plans for the future based on their experiences at the PD institute, and perceived limitations surrounding their action possibilities.

Current practices. The participants discussed some of the current practices, particularly during the pre-interview. For example, Lisa discussed activities she

implements in class such as students designing and building remotely operated vehicles, and taking students outside to photograph items and connect them to what they learned in class. She also gave an example of her students coming into her class with an understanding of cell division and mitosis. Rather than re-teaching the concepts, she had her students create a product that demonstrated their understanding.

Penny participated in a PD initiative the previous summer that emphasized field investigation and inquiry-based learning. Based on that experience, she developed an activity for the beginning of the school year in which her students designed their own experiments. This included hypothesizing and identifying dependent and independent variables. Penny also discussed her assessment practices, focusing the discussion more on formative assessment tools such as exit tickets and simulation-style software that allows students to manipulate and interact with concepts.

Tony discussed asking students “bigger picture questions” (Pre) and giving them time to “interact” with each other and him. He also mentioned “food science” (Pre) labs such as a gummy bear and marshmallow lab for bond angles. Tony also discussed his practice of co-planning with another chemistry teacher from his school. They split the planning and workload and then meet between classes to determine what they need to modify.

Barbara said that she enjoys “presenting information and helping students understand it” (Pre). She also discussed practices involving her students doing “little projects where they have to do some of the research on their own and having them present in class” (Pre). Examples included giving her students opportunities to “present information as a teacher”, “work in small groups”, and trying to implement “project based learning” (Pre),

in which students have to “create” things in order to determine their level of understanding.

Finally, Bill discussed bringing “real-world” (Pre) things into the classroom for students to view and discuss. Many of the things he brings in come from his personal vacations. He seems to want his students to see him doing science. He brings in pictures and videos of him doing things such as swimming with sharks or standing beside rocks in the Grand Canyon. He also brings live animals into the classroom for students to identify.

Plans for the future. During the mid- and post-interviews, participants discussed plans they were making for their classrooms that were based on their experiences with the PD institute. For example, Bill and Lisa were both planning to make a poster of the NOS principles to hang in their classrooms. Lisa was also planning to bring more open-ended questions into her teaching, and seemed to be thinking of taking more of a facilitator’s role. She gave the following example:

“So maybe instead of saying, let’s test how temperature is going to affect yeast fermentation, maybe I’ll say, you guys come up with an experiment that we can test on yeast fermentation and let them pick the variable, let them pick the procedure, let them pick whatever they want. And I will kind of model that with how you guys did that with us where I’ll give them the big picture and then let them collaborate and work together and maybe do some research and figure out what they could do and how they could do it and guide them through it” (Mid).

Bill was also making plans for bringing some of his PD experiences into his classroom. He discussed the idea of taking his students into the school yard, perhaps to put wells in to look at rainwater and drainage issues, which he referred to as a “mini-field trip” (Mid). He was also planning to do something similar to the plankton study he worked on during the PD, but on a smaller scale. He was intending to have his students

work in lab groups, and have them discuss ways to solve the small problems he would come up with in order to “figure out a solution on their own” (Post).

Penny said that she made a “huge list” (Post) of things she wanted to do in the classroom based on her PD experience. This included having the students design and carry out their own scientific investigation, using the LabQuests, and having the students work in groups that she purposefully designs. She was also looking to add some NOS activities such as an observation versus inquiry activity or something pertaining to creativity in science. Penny was also focused on working toward student autonomy, and was planning to refine her questioning techniques and provide her students with a more inquiry-based classroom, which she felt would further their autonomy.

Tony was considering having students do experimental design without doing the actual experiment. He explained that having them do the design without the experiment would be useful for instances when he does not have access to equipment, but knows it is actually available. He described what the process might look like, saying:

“I think it would scaffold over time, that at first you would start with just one step and then what instrumentation might you use and then what hypothesis would you have. And then in a different experiment, what hypothesis would you have and then what would you use. And then go through the research on finding out the instrumentation and what it requires” (Mid).

He was also considering doing a “brain trust concept”, which he explained as, “basically a think-pair-share group concept that you do think, and then you pair up and do small groups, and bigger small group of 4-6 and then those 4-6 can come up with results” (Post). He was also thinking of having his students do presentations, which would “still cover” all of the material, but “instead of 3 days of lecture”, you could have “only one day of lecture, one day of research, and one day of presentations” (Post).

Barbara was planning to have her students collaborate more. She was thinking of giving her students additional time for some activities such as reflection and reevaluating hypotheses. While she had not yet made any concrete plans, she said, “so at least I think I’m going to try to be a little bit more open” (Post). She was also thinking of giving her students more control in the classroom, including allowing them “to do...rather than just giving them something that’s already prepared” (Post).

Perceived limitations. Participants also discussed perceived limitations to their action possibilities. For example, Barbara discussed having to “spend a lot of time on basic things” (Pre) because her students enter the class without conceptual knowledge she feels they must have. Lisa felt that some of her practices were limited due to funding and time constraints associated with teaching an SOL-tested course. She gave examples of practices she was able to implement when teaching a non-SOL-tested course, which seemed to include a more project-based learning approach. She said:

“I was able to do so many environmental projects. Like we grew dune grass. We were able to plot it into a swampy area later in the year. We did oysters, and my kids raised the baby oysters and we monitored and measured them throughout the year. We did boat trips. We went out and planted dune grass” (Pre).

Now that she teaches an SOL-tested course, and there is less money in the budget, Lisa is looking for alternatives to some of the activities she no longer considers as options.

Penny also feels that some of her practices are limited due to the SOL. She gave several examples of how her labs differed pre- to post-SOL. The post-SOL labs seemed to include more of a focus on students doing, creating, and having choices.

Bill continually struggled with perceived limitations to his action possibilities. These limitations were based on his beliefs about his students’ inability as well as his beliefs about the way school works. For example, he did not think bringing his students

into the field would work well because “they’re just not going to be focused” (Mid). This led him to make plans to bring his experiences back into the classroom for his students to see, but he was struggling with that as well, saying, “...I don't know how I can translate walking across the mud flat to get the kids to get it” (Mid). Interestingly, although Bill felt that he could not take his students on large field trips, he also seemed to believe that a short field trip within his school yard was not a good option either. When discussing the possibility of doing so, he said, “...that's a small thing...that's a 10 minute discussion in your class. It's a mini-field trip, but it's not a whole lot” (Mid).

Alignment of components. The Theoretical Model of Professional Identity (Kaplan, et al., 2012a) conceptualizes teachers’ professional identity system as a dynamic system. Each participant’s self-perceptions, personal epistemology, sense of purpose, and action possibilities occur in a co-active, interdependent operation that is contextualized. Other factors including social context, culture, and individual characteristics also contribute to the dynamic construction of the model (Maehr & Braskamp, 1986), thus each person’s particular experience, available information, and sociocultural context combined with the PD context to influence the individual experience and led to the self-emergence of their professional role-identity. These interconnections, or alignments, were present, to differing degrees, within each participant’s professional identity system. Participants also experienced misalignments, in which components of the system were experiencing tensions due to a lack of coherence between one or more of the components of the model. An example of alignment comes from Penny’s interviews. She entered the PD institute demonstrating alignment in several areas. She perceived herself as an “approachable” teacher who loves her students, which aligned with her goal of creating a

safe learning environment with a family atmosphere and her practice of formatively assessing students in order to gauge their level of understanding and comfort. Penny valued a more student-centered, inquiry-based approach to teaching, believing that this type of instruction allowed her to see her students in a different light because they were actually “doing things” and that both she and they find the class more enjoyable. However, her purpose of preparing students for the SOL test combined with her perceptions and beliefs about the pressure to cover the material prior to the SOL test led her to adopt a direct-instruction approach to teaching more often than she would like, which indicated some misalignment between her beliefs about best practices and her goals and action possibilities involved in preparing students for the test.

Another example of alignment can be seen in Bill’s interviews. He came into the PD institute with alignment between his beliefs about not being able to take students into the field and his practice of bringing his vacations into the classroom in the form of photos, videos, and discussions. This also aligned with his purpose, which was to “give everybody experiences”. He echoed this alignment by referring to his perceptions of himself as a scientist as well as his belief that he had more authority in discussions due to his experiences and photo and video proof of those experiences. Bill also demonstrated alignment between his beliefs about assessment, his goals for his students, and his practice of giving them multiple opportunities to show understanding. Participants came in with various levels of alignment present. Over the course of the PD, some participants experienced misalignments and realignments and they negotiated the PD experience with their existing professional identity structure. These changes will be elaborated upon in the next chapter.

Pedagogical discontentment codebook. First cycle coding for pedagogical discontentment was done using provisional coding and subcoding. Provisional coding was applicable to this work due to Southerland et al.'s (2011a; 2011b; 2012) existing publications in which they describe and define six categories pedagogical discontentment as represented in the STPD scale. I developed the provisional pedagogical discontentment codes directly from definitions and descriptions provided in Southerland, et al.'s published papers in which they gave brief definitions of the categories of STPD along with three to four sub-categories of each (2011a; 2011b). These were based on interviews they did with 18 practicing teachers, which they then used to create the STPD scale. While Southerland, et al.'s (2012) sub-categories are a form of provisional coding, they are also considered to be subcoding because they further detailed the categories of STPD. Provisional codes were also developed from Southerland, et al.'s (2011a; 2011b; 2012) descriptions and definitions of contextual discontentment. Contextual discontentment was included in the codebook due to Southerland et al.'s inclusion of it in their discussion of STPD and in the directions for their STPD scale. The six provisional categories of STPD codes and provisional code of contextual discontentment are presented below along with definitions, descriptions, associated subcodes, and examples of coded sections. An example of the first cycle coding for pedagogical discontentment would be assigning the provisional code of 'Teaching NOS' and then further detailing it by assigning the subcode 'Developing strategies to teaching NOS'.

Implementing inquiry instruction (IB). IB was described as "...inquiry-based pedagogies as discussed in the national reforms, in which students are moved toward asking questions about phenomena, finding appropriate methods to answer those

questions, then generating explanations" (Southerland, et al., 2011b, pg. 451). Subcodes included:

a. Preparing students to assume new roles as learners within inquiry-based learning

Barbara: "It's helping me to think about some things that I want to do in the classroom in terms of helping the students become or use more inquiry for using inquiry to construct their own meaning and then me stepping out of the way and becoming more of a facilitator. I don't want to use teacher, but say becoming more of a facilitator and guiding them to find their own answers rather than telling them my answers or what they should think. Developing their own thinking or developing their own...it's kind of like developing their own hypothesis. You develop your hypothesis rather than developing what I think it should be." (Mid)

b. Using inquiry-based teaching within all content areas

Bill: "And like I said, it's just I've got to figure out how I can do this for all the different stuff I do. It's not going to happen overnight, but at least I'm motivated to find little ways." (Post)

c. Assessing students' understandings from inquiry-based learning

No instances were coded.

d. Ability to plan successful inquiry-based activities/learning

Penny: "So I'm going to do a field investigation. I'm going to give them time to design their own field investigation and I want to go out into the field and I want to use the Lab probes. And I think if I can't get a field trip, I can at least, there's a little lake, we call it Lake (school), there's a little lake on our campus, so maybe we could get out there and do some water sampling or whatever it might be. So I'm excited. I want to do it. I'm going to do it." (Mid)

Ability to teach all students science (AL). AL was described as "adapting teaching practices for a wide variety of student abilities" (Southerland, et al., 2011b, pg. 443). This included, "teaching science to students who were not like themselves with regard to science backgrounds, English language abilities, or learning dispositions..." (pg. 444) and recognition that "current teaching practices did not equally serve a heterogeneous student population" (pg. 445). Subcodes included:

a. Teaching science to students of lower ability levels

Bill: "And I'm dealing with lower end. If it was an AP class, I might be able to have a larger part where they think through it. I have to find ways that are small that allows them to think through it and then they can take a little ownership in what they did."

(Post)

b. Orchestrating a balance between the needs of both high and low ability-level students

Bill: "It's the fact that most of the kids taking oceanography haven't met the math requirements yet. So they're not the...I always call them the curdled cream of the crop. It's kind of...and I get some really smart kids. I get some seniors who have done their math and done their sciences and they go to senior year and they want to kick back so they take oceanography because everybody kind of knows that it's a lower end science because of who's taking it. And I do sometimes see them get flustered because sometimes they're so bright. So a lot of times they'll take initiatives on their own to do things, which is great. I give them little extra credit projects and they go to town on it. So, it just depends." (Post)

c. Including all ability levels during inquiry-based teaching and learning

No instances were coded.

d. Teaching science to students from economically disadvantaged backgrounds

Barbara: "[y]ou know our students are at risk and sometimes they need a lot more nurturing and guidance than a lot of other students." (Mid)

Science content knowledge (SC). SC was described as a "perceived lack of science content knowledge." (Southerland, et al., 2011b, pg. 448). This included, "ways in which teachers problematized aspects of their current science teaching through a discussion of science content" (pg. 448) as well as content knowledge's "...role in generating relevant teaching strategies (PCK)." (pg. 448). Subcodes included:

a. Having sufficient science content knowledge to generate lessons

Bill: "Well, like I said, I was a geologist, so I really used my science; I didn't just study the book. But I was also...I have a bachelors in geology and I also have a bachelors in environmental science, so I was the original science hippy, I guess. But yeah, so I'm more of a scientist than a teacher because I really used my stuff." (Pre)

b. Teaching science to students of higher ability levels

No instances were coded.

c. Teaching science subject matter that is unfamiliar to me

No instances were coded

d. Having sufficient science content knowledge to facilitate classroom discussions

Bill: "And a lot of the kids will ask me, well why did you quit the oil business, 'cus they know I would make a lot more money there. I say well, when businesses go under, you don't make any money, so it's just one of those things. So they always seem to key in on the money a little bit. But I guess that's normal for teenagers. They tend to be interested. I...if a student knows that you actually did those things...when you teach them, you're teaching more from authority than just from textbooks, so they tend to ask questions that are a little more real world sometimes because they know you did it, so they're asking." (Pre)

Balance depth versus breadth of instruction (DB). DB was described as a teacher's ability to "orchestrate a successful balance between covering a wide range of material and engendering deep student learning, including long term planning concerning scope and sequence of instruction." (Southerland, et al., 2011b, pg. 449). Subcodes included:

a. Balancing personal science teaching goals with those of state and national standards

No instances were coded.

b. Balancing personal science teaching goals with state/national testing requirements

Tony: "...this is actually one of the few places where I strongly disagree with the SOL. I think the SOL oversimplifies it, and if you can actually explain the theory, you will actually lose credit on it sometimes. There's only one correct answer that they will take, whereas if you actually know the theory behind it and have built that correct answer, there are 5 or 6 correct answers in your drawing." (Post)

c. Balancing the depth versus breadth of science content being taught

Bill: "I can't focus on really finite details on some concepts because they just don't stick with it. So I have to be, you know I do a broad explanation of something and then maybe hit some of the finer points." (Pre)

Assessing science learning (AP). AP was described as teachers discussing "the limitations of their current assessment practices and the teachers' need to find alternative ways of understanding what students did and did not know." (Southerland, et al., 2011b, pg. 446). Subcodes included:

a. Monitoring student understanding through alternative forms of assessment

Lisa: "So, I would like to give my kids the topic and see how they connect the ideas and that way I can have a visual to see who's gotten the conceptions; who's really got it and who needs a little work. I think it will really help me." (Post)

b. Planning and using alternative methods of assessment

Penny: "We were allowed to give alternative assessments, so let's say a student that might be unsuccessful on a multiple choice test, if he was just a terrible test taker, I could give him clay and say, make an atom and then tell me about all the parts." (Pre)

c. Using assessment practices to modify science teaching

Barbara: "Exactly. Take from that what I need to re-teach and reflect on how I can make it more meaningful for students." (Mid)

Teaching nature of science (TN). Southerland, et al. (2012) developed TN as the sixth category of their STPD scale during the factor analysis portion of developing their scale. However, they did not provide a discussion of NOS as a form of STPD. Thus, I relied on descriptions of NOS provided in the literature review of this work (Lederman, et al., 2002; McComas, et al., 1998). Southerland et al. (2012) did provide subcodes for TN, which are listed below:

a. Assessing students' nature of science understandings

No instances were coded.

b. Integrating nature of science throughout the curriculum

Bill: "I'm just trying to decide how I want to do it, but refer back to it on a regular basis during the school year. So I'm just not sure how I want to make it. I think it's more gonna be a picturesque kind of thing instead of words, but it will cover the

concept. I've gotta think about it. I haven't figured out how to put one together yet.”
(Post)

c. Developing strategies to teach nature of science

Lisa: “It made me more aware of what I needed to do this year. My focus is going to be on the assessments and making students aware of the NOS principles. I’m not worried about hitting the principles because when you read them, everything we do all year focuses on that, so my goal is to make them more aware that that is a NOS principle and then to work on the validity of my assessments.” (Post)

Contextual discontentment. Southerland et al. (2011a) define contextual discontentment as the “emotional reaction to their assessment of their teaching context.” (pg. 304). Contextual discontentment involves statements about a lack of something in an aspect of the school or the students such as: lack of support from principal, lack of freedom, lack of student preparation, lack of money, lack of time, lack of parent support, lack of good teaching materials, etc. Contextual discontentment came up frequently during Southerland et al.’s (2011b) interviews with teachers. They suggested that teachers might find it cathartic to discuss contextual discontentment and that those discussions may have opened the door to discussions of pedagogical discontentment.

Examples of contextual discontentment include:

Lisa: “Because other PD's are PowerPoints for 3 hours, so (laughs), it's kind of all cookie cutter with some of the other PD's that I've had where it's like, this is exactly what you have to do, you need to do this, and it's not very applicable to all different fields, all different people, all different students.” (Mid)

Bill: “Um....probably the worst one that's becoming a major issue in the class is...I don't know what you would call it...it's not entitlement...they just don't care. And there's a larger number of kids who just literally do not think they have to do anything. So they just don't care. That's probably the biggest problem coming out.”
(Pre)

Stage Three

Stage three of the data analysis included within case analysis, cross analysis, and cross case synthesis (Yin, 2009). Case analysis involved preparing a summary for each of the three interviews in each individual case to determine the structure of each participant's professional identity prior to, during, and after the PD institute (see Appendix C for individual case summaries). These analyses involved a triangulation of the investigators by utilizing revolving teams during the data analysis (Hays & Singh, 2012). For each case, the primary researcher developed the case summaries. The entire research team participated in the first case analysis. After that the remaining case analyses were split among the research team. For each analysis, the primary researcher sent the case summaries to a research team member. That member then analyzed the case summary and compared it to the transcribed data to determine if the case summary successfully captured the data. The researchers then met to discuss themes and patterns within the case and outlined revisions as necessary.

Cross analysis involved triangulating the data methods (Hays & Singh, 2012). The individual case interviews were compared with the Science Teachers' Pedagogical Discontentment pre/post scales, daily reflections, and exploration and commitment cards in order to better describe findings, and to look for complimentary data as well as inconsistencies (Hays & Singh, 2012).

Cross case synthesis involved comparative pattern analysis to understand how the coded data was similar and different, both within and among the data sources (Hays & Singh, 2012; Patton, 2002). The cross-case synthesis led to the generation of themes and theoretical understandings about the processes involved in participants' narrative constructions of their experiences as teachers and as participants in the PD Institute. After

establishing themes and theoretical understandings, the research team met as a whole to discuss these findings and offer insights into answering the study's research questions. The findings are presented in the next chapter.

Strategies for Establishing Trustworthiness

Validity in qualitative designs is known primarily as trustworthiness, which Hays & Singh define as, "...the truthfulness of findings and conclusions based on maximum opportunity to hear participant voices in a particular context" (2012, p. 192). They describe several criteria for establishing trustworthiness, and suggest multiple strategies to address validity criteria. The following criteria were addressed to increase trustworthiness.

Credibility refers to the internal validity or overall believability of the study. This was established through triangulation of the theoretical perspectives of professional identity and STPD, as well as triangulation of the unit of analysis by selecting multiple cases to study. Transferability refers to the external validity or generalizability of the study. It was established through thick description to provide vivid detail of the PD context, cases, and data analysis (Hays & Singh, 2013). Dependability, or the reliability or consistency of the study, was established through consensus coding of the data.

Coherence refers to the consistency of the research approach. This was established through the creation of an audit trail to provide physical evidence of the data collection and analysis procedures (Hays & Singh, 2013). The audit trail was composed of all materials associated with the study. This provides a collection of evidence regarding the consistency of the case study approach, and was reviewed by the auditor.

Sampling adequacy consists of appropriate sample size and composition for the research purpose. Referential adequacy helped establish this through checking findings and interpretations against existing research and literature. Substantive validation refers to the addition or supporting of existing information in the literature. It was enhanced through the use of triangulation, thick description, and an audit trail. It was also established through the use of the conceptual framework used to design the blueprint for interview questions. Lastly, creativity, or the use of novel and flexible methodological designs, was established through triangulation and the audit trail (Hays & Singh, 2012).

Chapter Summary

This chapter presented the methodology for the research, which was a multiple case study design within the social constructivist paradigm. Next, it outlined the roles of the researcher and research team. A discussion of the research plan followed, including contextual information as well as each of the measures. Data collection and analysis procedures were discussed and the codebooks for both professional identity and pedagogical discontentment were presented. The chapter ended with a discussion of ways in which the researcher increased the trustworthiness of the study.

Chapter 4: Results & Discussion

This study sought to explore and compare the constructs of teacher professional identity and pedagogical discontentment in practicing high school science teachers participating in a reform-based PD. This chapter begins with an overview of each participant's professional identity case summary. The findings are then presented by research question. I begin by providing a discussion of the patterns of change in the participants' professional identities, which will be showcased through themes related to the model that emerged from cross-case synthesis of the data. Next, I discuss aspects of the PD institute that served as triggers for change in participants' professional identity systems. I then provide a discussion of perceived pedagogical discontentment of the participating teachers. Finally, I discuss the potential relationship between pedagogical discontentment and teacher professional identity. The research questions for this study were:

- (1) What were the patterns of change in science teachers' professional identities who participated in a professional development institute?
- (2) What aspects of the professional development institute were perceived to serve as triggers for change in teachers' professional identity?
- (3) How did science teachers' perceptions of pedagogical discontentment change as they progressed through a professional development institute?
- (4) What is the relationship between pedagogical discontentment and professional identity?

Professional Identity Case Summary Overviews

Interviews were conducted at three time points, pre-, mid-, and post-PD Institute. This allowed for insight into the participants' construction of the PD experience and the changes they experienced. These interview narratives were compiled into case

summaries, which are presented in full in Appendix C. This section includes overviews of each case summary, which provide the reader a working knowledge of each of the participants.

Case Overview: Barbara

Barbara entered the PD with 21 years of teaching experience. She also considered herself to be a “*professional student*” due to her current pursuit of an Ed.D. She said that she continues to teach because she is “*trying to get it right*”. In her pre-interview, Barbara focused on her own learning preferences, and did not seem to take her students’ preferences into account. She entered the PD with a loosely defined goal of becoming “*more of a facilitator*” in order to increase student achievement. Barbara perceived that the PD experience was “*out of the box*” for her partly because she did not have control over the situation. This experience led Barbara to perceive herself as a student and to gain a new “*respect*” for her students’ perspectives as learners, including beginning to consider their preferences and how she might create experiences for them similar to the ones she had at the PD. She began to realize that the labs she implements are of the cookie-cutter variety, and left with the goal of using more inquiry in the classroom in order to better engage her students and make their learning more relevant to them. By the end of the PD, Barbara had better defined her goal of becoming a facilitation to include her stepping out of the way and letting her students “*do too*”.

Case Overview: Bill

Bill entered the PD with 26 years of teaching experience and several years of oil industry work experience prior to teaching. His degrees, prior experiences, and current practice of taking science-related vacations lead him to perceive himself as a “*scientist*”

who teaches” because he “*actually does these things*”, which he believes give him “*more authority than just from textbooks*”. Bill said that he would like to “*give everybody experiences*” and values authentic experiences for himself. However, his negative beliefs about his students and how school works limit his action possibilities such that he feels that he must make his classroom activities “*canned*” and must bring the science into the classroom to show his students rather than allowing them to do the science. Bill maintained these beliefs throughout the PD experience. Although he seemed to be very satisfied with his learning experience and took away ideas for his students such as finding “*ways that are small*” that allow them to “*think*” and have “*ownership*”, his discussions of plans and goals were also punctuated with his plans to create materials in order to let his students “*see the real stuff*”.

Case Overview: Lisa

Lisa entered the PD with seven years of teaching experience. She professed a love for science and a love for teaching due to the interactions with students. She expressed frustration with budgetary and time constraints, which she believes serves to limit some of her practices. The PD experience led to Lisa making goals and plans associated with altering how she teaches experimental design, inquiry, NOS, and assessments. For example, she was planning to ask more open-ended questions in order to “*guide them through inquiry instead of just handing it to them*”. However, Lisa did not express perceptions or beliefs that associated with these plans, making it difficult to determine how or why she developed these goals and plans over the course of the PD experience.

Case Overview: Penny

Penny entered the PD with 10 years of teaching experience. She previously taught at an alternative private school, which seemed to influence her beliefs about best practices. During her pre-interview, Penny expressed the belief that the time constraints associated with standardized testing necessitate her adopting a lecture style of teaching more often than she would like. However, her goals include creating an active, student-centered learning environment where students are “*actually doing things instead of just kind of sitting*” and learning “*on their own*”. Penny previously attended a PD about inquiry-based learning and tried an inquiry-based experience in which her students designed their own experiments at the beginning of the previous school year that she felt went “*really well*”. However, she had not continued to do inquiry-based experiences throughout the year. Penny perceived that the PD experience placed her in the role of a student and that her group was able to “*take ownership*” of their field study, which led to them learning “*so much more*”. She also perceived that the experience had given her “*so much more confidence*” facilitating this type of activity with her students. While she acknowledged the pressures associated with standardized testing, the PD experience made her “*reevaluate my teaching philosophy, so to speak, on what’s more important*”. She left the PD believing that her students should experience field work and making goals and plans associated with doing so in the upcoming year, saying “*I want to do it. I’m going to do it*”. She also left with goals and plans associated with developing “*better habits*” as a teacher.

Case Overview: Tony

Tony entered the PD with two years of teaching experience. Prior to teaching, Tony interned at an analytical methods laboratory, which made him realize that he did

not want to work in the hard sciences as a career. He perceives that he teaches students first and foremost, saying, “*I teach students chemistry; I don’t teach chemistry to students*”. Tony entered the PD seeking opportunities to collaborate with his colleagues in order to “*further relationships*” and create a “*stronger collegial community*”. Throughout the PD experience, Tony expressed that he perceived that he was furthering relationships with colleagues through collaboration. The PD seemed to reiterate Tony’s existing perceptions and beliefs, however, he did not perceive the field study as a high-school level experience. He left the PD with ideas regarding creating a “*brain trust concept*” that would encourage students to ask big questions and take risks, but overall, he did not seem to extend his beliefs, purpose, or action possibilities.

RQ 1: Patterns of Change in Professional Identities

Cross-case synthesis of the data revealed several themes related to patterns of changes in participants’ professional identities. These themes are presented below in two major categories: themes surrounding individual model components and themes pertaining to interplay of model components. These themes are then summarized and discussed in terms of generalized conceptual understandings.

Themes Related to Individual Model Components

Several themes emerged in relation to components of the professional identity model. These themes are presented below, including multiple constructed role identities, perceptions of collaborations with other teachers, self-related versus student-related goals, goals for PD Institute versus takeaways, and action possibilities in teaching role.

Self-perceptions: Multiple constructed role identities. Three of the participants entered the PD Institute with self-perceptions of role identities other than their role as a

teacher. These other role identities related to their teaching identity in different ways and influenced their construction of the PD experience. For example, both Bill and Tony had previous science experience outside of teaching, which seemed to influence their teaching identities. Bill's prior experiences in the oil industry and current practice of taking vacations centered on science topics led him to perceive himself as a "*scientist who teaches*" because he "*actually does these things*" rather than just reading them in a book. He also perceived that his experiences made him more capable of explaining concepts to his students, saying, "*having been in the field, you don't necessarily give the textbook definition; you can explain it other ways*" (Pre). As the PD Institute progressed, Bill began to perceive that the other teachers were scientists as well, saying things like, "*we're scientists; we just work together*" (Mid), perhaps because of their shared field experiences. However, he still seemed to perceive himself as different from the other teachers. He said that being out on the boat, "*is normal, which is strange (laughs) for other people. I get used to it,*" (Mid). He perceived that the lab work reminded him of college days, and spoke fondly of that time in his life. His positive perceptions of the PD experience left him longing for similar inquiry-based PD experiences in the future. He also left with the belief that every science teacher should participate in a similar PD experience because of his belief that most science teachers do not get the opportunity to "*do science*" in their teaching roles. However, Bill made few connections between his experiences with the PD and his students as learners. While this seemed to be mostly due to his negative beliefs about his students' abilities and attitudes, it may also have been influenced by his perceptions of himself as a scientist and the PD experience as a college or professional level science experience.

Tony seemed to see himself as a scientist as well, though he never referred to himself as such. While at college, he spent summer and winter breaks as an intern for an analytical methods laboratory. The experience led him to realize that he did not want to pursue hard science as a career because *“it was a big grind. There was not much difference in what happens on a daily basis. There was not much human interaction”* (Pre). Tony went into teaching partially because of this experience, and values the interactions and relationships he makes with both colleagues and students. Like Bill, Tony also seemed to perceive himself as being different from other teachers because of his *“very interesting”* prior experiences. Tony perceived that he did not follow a *“typical way”* to get into teaching, saying, *“I didn’t undergrad major in ed or science and ed and then just knew it was me. It was figuring it out, which was interesting”* (Pre). Tony’s experiences during the PD fit into his scientist role identity and beliefs about what scientists do. He perceived that he was very comfortable with the science intensive portions of the PD, saying that *“it was nice to get back into a lab”*, and feeling that the data analysis in particular, was *“right in normal life”* from a *“chemistry perspective”* (Mid). Tony perceived that the PD left him with reminders of what he liked and did not like about working in a lab. He said,

“I think it’s bringing it back to, not necessarily why, but how I got started. Being able to have the freedom to hypothesize and be amongst colleagues and amongst similar experiences of backgrounds. I think it is also, it makes me miss the lab setting a little, but it also reminds me why I’m not there in the first place (laughs). So it’s both” (Mid).

He perceived that he was *“forced into the grind of post-secondary academia”*, but enjoyed the experience. He said, *“[e]very so often, it’s nice to go back into to both access to what money can buy and access into being challenged on a journal level”* (Mid).

However, Tony made few connections between his PD experience and his students. This may have been due to his perceptions and beliefs surrounding his role as a scientist and the PD experience as being college or professional level work.

Barbara entered the PD with perceptions of herself as a “*professional student*” due to her years spent taking college-level coursework and current pursuit of an Ed.D. In her pre-interview, she expressed preferences for her personal learning more so than her students. For example, her perception of good learning environments for herself included those in which she can take an active role. She said, “*I find that when I’m able to construct my own meaning from learning, I retain the information longer*” (Pre). During the pre-interview, she did not extend this discussion to beliefs about how her students might learn best. Barbara perceived that the PD experience was appropriate for her as a learner because it allowed her to “*make my own meaning*” (Mid). However, she also began to make connections between her own learning preferences and emerging beliefs about best practices for her students. Her construction of the PD experience as a learner seemed to lead her to consider her students learning as well and she began to focus on goals and action possibilities related to her students’ learning.

Bill and Tony’s identification as scientists seemed to cause both of them to set themselves apart from other teachers. The scientist role identity also influenced their self-perceptions and beliefs about the PD experience. They both seemed to perceive the PD as an upper level science experience, and while they both felt that the experience fit with their identity as scientists and perceptions and beliefs about what scientists do, they made fewer connections to beliefs, goals, and action possibilities surrounding their students’ learning. They also came away from the PD with continued perceptions of themselves as

scientists and as different from other teachers. While Barbara's identification as a professional student seemed to prevent her from considering her students' learning preferences prior to the PD, her perceptions of being satisfied as a learner seemed to influence her beliefs, goals, and action possibilities surrounding her students' learning. These findings suggest that other role identities influence and connect with the teaching identity. These other role identities may serve to enhance or prevent connections between the PD experience and the participants' students based on their perceptions surrounding the experience. The connection between other role identities and teacher professional identity is an interesting one and warrants further investigation in future studies. It would be particularly interesting to look study other teachers with role identities as scientists to see if they have similar experiences to that of Bill and Tony, and what might be done to help them better connect the PD experience to their students.

Self-perceptions: Collaborations with other teachers. Each of the participants had positive things to say about their experiences collaborating with group members. The design of the PD Institute encouraged teachers from the same school to work in groups while also allowing for collaborations within subject area from different schools. For Tony, collaboration seemed to be the most salient part of the PD Institute. He perceived that the PD was a "*safe space*" to explore and that his group, which was composed of colleagues from his school, was "*very fluid from the beginning*" (Mid). He perceived that this allowed them to take risks together because "*you drop out that first stage of I don't know how I'm going to be judged because we're already close as colleagues*" (Mid). He also found it meaningful to be able to "*interact with others*" and to know that "*we're not*

on our own little islands" (Mid). Ultimately, he connected this to beliefs about teaching, saying that the experience "*justifies my philosophy of not doing it on my own*" (Mid).

Lisa and Tony were from the same school and worked in a group together along with two other teachers from their school. Lisa also had positive experiences with collaborating during the PD Institute, saying that it was "*nice to collaborate with teachers that are my friends and I see them every day, but I never truly get to work with them and now I'm able to*" (Mid). She perceived that each group member was able to bring his or her own "*expertise*" into the field study.

Penny and Barbara were from the same school and worked in a group together along with another colleague from their school. Both expressed positive perceptions of the group experience, but differed on their reasons. Penny said that it was nice to "*work with your co-workers in a different way*". She perceived that the connections she made led her to feel "*a great deal of support*" for trying new things in her classroom because she knew she could reach out to her group members if she needed help. Barbara had not previously enjoyed group work at PD's, saying, "*the challenge for me is working with other people*". She perceived that having group members "*who are familiar with what you encounter on a daily basis*" made the process "*a lot easier*" because they have the "*common goal*" of student achievement.

Bill was the only cohort two participant from his school, and as such, he worked within a group composed of teachers from three different schools. Because of this, his experience was different from the other participants. He perceived that "*meeting other people and making friendships*" was an important part of the Institute. One of his group members was also going to teach oceanography in the fall, and Bill was able to share his

lesson plans with her. He was looking forward to having someone to “*communicate with during the year and connect with*” (Post).

Overall, it seemed that the participants enjoyed working with colleagues in a setting outside of school. Tony, Lisa, Penny, and Barbara, who worked with group members from their own schools, all made comments about their positive perceptions of working with school colleagues in a different setting, perhaps finding new meaning in their interactions and seeing their interactions differently outside of the typical school-related planning project. Tony also made connections between his perceptions of the collaborations and his beliefs about teaching. Participants’ perceptions of the PD experience might have been quite different had they worked with teachers they were unfamiliar with, such as Bill. While Bill may have been less comfortable with his group, he still came away with positive perceptions of the experience and was able to make connections across schools. Placing teachers in school-based groups for PD’s may be a useful way to promote comfort, risk-taking, and allow teachers to see one another in different ways.

Sense of purpose: Goals for PD Institute versus takeaways. Participants came into the PD Institute with diverse goals and expectations for their PD experience. Each participant found some of what they said they were looking for, but these takeaways varied. For example, Barbara was seeking tools to help her students become life-long and self-directed learners, however she seemed to have a limited understanding of what those tools might look like. Her experience with the PD Institute led to the realization that her current labs are of the cookie-cutter variety, which caused misalignment with her emerging beliefs about appropriate learning experiences for her students and goals of

implementing more inquiry and better understanding of the role of a facilitator. Although she did not leave with concrete plans for altering her practices, she was planning to “*try to be a little bit more open*” to giving her students opportunities “*to do*”. She ultimately seemed to realize that facilitating experiences for students and allowing them to do more of their own thinking and working would help them become life-long and self-directed learners, but this involved her altering some of her beliefs and goals for both herself and her students along the way.

Tony was seeking to develop “*further relationships*”, to have a “*stronger collegial community*” within his school as well as the district, and to leave with a lesson that “*can connect all four years of science*”. He seemed to achieve his goals associated with building relationships with colleagues. His perceptions of the experience with colleagues were very positive, with him discussing feeling that he was among like-minded people and was safe to take risks. The experience also validated his beliefs surrounding the value of collaborating with peers. He did not, however, leave with a lesson to connect the four years of science. Although he enjoyed the field study experience as a learner, his perception of it as a college-level environmental science experience seemed to lead him to be unable to connect it to his high school students and chemistry teaching, which prevented him from developing goals surrounding the PD experience.

Penny wanted to gain more strategies for her “*teacher toolbox*”. Ultimately, she was looking for her students to develop a love for learning and for science, and said that she was willing to implement anything that would help facilitate that. Her experiences with the PD led her to emerging beliefs surrounding the value of more authentic work and how those types of experiences would help her students. This further led her to make goals

and plans surrounding these newly developed beliefs. She left the PD Institute with strategies for her toolbox as well as a new outlook on her teaching philosophy, goals, and action possibilities for the future.

Bill said that he is “*always looking for something*” in order to “*present better science in class*”. He was also seeking opportunities to do more with his students, saying, “*I want to do that more with the kids. I’m always looking for ways to do that*”. His experiences with the PD Institute led him toward plans for doing more with his students, including giving them small opportunities to solve problems on their own. He also seemed to find some ideas for presenting better science in class, which would include creating things to allow his students to “*see the real stuff*”.

Lisa seemed to be seeking ready-made activities that would “*fit within the time constraints and the budget*”. She was interested in “*resources that I can use right away in the class without having to buy certain software or having to jump through 82 hoops for an activity that will last 30 minutes*”. She came away from the experience with a limited amount of these types of activities, such as creating a NOS poster or displaying student work on a poster. In her written reflections, she tended to point out when she felt that she would be able to use information right away. However, Lisa also left with the newly developed goal of better understanding what her students know through assessment, and was planning to alter her assessments. She also left with the goals of developing student ownership through poster presentations and using open-ended questions to guide them through inquiry. Unfortunately, Lisa did not elaborate much on her goals and did not express beliefs associated with them, so it was difficult to determine why her goals

shifted except that her goals were aligned with her own experiences of developing a poster presentation and responding to open-ended questions throughout the PD Institute.

It is interesting to note the wide variety of goals with which participants entered the PD. Although each participant found at least part of what they came into the PD seeking, they did so to different degrees. Most also developed goals while at the PD, typically in conjunction with PD experiences and newly developed beliefs. Their expectations for the PD may have influenced their construction of the experience as well as the takeaways from the program. A useful extension of this research would be to look further into teachers' goals as they enter PD experiences, what led to those goals, if they achieve those goals, and what new goals emerge as a result of the PD experience.

Sense of purpose: Self-related versus student-related goals. Participants focused on a mixture of self- and student-related goals in their discussions, however there was variance in the amount of focus they placed on the goals and how those goals shifted during the PD Institute. For example, Bill was more focused on self-related goals. Although he would like for his students *“to do something, to think”*, his beliefs about his students and the way school works led him to try to *“find ways to bring other things in”* (Mid) to his classroom, which tied to his purpose for bringing his vacations back into the classroom. He said:

“That's one of the things I'm trying to do when I take my scuba diving vacations. I'm taking videos; I'm just trying to find a good program. I just want to make little 5 minute clips on different things like fish identification, fish camouflage, you know, things that I could show little blips in the class” (Mid).

He left the PD Institute with newly developed goals of having his students *“figure out a solution on their own”* and *“let them take some ownership”* (Post), however, he seemed to see accomplishing those goals by making something to show his students what he had

done during the PD. He said, "*I'll create something and use that as a way to get my kids to see the real stuff*" (Post). Although the goals for his students and himself are connected, it seems that he is doing the majority of the work rather than students.

Tony focused on a mixture of self- and student-related goals. His personal goals were more developed, including to "*interact with others*" (Pre), "*talk philosophy*" (Post), and "*take risks*" (Mid). He also discussed less-developed goals for students, which included getting them to "*take risks*", "*think bigger and think deeper*", "*understand why you got to those answers*", and be able to "*bring in that next level of thought*" (Pre). His goals for his students did not change throughout the PD, and although his goals for his students seemed to echo his goals for himself, he spent much more time discussing goals for himself as a teacher rather than goals for his students.

Lisa also expressed a mixture of self- and student-related goals. She entered the PD Institute with student-related goals such as giving opportunities to "*explore their own interests*" and "*do their own research*" (Pre). As the PD progressed, she seemed to further develop those goals. For example, she would like for her students to "*collaborate and work together and maybe do some research and figure out what they could do and how they could do it*" (Mid). She also began to discuss goals for herself that were related to student goals, including guiding students as they go through the process of doing research and using assessments to get a better idea of "*what the students really understand*" (Post).

Barbara entered the PD Institute with some student-related goals, but they seemed to involve her doing a lot of the work. For example, although she wanted her students to be self-directed learners, her goals also consisted of "*helping students understand*" what she is trying to teach them. She was looking for her students to:

“...get those aha moments. When I can see it on their face that they actually get it or they can tell me something that lets me know that they actually got it, you know, that they actually understood what I was talking about” (Pre).

These goals began to shift during the PD Institute to be more student-related. For example, she left the PD with the goal of students’ constructing their own meaning by giving them experiences that allow them to “*do the preparation*”, “*do the investigative work*”, and her “*guiding them to find their own answers rather than telling them my answers or what they should think*” (Mid). And while she entered the PD wanting to “*become more of a facilitator*” (Pre), she further developed this goal, and at the end came to the realization that facilitating would involve the goal of “*stepping out of the way*” (Post).

Penny consistently expressed student-related goals. For example, she said,

“I think that the kids having opportunities to be successful and then being successful and getting...not only knowing the material, where they've grown in their knowledge, but they're excited about learning also; they feel successful also, like they could do anything.” (Pre)

Her goals for herself were also directly related to her student goals. For example, she left the PD Institute with the goal of developing “*better habits*” (Post), including altering her questioning techniques and assessments. When discussing each of these goals, she focused the conversation on how her “*better habits*” would benefit her students.

Overall, the PD experience seemed to encourage participants to develop more student-related goals. However, the type and extent of the goals seemed to be related to the goals participants’ came in with as well as their experience of the PD. For example, Bill entered the PD with mostly self-related goals. His self-perceptions of the PD were focused on himself as a learner and scientist. While he left with more student-related goals, they seemed to be heavily influenced by his goals for himself as well as his beliefs

about his students' abilities and attitudes. In contrast, Barbara also entered the PD with mostly self-related goals. Her self-perceptions of the PD were very different than Bill's though, with her focusing more on connecting her learning at the PD to that of her students in class. The connections she developed may then have led her to begin developing more student-related goals based on altered beliefs surrounding best practices. Future studies should address this potential connection.

Action possibilities: Plans for adding/altering practices. Participants left the PD Institute with some similar action possibilities related to adding to or altering their practices. Each of the participants was making plans to translate portions of their field study experience to their classroom, three of the five participants were making plans to alter their assessments, and three of the five were making plans to include NOS in their classrooms. These are discussed further below.

Tony had the least amount of action possibilities associated with the field study experience. As previously stated, he did not seem to connect the PD experience to his high school students or his subject of chemistry. Instead, he thought of it as a college-level environmental science experience, which seemed to prevent him from making many plans associated with the experience. At the mid-interview, however, he discussed the possibility of having his students design experiments that utilized authentic materials they did not have access to and thus could not carry out. When asked how that might benefit students, he said that it would allow them to "*see what's out there*" and give them "*an ownership into taking the time to actually look from a science perspective*" (Mid). Tony was also thinking of having students research and then make posters associated with portions of the class in order to "*take some of the lecture out*" (Post) of their curriculum

rather than using them with a more inquiry based portion of the curriculum similar to his experience at the PD.

Bill was developing some small plans associated with the field study. He was thinking of implementing a smaller scale activity based on his experience with counting plankton. He was also planning to have students work on small portions of problems in lab groups, but believed that if he gave them too much, they would “*just freeze*”. Finally, he was planning to “*create something and use that as a way to get my kids to see the real stuff*” (Post) rather than them actually doing the real stuff.

Lisa was planning to use more open-ended questions with her students and then have them come up with the procedures in order to “*guide them through their inquiry instead of just handing it to them*” (Mid). She was also thinking of having students create posters to represent what they were working on, but it was not clear if the posters would be associated with inquiry experiences or more typical class work.

Barbara was planning to give her students more opportunities “*to do*”. Although she was not clear on the specifics yet, she mentioned preparing her students for inquiry by going over some “*basics*” and then adding “*more activities where students have to use inquiry*” (Mid). She also mentioned letting students come up with their own labs rather than using already established ones. Finally, Penny was planning to “*take the time*” to “*allow students the opportunity and time to design their own experiment and carry it out (within reason) during the school day*” (E&C Card). She reiterated her desire to do so several times throughout the interviews, saying, “*I want to do it. I’m going to do it*” (Mid).

Although each participant was making plans associated with the field study experience, the wide variance in the type and depth of their plans is an interesting outcome of the PD Institute. While it seemed that everyone was embracing the idea of including more inquiry-based activities in their lessons, Penny discussed the most concrete and most extensive plan for altering her practices. This may have been due to her previous experience with having students design their own lab based on materials she provided. Although she had positive perceptions of the experience and believed the students enjoyed and found value in it, she had not attempted further experiences. Penny may have entered the PD Institute already primed to want to try another experience and her feelings of increased self-efficacy associated with designing and carrying out such experiences after having done so herself combined with her emerging beliefs surrounding the value of such experiences, may then have led her to increased goals and plans associated with doing so. This suggests that PD experiences should build upon one another in order to allow teachers time to process, try smaller ideas, and then eventually attempt a larger change. This hypothesis would be useful to test in a more longitudinal study involving a series of PD experiences designed to build upon one another.

Three of the five participants were making plans to alter their assessment practices. These alterations consisted of varying depths and forms. Bill was planning to develop and include cornerstone assessment-style questions on his existing tests because they are “*a part of the way of thinking*” (Post). Penny was planning to alter her assessments to make them more effective. She was questioning the value of her department’s existing tests and was planning to revamp them to be more alternative in nature and to more effectively measure what students know and understand. Lisa was also planning to alter her existing

assessments. She would like to make them more valid and reliable and also discussed rewording test questions and trying to use questions from each level of Bloom's Taxonomy. Tony and Barbara's lack of action possibilities surrounding the assessment portion of the PD Institute may have been influenced by their negative perceptions of the experience. Tony felt that the information covered was repetitive for him and too slow. In contrast, Barbara felt that pace of the information was presented was too quickly.

Three of the five participants were also making plans to include NOS in their classroom. Lisa and Bill were planning to make a poster to hang in their classrooms. Lisa expressed the belief that the NOS principles are inherently covered within her curriculum, so her plan involved using the poster to "*make them more aware that that is a NOS principle*" (Post) when they come up in lessons. Bill was planning to make the poster picturesque so his students would be able to read it and he could refer to it throughout the year. Of note, Lisa mentioned that Tony was planning to make the NOS poster and then share it with the PD Institute group; however, Tony did not mention this plan in his interviews, reflections, or E&C card. Finally, Penny was planning to add some NOS activities to her class. She mentioned an observation versus inquiry activity as well as an activity pertaining to creativity in science. It is interesting to note that Penny was the only participant making NOS plans beyond the use of a poster to teach concepts. It is not clear where she came up with the ideas she discussed. Overall, it seems that there may also be a connection between the action possibilities as a teacher each participant came away with and the level of interaction between their roles as a learner and teacher. This potential connection is discussed further in the next section.

This section provided a discussion of five themes related to individual model components. First, teachers brought self-perceptions of other role identities into PD experiences and these role identities impacted how they interpreted and responded to the PD experience. Second, collaborations among school colleagues were a positive experience for participants and may have led to an increased comfort level and sense of safety. Third, teachers' goals for the PD seemed to influence their PD experience. And while some goals were achieved and others were shifted, participants were actively seeking additional learning. Fourth, participants came in with both self- and student-related goals and for the most part, these goals shifted to be more student-related by the end of the PD Institute. However, if the participant was unable to connect the PD experience to their students, they were less likely to make student-related goals. Finally, participants made action possibilities associated with various portions of the PD Institute. However, these plans also seemed to be related to the amount of connections participants made between their learning experiences at the PD and their students' learning as well as their prior experiences with similar action possibilities. It was also obvious within the themes discussion that the individual model components are interdependent, and that it is important to examine how the components interact with one another. This is the topic of the next section of themes.

Themes Related to Interplay of Model Components

Several themes emerged in relation to interplay between components of the professional identity model. These themes are presented below, and include interaction between roles of learner and teacher, variability in alignments, variability in change, and dynamic nature of changes.

Interaction between roles of learner and teacher. Participants were placed in the role of a learner during their PD experience. There were differences in the types and depth of connections participants made between their role as a teacher and learner, which seemed to have an effect on their plans for using PD-like experiences in their classrooms. For example, Penny made a lot of connections between her roles as a learner and as a teacher and perceived that her learner role was like being a “*student again*” (Mid). Her perceptions, beliefs, goals, and action possibilities as a learner and teacher were consistently integrated during the interviews, which led to reflection and planning about translating her experiences. She transferred her self-perceptions and beliefs surrounding her experiences with a more authentic learning experience into goals and action possibilities for her students. For example, Penny perceived that her group was able to “*take ownership*” of their field study, which led to them learning “*so much more*”. She said, “[w]hen we got out into the field, it was our experiment, you know...this is our project, our thing” (Mid). These self-perceptions led to emerging beliefs about the benefits of similar experiences for her students. She said, “we’ve gotta get the kids out into the field; we’ve gotta get these kids designing their own experiments, like there’s so many great benefits to them going through this process” (Mid). She left the Institute wanting to give her students experiences that would be more in line with her perceptions of the PD learning experience.

Barbara also made many connections between her roles as a learner and teacher during the PD Institute. Barbara also perceived that her learner role was like being a student. She said that being in a “*learning situation*” led her to “*see things from a student perspective*”. She expressed the belief that “*as a teacher you sometimes forget that you’re*

still a learner and you see things differently" (Mid), and said that the experience gave her more "*respect*" for her students' perspectives. Like Penny, Barbara left the Institute wanting to give her students more authentic experiences and was reflecting and planning. Though she was struggling with specific ideas, she was planning to try to "*be a little bit more open*" and give her students opportunities "*to do too*"(Post).

The other three participants made fewer connections between their roles as learners and teachers. For example, Bill found enjoyment and satisfaction as a learner at the PD Institute. However, he struggled to connect the more authentic style of learning he experienced with his teaching, perhaps due to his beliefs about instruction and his students' inabilities and apathy as well as his perceptions of the experience as being at a college or professional level. Although Bill left the PD Institute with goals for his students that included giving them more ownership and having them find a "*solution on their own*", this type of talk was juxtaposed with discussions of him creating things to allow them to "*see the real stuff*" rather than actually experience it. He left wanting to implement small changes in his classroom, but felt that the experiences would have to be "*canned*" rather than more authentic.

Lisa also seemed to struggle with making connections between her experiences as a learner and her role as a teacher. She never seemed to view herself as a student, perceiving the experience entirely as a teacher going through PD. Although she left with some goals and action possibilities related to the PD, these did not seem to be tied to how she experienced the PD as a learner.

Likewise, Tony also made very few connections between his roles as a learner and teacher. He perceived that the field study was a college level environmental science

experience. Because of this, he seemed to be unable to connect his experience to his students or his teaching. Although he enjoyed the experience, it seemed to be because it fit in with his former identity as a scientist and his desire for social interaction with other teachers. He left with plans to have his students interact more and grapple with “*difficult questions*” rather than do more authentic science, though it was also unclear what roles he and his students currently took in the classroom.

It is interesting to note that Penny and Barbara, who both equated their learner role to that of their students, were also the teachers making the most plans associated with the experience. There may be a connection between the action possibilities as a teacher each participant came away with and the level of interaction between their roles as a learner and teacher. This would be a useful topic to explore in future studies, particularly to see if connections between the learner and teacher role could be explicitly engendered.

Variability in alignments. As previously mentioned, each participant exhibited alignment between identity model components. However, there was variability in the extent, type, and depth of these alignments. For example, Penny demonstrated alignment in many areas. Her perceptions and beliefs of the benefits of a more authentic, process-oriented style of learning aligned as she went through the PD Institute. Her goals of giving students opportunities to grow, experience success, and feel excited about learning aligned with her belief that students should be doing more in their learning. Penny experienced some misalignment during the middle of the PD Institute. She was struggling with her newly developed beliefs about the value of a field study experience and her perceptions and beliefs about the pressure she feels to cover material prior to the SOL test and how that affects her teaching. By the end of the PD Institute, she felt that the benefits

of “*taking the time*” to allow for a process-oriented approach outweighed the costs. Her goal of helping her students become more autonomous became more aligned with her beliefs about the benefits of designing scientific investigations and her plans to create those opportunities for her students.

Bill entered the PD with beliefs about students' inabilities aligning with his practice of bringing things into the classroom with the goal of giving all of his students experiences. He maintained this alignment throughout PD, and although he left with plans to make small changes to his lessons to provide his students with ownership, he still felt that these experiences had to be product-oriented and “*canned*”. Further, although he talked about giving students some opportunities to come up with solutions on their own, it seemed as though these opportunities would be part of something he would create in order for his students to “*see the real stuff*” rather than providing them with authentic experiences. Bill’s beliefs about his students continually aligned with and also led to limitations in his perceived purpose and action possibilities. He maintained his belief that he cannot give his students more authentic learning experiences. This was based on his beliefs regarding their inabilities, including apathy, misbehavior, and them “*being on the lower end*” (Post). While he desires more authentic science opportunities for himself as a learner, and perhaps sees the value of these types of experiences for his students as well, his beliefs about what he can and cannot do with his students lead him to feel that he must create canned activities and bring things into the classroom.

Barbara also demonstrated several areas of alignment. She entered the PD Institute perceiving that good learning experiences for herself involved being able to construct her own meaning. She seemed to believe that she was providing those types of experiences to

her students through her practice of allowing them to research some on their own, present as a teacher, and make presentations. These practices aligned with her perceived purpose of student achievement and goal of helping them understand. Her experience with a more authentic learning environment at the PD aligned with her perception of a good learning environment for herself, but it also served to cause some misalignment in her beliefs about best practices for her students. She perceived new “*respect*” for her students’ perspectives. She also realized that her labs are cookie-cutter, which was misaligned with her emerging goal of implementing more inquiry and better understanding of the role of a facilitator. She left the PD moving toward re-aligning her practices with her new beliefs and purposes. Although she did not have concrete plans in place, she was planning to “*try to be a little bit more open*” to giving her students opportunities “*to do*”. Barbara also developed perceptions and beliefs about the value of reflection, which she attributed to the PD Institute as well as another PD course she had recently taken about reflective teaching. These aligned with her perceived purpose of becoming a “*reflective teacher*” in the classroom and her associated goal of giving her students more time for reflection.

Lisa demonstrated less alignment in her identity system than Penny, Bill, or Barbara, which may have been due to her lack of elaboration about some of her beliefs, goals, and practices. Her love of students and science aligned with her purpose of wanting to spread her love of science to students. Her beliefs regarding how she learns best aligned with her perceptions and experiences at the PD and her plan to begin using more open-ended questioning and presentations with the goal of developing student ownership. Lisa entered the PD seeking ready-made activities that she could easily implement. Some of her plans at the end of the PD seemed to be aligned with this goal.

For example, she was planning to make her students aware of NOS principles, which she believed could be accomplished by hanging a poster of the principles in her room. Lisa may have also left with some misalignment present. Although she entered the PD with the perceived purpose of sharing her love of science to students, her purpose shifted. She left with the goals of better understanding what her students know through assessment, developing student ownership through poster presentations, and using open-ended questions to guide them through inquiry. Her lack of elaboration about these newly developed goals and failure to express beliefs associated with them made it difficult to determine her level of alignment.

Tony's perceptions and beliefs surrounding the value of social interaction and feeling comfortable enough to take risks demonstrated alignment across the interviews. He perceived that he was able to take risks at the PD due to his group's comfort level and that the social interaction he was experiencing both as a learner and as a teacher was valuable. The field study aligned with his perceptions of the experience being "*right in normal life*" from a "*chemistry perspective*" and served to remind him why he is no longer in that field and why he became a teacher. His goals and practices involving social interaction continued to align with his belief in the value of collaborating as well as his perception of the PD experience. Tony perceived the PD field study as college-level work rather than something that could be appropriate for high school students. He also believed that the field study was about AP Environmental Science more than anything. This led to a lack of integration between his roles as a learner and teacher, and although this was not a misalignment, it did seem to cause him to make very few plans or goals associated with the PD experience.

The four components of the professional identity model are co-active and interdependent. These components combined with the context led to the self-emergence of a professional identity system. Alignments within the professional identity system served to showcase coherence for the person and for others trying to understand the person in their professional role. Those who demonstrated more alignment, such as Bill, Penny, and Barbara, were easier to understand as they progressed through the PD experience and made changes to portions of their professional identity system.

Variability in change. The professional identity model is used to study the changing configurations of professional identity experienced over a course of time. This section focuses on changes in participants' beliefs, goals, and plans to be more in line with student-centered practices.

Each of the participants experienced some form of change in their beliefs, goals, and plans to be more in line with student-centered practices. There was variability in the depth of these changes. Some of the changes occurred on a smaller scale. For example, Bill left the PD Institute with plans to make some small strides toward allowing students to do more in the classroom. He was planning to have groups of students work on small pieces of problems in order to let them figure out their own solutions and develop ownership. Lisa also experienced a small-scale change in her goals for herself and students. She entered the PD seeking ready-made materials, but left with plans to begin altering her assessments in order to better know her students and to help students develop ownership by using more open-ended questions that would allow students to do more.

Penny seemed to experience larger-scale changes in comparison to the other participants. Although she said she had previously tried having students design their own

experiments and thought it was successful, she had not continued to facilitate those types of experience, perhaps due to perceived constraints associated with the SOL test. However, going through the process of designing and carrying out her own field study allowed her to gain personal experience with the benefits, which seemed to alter her beliefs regarding how students should be learning. The experience also heightened conflicts with needing to cover material, time issues, and assessment practices. She left the PD feeling more confident and motivated to make some changes in her practices based on newly developed goals. She was planning to facilitate field study experiences for her students, alter her questioning techniques and assessments, and generally provide her students with more opportunities to develop autonomy. Although Barbara's change was not as large as Penny's, she did develop beliefs about good practices as well as associated goals and plans to let her students "*do too*". Though she was not yet clear on the specifics, she was planning to step out of her students' way in order to become more of a facilitator.

In contrast, Tony seemed to experience very little change during his time at the PD Institute. He gave several examples of his perceptions and beliefs being reinforced by his experiences, but no examples of altering his perceptions, beliefs, or goals. For example, he perceived that the PD experience reinforced his philosophy of collaborating with others, both as learners and as teachers. He also perceived that the data collection and analysis experience reminded him of why he loves the lab as well as why he left that career option. Although he said that the PD experience "*forced me to go back and begin to question, I guess, my whole reasons that through philosophy and classroom practice*" (Post), he did not further elaborate on the statement or express any changed beliefs as a

result. Tony did come away with the idea of having students design labs without actually doing the labs. Although he explained that this would remove constraints and force students out of their comfort zone, he again did not elaborate enough to determine his underlying beliefs or purpose surrounding the plan.

As previously discussed within the theme of action possibilities for adding/altering practices, Penny's prior experience with implementing an inquiry-based lab with students may have led to her larger-scale plans for changes in her classroom relative to the other participants. It is not clear if the other participants had tried similar experiences in their classrooms as well, but they did not speak of such practices in their narratives. However, it is also interesting to note that those planning for larger changes to their practices, Penny and Barbara, were also the teachers who made the most connections between themselves as learners and their students.

Dynamic nature of changes. An important theme to the narratives was the dynamic nature of changes. This refers to the tendency for change in one component of the model to bring about change in other components. For example, Barbara's perceptions of being placed in the role of her students during the field study led her to the realization that her labs are of the cookie-cutter variety. She said, "*most of the labs that we give, the objective is already there, they already know what procedures to take, so they're just kind of basically following somebody else's structure*" (Mid). This realization was accompanied by emerging beliefs about the value of a more inquiry-oriented curriculum. She said, "*But if we get them to develop their own investigation, then they can see things from a different perspective. It's more engaging and I think it's more relevant*" (Mid). Barbara's change in beliefs was followed by changes in her goals for students and plans for her

practices. One of her newly emerged goals was to facilitate experiences for her students that would enable them to “*construct their own meaning*” (Mid) by letting them come up with their own labs.

Penny also experienced dynamic changes in her professional identity system. Similar to Barbara, Penny’s perceptions of being a student led her to realize the value of a process-oriented, inquiry based experience such as the field study. These emerging beliefs led her to alter some of her goals and action possibilities to include students developing and carrying out their own field studies in order to develop 21st century skills and autonomy. Conversely, Tony did not experience dynamic changes. Rather, the PD served to reinforce his existing perceptions, beliefs, and goals.

It is important to note that the dynamic nature of the professional identity model acknowledges that meaningful change may not be proportional to inputs. This allows for the possibility that “*small inputs at the right time can produce a dramatic impact, large inputs at the wrong time can produce nothing at all, and that there are many possible patterns of change*” (Guastello & Gregson, 2011, pg. 3). Thus, it is possible that Penny was already primed for larger changes because it was the right time for her and that it was the wrong time for Tony to experience changes associated with the PD Institute. Dynamic changes seemed to be more prevalent when participants were readily making connections between their roles as learners and teachers, as was the case with Penny and Barbara. Dynamic changes were not evident within Tony’s professional identity system, perhaps due to his lack of connection between his role as a learner and teacher. It would seem that PD that explicitly forces connections between authentic experiences for teachers and their

students might better assist teachers in experiencing dynamic changes to their professional identity systems. This hypothesis should be studied further in future studies.

This section provided four themes related to the interplay of model components. First, the level of interaction between participants' roles as a learner and teacher may have influenced and increased action possibilities associated with the PD experience. Second, participants demonstrating greater levels of alignment were easier to understand as professionals as they navigated the PD experience. Third, although all participants experienced changes, those who were more primed for change, perhaps due to prior experiences, made plans for more comprehensive changes. Finally, the changes in participants' professional identity systems tended to be dynamic in nature, particularly when the participant readily made connections between their self-perceptions of the PD experience, their students, and their role as a teacher.

Summary

This section presented the themes resulting from cross-case synthesis of the participants' data. There were a multitude of similarities and differences in participants' construction of the PD Institute experience. These themes served to form an aggregate of the patterns of change for PD participants. These patterns of change gave us the understanding that teachers may enter and experience the PD with other role identities already in place. These role identities may be linked with initial expectations of the PD and may influence the takeaways of the experience. Acknowledging and understanding these role identities prior to the PD experience may assist PD developers in creating opportunities to make connections between the various role identities with which teachers enter PD. Group collaborations also seemed to be influential to the PD experience,

particularly when teachers worked with school colleagues, perhaps due to their established comfort level, which may have brought about a sense of safety for exploring aspects of their professional identity system. Teachers seemed to be actively seeking additional learning, and generally, if a shift took place in beliefs, goals, and action possibilities, it was toward more student-centered views of teaching. These shifts also seemed to be directly related to self-perceptions of the PD experience. And, when teachers made action possibilities associated with portions of the PD experience, the plans seemed to relate to the amount of connections they made between their learning and teaching selves as well as their prior experiences with similar practices. The interconnectedness of the professional identity model components was also evident within the patterns of change. For example, when teachers were more readily able to connect their roles as learners and teachers across the four components of the model, they also increased their action possibilities associated with the PD. This also seemed to relate to being primed for changes, perhaps due to prior experiences. Alignment of model components was also shown to be significant with regard to better understanding teachers throughout the PD Institute in that more aligned teachers were better able to express their perceptions, beliefs, goals, and action possibilities surrounding their professional role. Finally, the dynamic nature of changes in the professional identity system was evident, particularly in teachers who were able to make explicit connections between themselves and their students as learners. A particularly powerful example of the dynamic nature of changes was evident when teachers' self-perceptions of the PD experience then served to cause shifts in their beliefs, goals, and action possibilities. These patterns of change

showcase the need to better understand what portions of the PD experience triggered participants to make changes. This is the topic of exploration in the next section.

RQ 2: Triggers for Change

This section focuses on the variety of aspects of the PD Institute that were perceived to serve as triggers to instigate change in participants' professional identity. This included both internal and external triggers. An example of an internal trigger comes from Penny, who entered the PD already oriented toward seeking opportunities for improvement. She said, *"I am willing to implement anything that I think will help my students develop a love for learning, really a love for the sciences, but you know, get them excited about learning"* (Pre). As a result, she may have been more open to ideas and practices that were introduced during the PD experience.

Another example of an internal trigger comes from Barbara, who also entered the PD already oriented toward seeking opportunities for improvement. She perceived that she continues to teach because she is *"trying to get it right"*. She entered the PD seeking *"tools I need to help my students become life-long learners and self-directed learners"* (Pre). Like Penny, Barbara may have been more open to ideas and practices introduced during the PD experience because of this internal trigger. Bill also entered the PD internally triggered for change. He continually seeks out and attends PD in the hope that he will find new ideas, even if they are small ideas from a long PD. He said,

"I'm always looking for something. And everything I take, you know when you take a class, you might take an 8-hour seminar or a 3-day class or something. You may not be able to use everything, but there's something you're going to get to manipulate to pull into your classroom, so I'm always looking for something" (Pre).

Although Bill did not experience as much change as Penny or Barbara, perhaps due to his beliefs about his students' inabilities and how school works, his desire for new ideas may have led him to be more open to ideas and practices introduced during the PD.

Participants also experienced a variety of external triggers for change. For example, designing and carrying out the field study triggered Barbara and Penny in different ways. Penny perceived that her group was able to “*take ownership*” of their field study, which led to them learning “*so much more*”. She said,

“When we got out into the field, it was our experiment, you know? If something happened, we had to fix it. If we weren't sure what to do next, we had to figure it out, this is our project, our thing. So, I think just the whole experience was so much better than being like, here's your experiment that you're going to do, go do it. I don't think that we would have learned nearly as much or had those opportunities of growth” (Mid).

Penny then transferred those perceptions and beliefs to her students' experiences in her classroom, which resulted in changes in her goals and action possibilities for herself and her students.

Barbara's experience with designing and carrying out the field study triggered her to see things from her students' perspective and to feel “*respect*” for their position as learners in her classroom. She said,

“I think that it's a good opportunity for me as a learner because as a teacher you sometimes forget that you're still a learner and you see things differently. But once you are in a learning situation, you kind of see things...are able to see things from a student perspective and I think that's...it makes us better teachers because we will better be able to sympathize with our students and kind of help them capitalize on their strengths rather than, you know, going through the process of making them learn things, we can now go through the process of getting them to want to learn things” (Mid).

Like Penny, Barbara's perceptions and beliefs surrounding her experience transferred to her students. She then developed goals and action possibilities for herself as well as her

students. Both Penny and Barbara were triggered by designing and carrying out the field study toward emerging beliefs about the value of more authentic experiences for their students and ultimately, to their plans for providing their students with at least portions of that type of experience.

The assessment portion of the PD also served as an external trigger for Bill, Penny, and Lisa. Bill and Penny were triggered toward emerging beliefs about the value of alternative assessments and were making plans to alter their assessment practices based on these emerging beliefs. While it was not clear what led to Lisa's plans for altering her assessments due to her lack of elaboration, she was still making plans and goals associated with doing so.

Lastly, Tony may have experienced a trigger for change associated with the interactions he had with colleagues and other teachers at the PD Institute. The following discussion seems to suggest that he felt triggered to question his teaching philosophy and practices. He said,

"I liked how in this context, it was more than just small things. It forced me to go back and begin to question, I guess, my whole reasons that through philosophy and classroom practice, being able to pick up on what others do and why and the benefit in why and how others do allows me to process through what I do and how I do and pick up new material or new methods in how I can make my classroom experience better"(Post).

However, since Tony did not elaborate on changed beliefs, purpose, or practices, it was difficult to tell if he actually did experience a trigger for change.

It is also probable that the participants experienced change in their professional identity systems due to their PD experience after the final interview. Follow-up interviews with participants would be useful and interesting possibilities for future work

in order to determine if and how participants made changes to their practices and to identify the triggering mechanisms that led to these changes.

Summary. This section gave an overview of perceived triggers to change in participants' professional identity systems. These came in the form of both internal triggers such as a drive to find new practices, and external triggers such as the field experience, which served to showcase the value of inquiry based learning. It seemed that teachers who came into the PD already internally triggered for change who then experienced external triggers that coincided with the internal triggers, as was the case with Penny and Barbara, experienced more change. A valuable extension of this research would be to identify internal triggers present in teachers' professional identity system in advance of PD so that external triggers could be better catered to their specific needs. It may also be possible to predict or better understand triggers based on the initial identity system structure. For example, knowing that Tony was predisposed to wanting to collaborate with other teachers may have been useful for designing opportunities for explicit collaboration efforts aimed at helping him better connect his learning and teaching to the PD topics.

RQ 3: Perceived Pedagogical Discontentment

In this section, I will move from professional identity to provide a discussion of participants' perceptions of pedagogical discontentment and how those perceptions changed as they progressed through the PD Institute. Pedagogical discontentment is defined by Southerland, et al. (2011b) as "the unease one experiences when the results of teaching actions fail to meet with teaching goals" (pg. 439). The Science Teachers Pedagogical Discontentment (STPD) scale provided a snapshot of participants' level of

pedagogical discontentment prior to and after the PD Institute. Interviews were also coded for the six categories of pedagogical discontentment as well as contextual discontentment in order to see if and how participants discussed the concepts. A discussion of the STPD scale and coded data is presented below along with a discussion of contextual discontentment.

STPD Scale

The STPD scale (see Appendix A) contains 105 points possible, with higher scores indicating greater discontentment. Scales were totaled for an overall score and then broken down into the six categories of discontentment for subscale scores. These included (AL) ability to teach all students science, (DB) balancing depth versus breadth of instruction, (AP) assessing science learning, (IB) implementing inquiry instruction, (TN) teaching nature of science, and (SC) science content knowledge. The AL and IB subscales each contained four questions, while the rest contained three. Because of this, mean scores were calculated for each of the subscales in order to compare scores across the scale. One of the ways Southerland et al. (2012) suggest using the STPD scale is to track changes in individual teachers' pedagogical discontentment as they participate in a PD experience. The PD Institute contained connections to four of the six subscales. NOS and assessment were explicit topics of discussion at the PD Institute. Science content knowledge and inquiry instruction were implicitly referred to during the Institute as participants developed and carried out their field studies. Each of the participants' scores and graphs of pre/post subscale means are presented below along with a discussion of their pedagogical discontentment.

Barbara scored a 39 out of 105 prior to the PD Institute (Figure 3 below). She was most discontent with balancing the depth versus breadth of instruction (DB) at pre, followed by her science content knowledge (SC), teaching NOS (TN), assessing science learning (AP), implementing inquiry instruction (IB), and ability to teach all students science (AL). At post-PD, her score decreased by nine points, for a total of 30 out of 105 points. Her highest and lowest discontentment subscales changed places. She was most discontent with her ability to teach all students science (AL), followed by teaching NOS (TN), implementing inquiry instruction (IB), assessing science learning (AP), science content knowledge (SC), and finally, balancing depth versus breadth of instruction (DB).

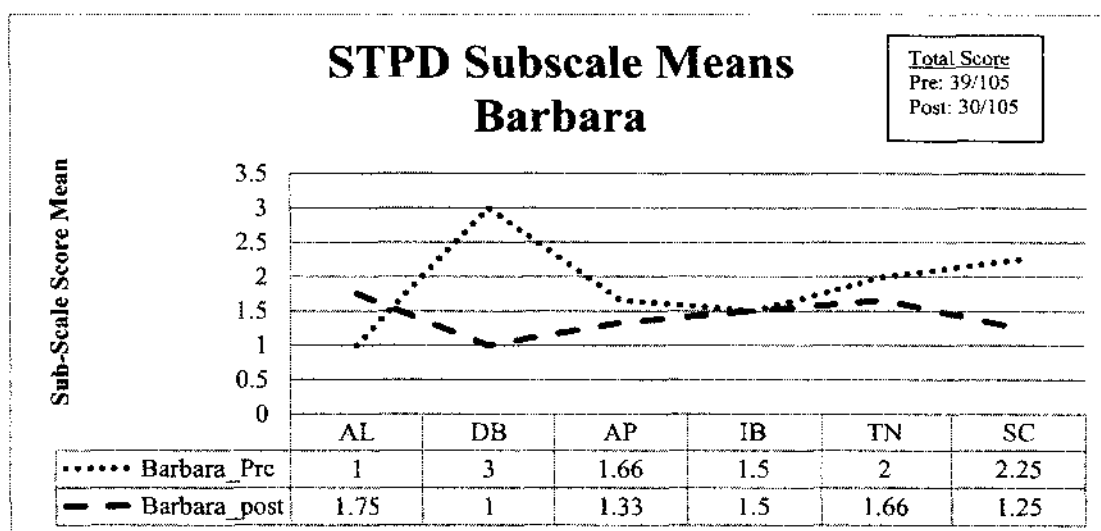


Figure 3. STPD Subscale Means for Barbara

Bill's STPD total scale score was a 48 out of 105 points at pre-PD (Figure 4 below). He was most discontent with assessing science learning (AP), followed by implementing inquiry instruction (IB), balancing the depth versus breadth of instruction (DB), which was tied with teaching NOS (TN), ability to teach all students science (AL) and finally, science content knowledge (SC). At post-PD, his score decreased by four points, for a total of 44 out of 105 points. Although the score for implementing inquiry

instruction (IB) remained the same, it became his most discontented subscale. This was followed by balancing depth versus breadth of instruction (DB), which was tied with assessing science learning (AP), ability to teach all students science (AL), teaching NOS (TN), and science content knowledge (SC) was again his lowest subscale of discontent.

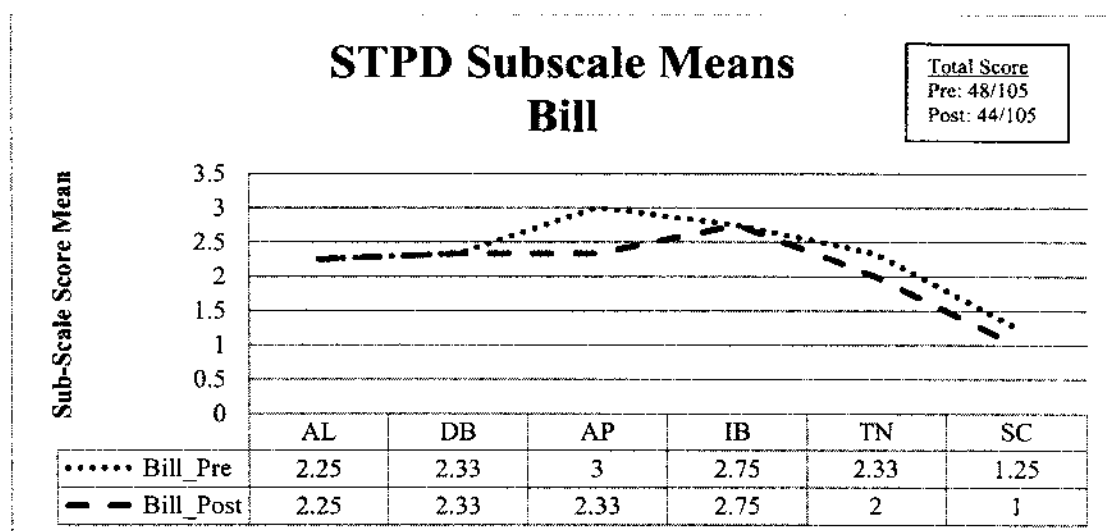


Figure 4. STPD Subscale Means for Bill

Lisa's STPD total scale score was a 29 out of 105 points at pre-PD (Figure 5 below). She was most discontent with her ability to implement inquiry instruction (IB), followed by teaching NOS (TN), ability to teach all students science (AL), balancing depth versus breadth of instruction (DB), and assessing science learning (AP), which was tied with science content knowledge (SC). Her post-PD scale score increased by 11 points for a total of 40 out of 105. She became equally discontent with four of the subscales: assessing science learning (AP), implementing inquiry instruction (IB), teaching NOS (TN), and science content knowledge (SC). These were followed by ability to teach all students science (AL) and finally, balancing depth versus breadth of instruction (DB).

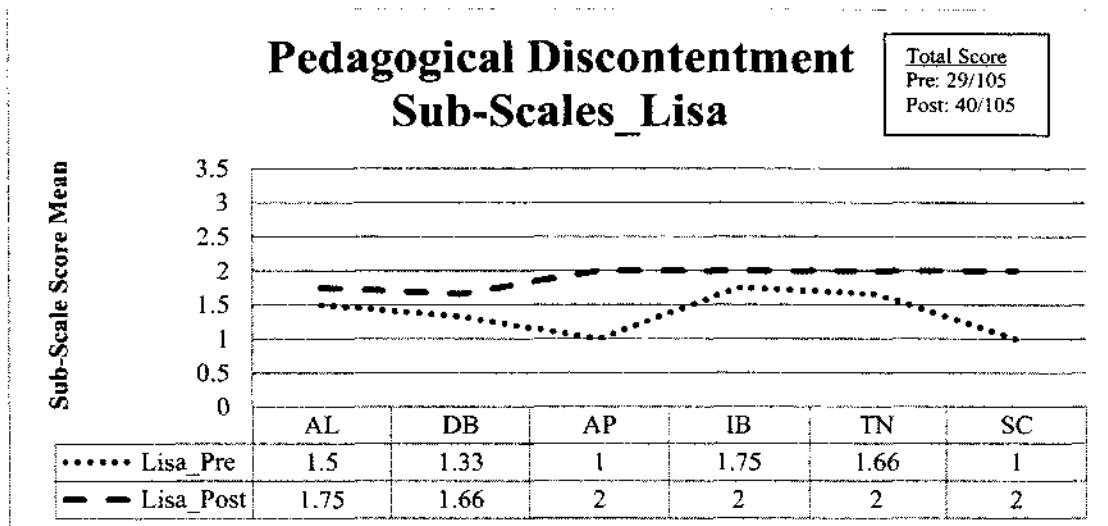


Figure 5. STPD Subscale Means for Lisa

Penny's STPD total scale score was a 33 out of 105 points at pre-PD (Figure 6 below). She was most discontent with her ability to balance depth versus breadth of instruction (DB) as well as her science content knowledge (SC). These were followed by her ability to teach all students science (AL), assessing science learning (AP), which was tied with teaching NOS (TN), and finally, implementing inquiry instruction (IB). Her post-PD scale score decreased by eight points for a total of 25 out of 105. Assessing science learning (AP) became her most discontent subscale. This was followed by balancing depth versus breadth of instruction (DB) and science content knowledge (SC). She was least discontent about her ability to teach all students science (AL), implementing inquiry instruction (IB), and teaching NOS (TN).

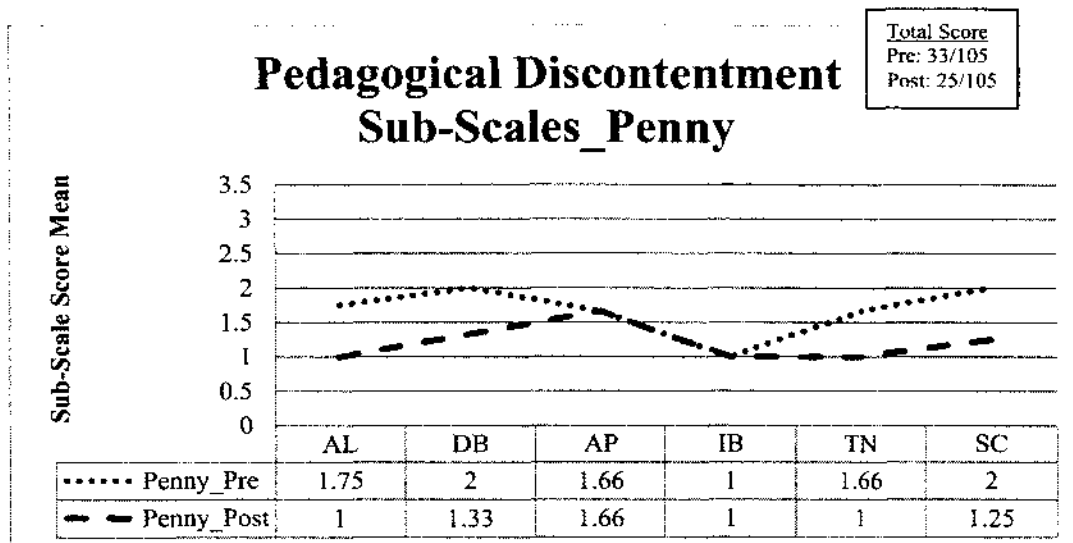


Figure 6. STPD Subscale Means for Penny

Tony's STPD total scale score was a 37 out of 105 points at pre-PD (Figure 7 below). He was most discontent with his ability to teach NOS (TN), followed by science content knowledge (SC), ability to teach all students science (AL), which was tied with implementing inquiry instruction (IB), assessing science learning (AP), and finally, balancing depth versus breadth of instruction (DB). His post-PD scale score increased by five points to be 42 out of 105. At post, he was most discontent with both his ability to teach all students science (AL) and his ability to implement inquiry instruction (IB). These were followed by teaching NOS (TN), science content knowledge (SC), assessing science learning (AP), and finally, balancing depth versus breadth of instruction (DB).

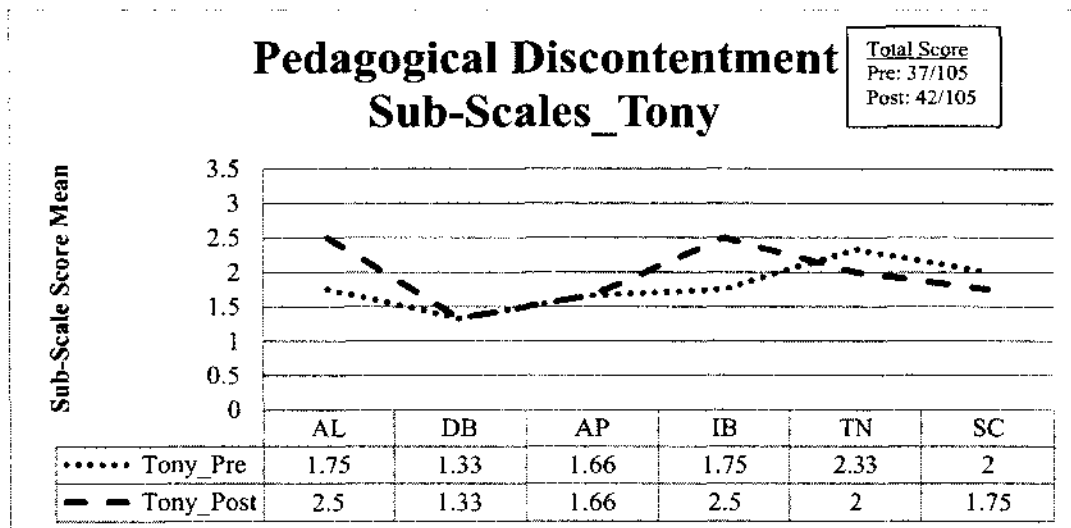


Figure 7. STPD Subscale Means for Tony

Participant scores were compiled together and are presented in Table 4 by pre- and post-PD. Total scores are given first followed by mean scores for each subscale.

Pseudonym	Total Score		AL Mean Score		DB Mean Score		AP Mean Score		IB Mean Score		TN Mean Score		SC Mean Score	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Barbara	39	30	1	1.75	3	1	1.66	1.33	1.5	1.5	2	1.66	2.25	1.25
Bill	48	44	2.25	2.25	2.33	2.33	3	2.33	2.75	2.75	2.33	2	1.25	1
Lisa	29	40	1.5	1.75	1.33	1.66	1	2	1.75	2	1.66	2	1	2
Penny	33	25	1.75	1	2	1.33	1.66	1.66	1	1	1.66	1	2	1.25
Tony	37	42	1.75	2.5	1.33	1.33	1.66	1.66	1.75	2.5	2.33	2	2	1.75

Table 4. STPD Scale Pre/Post Scores

It would be questionable practice to make comparisons across participants given the small number of participants and the fact that the scale has not been previously used to do so. However, it is interesting to note that Bill was consistently the most pedagogically discontent of the participants. Barbara, Bill, and Penny all experienced decreases in their level of pedagogical discontentment from pre- to post-PD while Lisa and Tony experienced increases in their level of pedagogical discontentment. Lisa experienced the most amount of change in pre- to post-scale, increasing by 11 points. Bill experienced the least amount of change in his pre- to post-scale, decreasing by four points. I also averaged the subscales to see which garnered the most and least amount of

discontentment across participants at pre- and post-PD. At pre-PD, participants were tied for most discontent in balancing depth versus breadth of instruction (DB) and teaching NOS (TN). At post-PD, they were most discontent with implementing inquiry instruction (IB). At pre-PD, they were least discontent with assessing science learning (AL), and at post-PD, they were least discontent with their science content knowledge (SC).

I was also interested to see the breakdown of level of discontentment indicated by each participant. Table 5 specifies the number of questions answered for each level of discontentment at pre- and post-PD. None of the participants felt “very high discontentment” for any of the scale questions, thus the score of 5 was not included in the table.

Pseudonym	1 = “no discontentment”		2 = “slight discontentment”		3 = “moderate discontentment”		4 = “significant discontentment”	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Barbara	11	12	2	9	8	0	0	0
Bill	4	5	9	10	8	5	1	1
Lisa	13	2	8	19	0	0	0	0
Penny	8	17	12	4	1	0	0	0
Tony	9	6	9	10	2	4	1	1
Percent Total	42.8%	40%	38.1%	49.5%	18.1%	8.6%	1.9%	1.9%

Table 5. STPD Scale by Level Score

Scores of “no discontentment” decreased slightly from pre- to post-PD. Scores of “slight discontentment” rose by over 10% points from pre- to post-PD. Scores of “moderate discontentment” decreased by about 10% points from pre- to post-PD. Finally, scores of “significant discontentment” stayed the same. Bill and Tony were the only participants who indicated that they had “significant discontentment” in an area listed on the STPD. At both pre- and post-PD, Tony was significantly discontent with “teaching science subject matter that is unfamiliar to me” (SC). At pre-, Bill was significantly discontent with “monitoring student understanding through alternative forms of assessment” (AP).

At post-, he was significantly discontent with “orchestrating a balance between the needs of both high and low ability-level students” (AL).

Pedagogical Discontentment in the Interviews

I also coded the interviews for each subscale of pedagogical discontentment in order to see if and how participants discussed perceptions of pedagogical discontentment. Much of what is discussed below actually contains instances of pedagogical contentment rather than discontentment. It is important to note the differences in the questions asked by Southerland et al. (2011b) during their interviews to develop the STPD scale from those asked during the PD Institute interviews. Southerland et al. (2011b) used language targeted toward teachers expressing discontentment with their current teaching practice. As such, their questions tended to have a negative quality to them. They also asked specific questions regarding practices and goals. Examples of questions Southerland et al. (2011b) used are listed below in Table 6.

Type of Question	Question
General	Are there aspects of your teaching that you are not completely satisfied with?
Discontentment/Change	How would you know/recognize when something is not successful/effective in your classroom? What signs do you look for? Describe any constraints that you feel are preventing you from achieving your science teaching goals?
Goals/Ends	Explain/describe any discrepancies between your personal goals and what you are able to currently achieve in your science classroom. Explain/describe the alignment with your personal teaching goals and the goals put forth by the curriculum or by national and local science/teaching standards.
Instructional Strategies and Practices/Means	Currently, are there particular kids (or groups of kids) that you're particularly good at teaching/reaching? Some that you are not? Do you feel that your current teaching practices/strategies equally reach all of your students? Where/how/when do your science teaching practices not fully become effective or successful?

Table 6. Questions from Southerland et al.'s Interview Protocol (2011b)

In contrast, the questions used for the series of PD Institute interviews (see Appendix B) were broader. These questions used language targeted toward the general and were of a more positive nature, including questions about “meaningful experiences” and what

provides “satisfaction” as a teacher. Only one of the questions was specifically targeted toward the negative, asking participants to describe “dilemmas or challenges” they have as teachers. Based on the difference in questions, one would expect to also see a difference in the types of answers received, however the lack of pedagogical discontentment discussed initially came as a surprise.

I also coded the interviews for contextual discontentment, which includes discontentment surrounding contextual factors of teaching such as administrative support, class size, lack of materials, parental involvement, student behavior, textbooks, standardized tests, etc. (Southerland et al., 2011b). As with Southerland et al.’s interviews (2011b), contextual discontentment surfaced in each interview to varying degrees. Each subscale is discussed below and is followed by a discussion of overall pedagogical discontentment found in the interview data and the role of contextual discontentment.

Ability to teach all students science (AL). AL was only discussed once across the pre-institute interviews. Bill related his very first teaching experience as a meaningful experience because he was able to ‘orchestrate a balance between the needs of both high and low ability-level students’ who were learning about DNA. He expressed contentment with the experience, saying that everyone in the class “*got it*” at the same time, which was unusual, and “*awesome*”.

AL was only mentioned once during the mid-institute interviews as well. Barbara discussed ‘teaching science to students from economically disadvantaged backgrounds’ as a dilemma or challenge she was facing. It was mentioned five times by only one participant during the post-institute interviews. Bill discussed three instances of ‘teaching science to students of lower ability levels’ when talking about translating his meaningful

PD experiences into his classroom and the problems he might face. He also made two mentions of 'orchestrating a balance between the needs of both high and low ability-level students' when discussing dilemmas or problems concerning the variation in students in his classes. Overall, AL was not a portion of pedagogical discontentment that was of particular concern to the teachers. Bill's discussions of AL during the post-interview coincide with his beliefs about his students' abilities.

Balance depth versus breadth of instruction (DB). DB was mentioned by two participants during the pre-institute interview. Penny made three mentions of 'balancing personal science teaching goals with state/national testing requirements'. Each of these was part of her discussion about meaningful experiences, and her perception that the time after the SOL tests is often best for her because she can give her students more choice and do more things that interest them. Bill made one mention of 'balancing the depth versus breadth of science content being taught'. This was part of a discussion of dilemmas or challenges he experiences in teaching, and was tied to his sense of contextual discontentment concerning his students' apathy toward school. He felt that this apathy limited him to broad explanations rather than being able to focus on some of the finer details of his curriculum.

DB was mentioned twice by one participant during the mid-institute interview. Penny discussed 'balancing personal science teaching goals with state/national testing requirements' with regard to changes she wished to make in her classroom. She experienced contextual discontentment surrounding the SOL test, and wanted to reevaluate her personal teaching philosophy to determine what is most important.

DB was mentioned only once by only one participant during the post-institute interviews. When discussing the oversimplification of some of the concepts he teaches, Tony mentioned a conflict with 'balancing personal science teaching goals with state/national testing requirements'. Again, overall, DB was not a primary area of concern for the participants, however it did surface somewhat when discussing assessment. Of interest, Barbara's high STPD subscale for DB did not coincide with a discussion of it during the interviews.

Assessing science learning (AP). AP was mentioned by four of the five participants during their pre-institute interviews. Bill was the only participant to mention 'monitoring student understanding through alternative forms of assessment'. He made two mentions of it during a discussion of what provides him satisfaction as a teacher. Both of these were instances of contentment surrounding his ability to assess students' understanding through a combination of traditional and alternative assessments, including conversations and daily work.

The other three teachers discussed examples of AP pertaining to contentment surrounding 'planning and using alternative methods of assessment'. Lisa mentioned one positive instance of using alternative assessments and student choice when discussing meaningful experiences. Barbara discussed using conversation and application rather than multiple-choice tests to determine when students have an "*aha moment*" during a conversation about meaningful experiences. Finally, Penny mentioned using alternative assessments during her time at a private school for twice exceptional students.

AP was discussed four times by two of the five participants during the mid-institute interviews. Lisa mentioned 'monitoring student understanding through

alternative forms of assessment' with regard to using student reflection on labs as a formative assessment tool. Barbara was planning to use concept mapping as a formative assessment tool as well as a means to inform her teaching practices. This discussion was triple-coded as 'monitoring student understanding through alternative forms of assessment', 'planning and using alternative methods of assessment' and 'using assessment practices to modify science teaching'.

AP was mentioned ten times by four of the five participants during the post-institute interviews. Barbara discussed using poster presentations with her students, such as those done as the culminating activity in the PD, as an example of 'planning and using alternative methods of assessment'. Lisa was also thinking of using the poster presentation idea in her classroom. Penny mentioned 'planning and using alternative methods of assessment' twice when discussing plans for altering her current assessment methods, which were heavily reliant on traditional testing. Lastly, Bill was planning to create questions similar to those in the Cornerstone Assessments for use in his current assessments.

Penny also mentioned two instances of 'using assessment practices to modify science teaching' when discussing how she might use alternative assessment to inform her teaching practices. Finally, Lisa mentioned 'monitoring student understanding through alternative forms of assessment' through the use of concept mapping. The increases in discussions of AP are unsurprising given the assessment portion of the second week of the PD Institute.

Implementing inquiry instruction (IB). IB was only discussed once during the pre-institute interviews. During a discussion of her hopes for the PD Institute, Penny

related an experience she had from the beginning of the previous school year regarding 'ability to plan successful inquiry-based activities/learning'. This was based on a previous PD experience involving inquiry instruction. The lesson went well, but she did not continue with that type of lesson throughout the school year. However, she did note how much her students enjoyed the lesson and that she felt that it went "*very well*".

Each of the participants discussed IB during the mid-institute interviews. 'Ability to plan successful inquiry-based activities/learning' was mentioned by each of the participants. Tony was planning to have students design their own labs but not actually do them. Penny again mentioned the inquiry activity she designed the previous year, and discussed plans for doing a field study with her students. Lisa mentioned having students begin to make decisions regarding their labs, including their procedures and hypotheses. Barbara was planning to have students design their own labs. Lastly, Bill was trying to figure out how to implement some inquiry instruction, but was struggling due to his perceptions of contextual discontentment surrounding his students' apathy and abilities.

'Preparing students to assume new roles as learners within inquiry-based learning' received four mentions by three of the five participants, always in conjunction with and sometimes double-coded with their plans for 'Ability to plan successful inquiry-based activities/learning'. Lisa gave an example of having students begin to pick their own variables and procedures with some modeling from her. Barbara was making plans to facilitate students as they begin to develop their own hypotheses. She also mentioned knowing that students would struggle initially, so she would have to do prep work. Lastly, Tony discussed scaffolding students by having them do just one-step themselves and then increasing their load from there.

There were nine mentions of IB during the post-institute interviews. One comment was made by Lisa, and the rest of the comments were made by Bill. Lisa maintained her plans to begin having open-ended questions for which students designed their own procedures. This was coded as 'ability to plan successful inquiry-based activities/learning'. Bill mentioned six instances of 'ability to plan successful inquiry-based activities/learning', however he was also experiencing discontentment associated with his perception of the freedom surrounding inquiry based activities.

Bill also made one mention of 'using inquiry-based teaching within all content areas' when discussing trying to "*figure out how I can do this for all the different stuff I do*", and was motivated to try while also knowing that it was going to be a process. Lastly, Bill made one mention of preparing students to assume new roles as learners within inquiry-based learning' when discussing starting with little problems and then seeing how it goes. Increases in discussions surrounding IB were also unsurprising given the inquiry-based nature of the field study portion of the PD Institute.

Teaching NOS (TN). TN was not mentioned during the pre- or mid-institute interviews. TN was mentioned five times by three of the five participants during the post-institute interviews. Lisa made one mention 'developing strategies to teach NOS' by using a poster to teach NOS principles. Bill made one mention of NOS that was double-coded as 'integrating nature of science throughout the curriculum' and 'developing strategies to teach nature of science' when discussing how he might create something to refer back to during the school year. Penny made two mentions of 'developing strategies to teach NOS' when discussing ideas she might take back into the classroom. Of note, Penny was the only one of the three who described students doing something with NOS. She was

making plans to have students do an inference versus observation lab as well as students creating something in order to learn about creativity in science. As with IB and AP, increases in discussions surrounding TN were unsurprising given that NOS was explicitly covered during the second week of the PD Institute.

Science content knowledge (SC). SC was discussed only by one participant, and only in the pre-institute interview. Bill discussed ten instances of ‘having sufficient science content knowledge to generate lessons’. He seemed content with his science content knowledge, giving several examples of how he had really used his science as opposed to just studying the book. He also gave one example of ‘having sufficient science content knowledge to facilitate classroom discussions’ when discussing talking with students about his time spent in industry. SC played an implicit part in the PD experience. The lack of mentions of SC during the interviews may have been due to teachers’ positive perceptions of the level of comfort with SC, particularly since they are all secondary teachers with degrees in specific science subjects.

Changes in pedagogical discontentment. There were 60 instances of coding associated with pedagogical discontentment. Of those, 13 of the instances coded were of perceptions of pedagogical discontentment. Participants discussed perceptions of discontentment surrounding their ability to teach all students science (AL) and balancing depth versus breadth of instruction (DB) only, and these were scattered throughout the interviews. It is not clear why these two categories were the only ones involving discontentment, particularly since the PD was not focused on either of these topics, thus they were less likely to come up in the narratives. 16 of the instances coded dealt with pedagogical *contentment* rather than discontentment. Participants discussed perceptions

of contentment surrounding their ability to teach all students science (AL), ability to assess science learning (AP), implementing inquiry instruction (IB), and science content knowledge (SC). Interestingly, each of these instances occurred during the pre-institute interviews. Finally, the remaining 31 instances coded were of plans participants were making associated with the categories of pedagogical discontentment. Codes related to planning were from the mid- and post-institute interviews only. These plans included only three of the six categories, assessing science learning (AP), implementing inquiry instruction (IB), and teaching NOS (TN). Plans associated with these three categories were unsurprising given that they coincided with explicit portions of the PD Institute. It is possible that participants were making plans for changing portions of the practices associated with AP, IB, and TN due to pedagogical discontentment, however they did not mention discontentment while discussing their plans. Rather, they were excited about making changes, which suggests that they may have been less pedagogically discontent with these areas, perhaps due to their experiences with the PD Institute. This finding is elaborated on further later in this section.

Contextual Discontentment. Contextual Discontentment was mentioned by each of the teachers during their interviews. These discussions fell into two major categories, discontentment surrounding students and discontentment surrounding the profession. A table of the pre-, mid-, and post-interview mentions broken down by category and person is presented in Table 7.

Pseudonym	Contextual Discontentment Surrounding Students			Contextual Discontentment Surrounding the Profession			Contextual Discontentment Per Interview			Total Per Participant
	Pre	Mid	Post	Pre	Mid	Post	Pre	Mid	Post	
Barbara	4	0	0	0	1	0	4	1	0	5
Bill	2	8	0	0	0	7	2	8	7	17
Lisa	0	0	0	6	1	0	6	1	0	7
Penny	3	0	1	0	1	1	3	1	2	6
Tony	0	1	0	1	6	0	1	7	0	8
Total	9	9	1	7	9	8	16	18	9	

Table 7. Contextual Discontentment for Each Interview

There were a total of 16 mentions of contextual discontentment during the pre-interview. Discontentment surrounding students was mentioned by three of the five teachers. Bill made two mentions of this during his discussion of dilemmas and challenges he faces, which included student apathy and discipline problems. Barbara made four mentions of this, which included student apathy and being thankful that her class was not SOL tested because she did not want her “abilities reflected” by her students. Penny mentioned three instances of this, including students’ lack of autonomy, lack of algebraic skills, and her considering it unfair that her students, many of whom are from disadvantaged backgrounds, are compared to all other students in the district.

The second major category was discontentment surrounding the profession. Tony made mention of a lack of collaborative effort between the mathematics and science departments due to his perception that this type of effort would not be appropriately rewarded. Lisa made two mentions of frustration with PD that overused Power Points. She also mentioned four instances of having to spend personal money on supplies as well as time constraints surrounding SOL-tested courses.

Contextual Discontentment was discussed 18 times during the mid-institute interviews. Lisa, Barbara, and Penny each mentioned Contextual Discontentment only

once, while Tony made seven and Bill made eight mentions respectively. Again, these fell into the two broad categories. Discontentment surrounding students was discussed once by Tony with regard to students' compartmentalization of their mathematics and science learning, which prevented them from using their knowledge in other classes. Each of Bill's eight mentions dealt with discontentment surrounding his perceptions of students, including his desire to do more with his students, and his sense that they were incapable of many things due to their apathy and lack of attention span.

Discontentment surrounding the profession was discussed by Penny, Barbara, Lisa, and Tony. Penny discussed lack of time to collaborate with other teachers. Barbara also discussed time constraints. Lisa talked about other PD's as being "cookie cutter" and not broadly applicable to her teaching. Lastly, Tony discussed six instances of discontentment surrounding the profession. Two of these pertained to SOL's, both the score turnaround time as well as the SOL's effect on teaching. He also made mention of teachers' focus on grades and product creation rather than allow students time to fail. Professional isolation was also a topic of discussion for Tony. Lastly, in concert with his discussion of student compartmentalization, he again mentioned a lack of collaborative effort between the mathematics and science departments due to his perception that this type of effort would not be appropriately rewarded.

There were nine references made regarding Contextual Discontentment during the post-institute interviews, however, these were made by only two of the five participants. Of these, only one fell in the category of discontentment surrounding students. Penny made a comment about students' lack of autonomy, and her desire to change that by

making changes in her classroom. This was similar to a comment she made during the mid-institute interview.

Eight of the nine comments were about discontentment surrounding the profession. Penny made one comment about her status within the chemistry department of her school. She had previously felt like she could not go against the status quo, however, she was making plans to do so now that she had been with the school for five years. Interestingly, Bill's comments about contextual discontentment shifted from being about his students to being about PD. He expressed dissatisfaction with current PD offerings due to their lack of professionalism, repetition, and quality.

Contextual discontentment was definitely on participants' minds, and surfaced in most of their interviews. It is interesting to note that there were far fewer references to contextual discontentment at the post-interviews. This may have resulted from the teachers becoming more focused on plans based on the PD experience, which caused them to feel, or at least to discuss, less contextual discontentment. Future studies could address this hypothesis by specifically asking teachers about their contextual discontentment as they proceed through a PD experience and make plans for their classroom.

It is also interesting to note the totals for each participant. Of the 43 total references to contextual discontentment, Barbara made the least amount with five coded sections, followed by Penny, who made six references, Lisa, who made seven references, and Tony, who made eight references to contextual discontentment. In contrast, Bill made 17 references to contextual discontentment, almost twice the number of any other participant. Many of Bill's references pertained to discontent surrounding his students,

including his apathy and inability. This contextual discontentment with his students seemed to limit Bill's ability to see the applicability of the PD Institute to his classroom practices, especially on a larger scale. Though he made plans associated with the PD experience, he continually juxtaposed this planning with discussions of his students' limitations, causing him to believe that he could only do small pieces of PD-like experiences with his students. In Southerland et al.'s (2011b) pedagogical discontentment interviews with teachers, they reported on a case that seems quite similar to Bill. Their interviewee also focused the discussion on students' deficits, which seemed to limit his ability to then problematize his own practices. Although Southerland et al. (2011b) suggest that contextual and pedagogical discontentment are interdependent, they also discuss the interviewee mentioned as an example of contextual discontentment overshadowing pedagogical discontentment. Bill's case lends support to their finding since his discussions pertaining to pedagogy were continually overshadowed by expressions of contextual discontentment. Future studies should further address the role contextual discontentment plays in pedagogical discontentment, particularly to see if it is possible to trigger teachers similar to Bill to see past their contextual discontentment and to the deeper issues that may be associated with their pedagogy.

Comparison of STPD Scales and Pedagogical Discontentment in Interviews

An interesting theme discovered when comparing the STPD scale and interview data was that four of the five participants' highest post-subscale scores corresponded with plans discussed during the interviews. For example, Lisa's post-scale indicates that she was most discontent with assessing science learning (AP), implementing inquiry instruction (IB), teaching NOS (TN), and science content knowledge (SC). Lisa also

discussed plans associated with three of the four categories during the mid- and post-interviews. She was planning to alter her assessments, implement more inquiry instruction, and hang a poster about NOS that she could refer to during the school year. Likewise, Penny's post-scale indicates that she was most discontent with assessing science learning (AP). She also discussed plans associated with AP, including questioning her assessment practices and making plans to revamp them in the coming year to be more alternative in nature. Tony's post-subscale scores indicated that he was most discontent with implementing inquiry instruction (IB) and teaching all students science (AL). He discussed one plan associated with IB, however he did not mention AL. Finally, although Bill's post-subscale score for implementing inquiry instruction (IB) remained the same, it became his most discontented subscale due to decreases in another subscale. He also discussed several plans associated with IB during his mid- and post-interviews, including trying to find small ways to let his students do more inquiry. However, of note, Bill's planning discussions were also always juxtaposed with discussions of his contextual discontentment surrounding his students. STPD subscale increases and discussions of planning may be related. The relationship may center on teachers' gaining a better understanding of deficits in their pedagogy through PD experiences, which may lead to increases in their subscale scores, indicating more discontentment, but also with plans associated with trying to do something about their pedagogical discontentment. Future studies could address this by using both the STPD scale and interviews to better unearth the reasoning behind scale scores.

It is also interesting to note that although Penny's score for assessing science learning (AP) corresponded with planning, this was not the case for implementing inquiry

instruction (IB) and teaching NOS (TN). Penny's post-subcales for IB and TN indicate that they were the categories with which she was experiencing the least discontentment. However, they were also the two other categories she discussed during the mid- and post-interviews. The IB decreases might be explained by Penny's previous experiences with having students design their own labs and her PD-based plans to have students do so again. Allowing teachers multiple opportunities to learn about new practices, process their learning, try new practices, reflect on those practices, and then try again may be the key to lessening their pedagogical discontentment and ultimately to adopting reform-based practices. Future studies should test this hypothesis of a more longitudinal style of PD learning.

Also notable is that the series of interviews highlighted Bill's continual contextual discontent surrounding the inabilities of his students, which may have contributed to him feeling more discontentment with AL, specifically 'orchestrating a balance between the needs of both high and low ability-level students' (AL) at the end of the PD, which he scored as a four "significant discontentment". This gives further credence to the interdependence of pedagogical and contextual discontentment. Finally, it is interesting that Tony's pre- and post-scoring of SC 'teaching science subject matter that is unfamiliar to me' was a four "significant discontentment". During Tony's pre-institute interview, he discussed his perception that he could easily teach other topics. He said, "*if I were to walk into another classroom, I think I could pick up, with the exception of probably a foreign language, I think I could pick up most things and just teach it with about 10-15 minutes*", which seems to contrast the significant discontentment he felt associated with teaching unfamiliar concepts. This could be due to misunderstanding the

STPD scale question or perhaps Tony was thinking of particular instances within his own chemistry curriculum during which he felt discontentment. It would be interesting to see how participants STPD scale scores changed as they went through the school year after the PD experience and may have tried to enact some of the plans they were making. A more longitudinal-style of study would certainly be beneficial for the future.

Overall, STPD scores underwent some changes from pre- to post-PD, and participants discussed pedagogical discontentment, contentment, planning, and contextual discontentment during their series of interviews. However, the STPD scale and the instances of coding related to pedagogical discontentment alone did little to provide information about why teachers might be pedagogically discontent, how that discontentment is represented, or what their plans for the future were associated with the pedagogical discontentment. This leads to a discussion of the relationship between pedagogical discontentment and professional identity, which is the topic of the next section.

RQ 4: Relationship between Professional Identity & Pedagogical Discontentment

The final research question associated with this study looks at the relationship between professional identity and pedagogical discontentment. In order to answer this question, I will first discuss analysis of sections of the interviews that were simultaneously coded for aspects of the professional identity model as well as pedagogical discontentment. I will then discuss comparisons between the STPD subscale scores and triggers for changes in the professional identity system components.

Instances of Simultaneous Coding

The differences between Southerland et al.'s (2011b) interview protocol and the protocol used for the PD Institute interviews coupled with the few instances of actual pedagogical discontentment make it difficult to analyze the data completely. Since pedagogical discontentment was only expressed in two of the categories (AL and DB), I have chosen to include any reference coded for pedagogical contentment and plans surrounding categories of pedagogical discontentment, in order to better capture the data.

Southerland et al. (2011b) define pedagogical discontentment as “the unease one experiences when the results of teaching actions fail to meet with teaching goals” (pg. 439). This would seem to indicate that pedagogical discontentment would fall within the professional identity model components of sense of purpose and action possibilities with the unease being represented by self-perceptions. I found this to be the case for some sections. For example, sections coded for implementing inquiry instruction (IB) and assessing science learning (AP) were also coded for sense of purpose and action possibilities. An example of a section that was simultaneously coded for IB, sense of purpose, and action possibilities comes from Lisa, who was discussing ideas she was planning to take back into her classroom based on the PD experience. She was planning to take back, “*the idea of having kind of an open-ended question and letting kids come up with procedures and guide them through their inquiry instead of just handing it to them*” (Mid). An example of a section that was simultaneously coded for AP, sense of purpose, and action possibilities comes from Barbara, who was planning to use concept mapping with her students. She said, “*I'm going to use it for formative assessments... Take from that what I need to reteach and reflect on how I can make it more meaningful for students*” (Post).

The other four categories contained references to personal epistemology as well as other professional identity components. For example, teaching NOS (TN) references were simultaneously coded with sense of purpose and action possibilities, however there were also instances of personal epistemology as participants' expressed their beliefs surrounding NOS and teaching NOS. An example of this comes from Bill, who was discussing plans to make a poster with the NOS principles. He said,

“There was one teacher that mentioned that she'd made a poster and I think that would be kind of a cool thing to do. I'm just trying to decide how I want to do it, but refer back to it on a regular basis during the school year. So I'm just not sure how I want to make it. I think it's more gonna be a picturesque kind of thing instead of words, but it will cover the concept...and I can keep referring back to it though, so by the end of the year, when they ask me a question, I'll be pointing to the poster and they'll be like, oh yeah, like...” (Post)

This led into a discussion of beliefs surrounding NOS. He continued by saying, *“It's just refocusing the way we look at things. None of that's a surprise to me, it's just not presented in a simple, you know, 5-step thing. So it's just something that...it's just repackaging something that we kind of lose track of as we go”* (Post).

Ability to teach all students science (AL) was simultaneously coded with personal epistemology and action possibilities. An example of this comes from Bill, who was discussing plans to let students grapple with small problems in groups. He expressed concern about doing so that was based on beliefs about his students. He said,

“sometimes the class dictates what you can and can't do, so it does vary, especially with me, because they lump them together in math class, so I get them at a certain block and depending on which math they're in, they want to learn, don't care about learning, or they can't learn. There's a mix, so it'll change a little bit from class to class too. That'll be the challenge trying to get it to work” (Post).

Balancing depth versus breadth of instruction (DB) was simultaneously coded with personal epistemology as well. An example of this comes from Tony, who expressed

discontentment and beliefs associated with the oversimplification of concepts such as quantum mechanics because of the SOL test. He said, *“I think the SOL oversimplifies it...that oversimplification is sometimes good because it develops understanding, but if that oversimplification wasn't the whole point of the original or the process of the original, it's not a benefit to our kids”* (Post). Finally, science content knowledge (SC) was simultaneously coded with both personal epistemology and self-perceptions. An example of this comes from Bill, who was discussing his practice of taking science-related vacations that he then uses in the classroom. He said,

“I can use that first-hand experience to explain to them about the Chesapeake Bay and stuff like that. And, I don't know, whatever I do on one thing, I always just pull back into the class whenever I'm teaching something. So instead of saying, this is what the Chesapeake Bay is like, I can say, when I was out there, it was...and give them a little more detail” (Pre).

Based on this analysis, which is small and very contextualized, I suggest that pedagogical discontentment is related to professional identity in that it allows for more thoroughly problematizing the contents within some of the teacher's identity components, such as their action possibilities. However, while action possibilities might be limited because of teachers' perceived pedagogical discontentment, discontentment itself may be explained in more detail by way of reference to teachers' beliefs and sense of purpose. So, while pedagogical discontentment seems to be most related to sense of purpose and action possibilities, as supported by Southerland et al.'s (2011b) definition, it also contains elements of self-perceptions and personal epistemology. Future study might better reveal the relationship and demonstrate the usefulness of having both types of data.

STPD Subscale Scores and Triggers for Change

Another interesting potential relationship emerged when looking at the STPD post-subscale scores and the triggers for change to professional identity system components in the form of the assessment portion of the PD. Penny, Lisa, and Bill's experience of external triggers to their professional identity system in the form of the assessment portion of the PD may also correspond with their post-PD discontentment surrounding assessing science learning (AP). AP was Penny's most discontent subscale at post. It tied for Lisa's most discontent subscale at post, and was Bill's second most discontent subscale at post. However, this relationship does not hold true for the other external trigger, the field study. Barbara and Penny were both triggered by the experience of the field study, which was related to implementing inquiry instruction (IB) and science content knowledge (SC). Barbara's post-subscale scores indicated that IB was her third most discontent subscale and SC was her fifth most discontent subscale. Penny's post-subscale scores indicated that SC was her third most discontent subscale and IB was in a three-way tie for the least discontent subscale. Based on this conflicting data, it would be useful to continue to look for the potential relationship between changes in the STPD subscale scores and triggers for change in professional identity components in future studies.

It is also interesting to note that Lisa experienced the most change in her STPD score from pre- to post-PD, becoming more discontent by 11 points. Further, her post-STPD subscale scores indicate that she was equally discontent with assessing science learning (AP), implementing inquiry instruction (IB), teaching NOS (TN), and science content knowledge (SC). While she did not discuss SC during her interviews, Lisa did place focus on AP, IB, and TN, representing a shift in her sense of purpose and action

possibilities. I was unable to explain the shift through Lisa's narratives due to her lack of elaboration surrounding her goals and plans. This may also have been demonstrated by Tony, who was the only other participant to experience an increase in his level of discontentment and was also less elaborative interviewee. This may demonstrate another potential relationship between professional identity and pedagogical discontentment in that the STPD data demonstrates that they did undergo some sort of trigger for change that was not well-captured through the interviews. Lack of elaboration is also discussed further in the limitation section of the next chapter.

Overall, it seems that pedagogical discontentment may serve to assist in more thoroughly problematizing specific aspects of the professional identity components in relation to science teaching. STPD scale data may also assist in identifying tensions and possible changes to the professional identity system in less elaborative speakers. Future studies should look to see if the same subscales aligned with model components as in these findings. This type of extension to the research could eventually lead to complimentary and increased understandings of both professional identity and pedagogical discontentment.

Summary of Findings

This chapter presented findings for each of the four research questions. To answer the first research question, of the patterns of change in participants' professional identities, it is clear that teachers can be influenced by other role identities. These other role identities may be linked with expectations and takeaways of the PD experience. Teachers are also actively seeking additional learning according to their goals. These goals may shift during the PD, and seem to be directly related to their self-perceptions of the PD

experience. These goals are also related to action possibilities teachers make associated with the PD experience, and these plans seem to be influenced by the connections made between self as a learner and as a teacher. Collaborations among teachers from the same school may serve to more quickly establish comfort and sense of safety, which could lead to teachers more readily taking risks. Further, it was also evident that the components of the professional identity model are interrelated, as seen by the connections, alignments, and dynamic changes in the teachers' professional identity systems. Teachers who were more aligned were also more easily understood through the narratives because they were better able to express the four components of the model. Teacher professional identity is dynamic, with changes in one aspect of the model often resulting in changes in other aspects of the model. These changes also seemed to be associated with teachers' abilities to make explicit connections between themselves as both learners and teachers and their students.

The second research question, regarding perceived triggers for change in professional identity, was showcased through internal and external triggers. Some teachers entered the PD experience already internally triggered for change. These internal triggers may be the result of personal characteristics or of a building of PD experiences over a course of time, which led to internal triggering. Teachers were also externally triggered by various experiences with the PD, such as the field study and assessment portions. In particular, it seemed that their self-perceptions of the experience led to changes in other portions of their professional identity system. It also seemed that the combination of an internal and external trigger served to produce more change in the professional identity system.

Further research into triggering mechanisms is warranted to determine if this hypothesis is correct.

To answer the third research question, of changes in perceptions of pedagogical discontentment, all participants experienced change in their perceptions of pedagogical discontentment as measured by the STPD scale. These changes seemed small; however, there is no established basis for determining the relative levels of STPD, thus there is no comparison data. While the STPD scale and instances of pedagogical discontentment coded within the narratives served to highlight more specific tensions and positive feelings in the teachers' pedagogy, ultimately, they did little to enlighten us about the pedagogical discontentment of the participants, including how the discontentment began and how the teacher is navigating the tension.

Finally, to answer the fourth research question, of the relationship between professional identity and pedagogical discontentment, I argue that pedagogical discontentment serves to assist teachers in more thoroughly problematizing and researchers in more thoroughly understanding the various aspects of the professional identity model as it relates to science teachers. Specifically, pedagogical discontentment appears to assist in further determining potential tensions in a teachers' sense of purpose and action possibilities. The STPD scale may also assist in identifying tensions and possible changes in less elaborative interviewees. Future study is warranted to determine if the STPD scale can serve to compliment narrative data in order to better determine triggers and potential changes in teachers' professional identity system.

Chapter 5: Conclusions

This multiple case study sought to explore and compare the constructs of teacher professional identity and pedagogical discontentment in five practicing high school science teachers participating in a reform-based PD Institute. The purpose of case study is to yield analytic generalization, “in which a previously developed theory is used as a template with which to compare the empirical results of the case study” (Yin, 2009, pg. 38). This study used an emerging model of professional identity (Kaplan, et al., 2012) to capture the professional identity systems of participants as they navigated the PD institute. The study also looked at participants’ perceptions of pedagogical discontentment (Southerland, et al., 2011a, 2011b, 2012) and compared the two constructs. The results provide meaningful insights that inform broader understandings of the constructs studied. This chapter begins with a summary of the findings, which is followed by a discussion of theoretical implications, implications for practice and future research, and limitations.

Summary of Findings

The analysis of narratives, STPD scales, reflections, and E&C cards offered insight into the experience of the five participants as they participated in the PD institute. This summary of findings is broken down by research question, beginning with the patterns of change in professional identities, and followed by triggers for change in professional identity, perceived pedagogical discontentment, and finally, the relationship between professional identity and pedagogical discontentment.

Patterns of Change in Professional Identities

Patterns of change in participants' professional identities were illustrated by nine themes within two major categories. Themes related to individual model components included (a) self-perceptions: multiple constructed role identities, (b) self-perceptions: collaborations with other teachers, (c) sense of purpose: goals for the PD institute versus takeaways, (d) sense of purpose: self-related versus student-related goals, and (e) action possibilities: plans for adding/altering practices. Themes surrounding the interplay of model components included (a) interaction between roles of learner and teacher, (b) variability in alignments, (c) variability in change, and (d) dynamic nature of changes. These themes are elaborated upon further below.

Themes related to individual model components. Participants expressed both similarity and diversity in their self-systems throughout the PD experience. This section is divided into each of the themes discovered in the analysis. It includes a summary of each theme in relation to overall patterns of change.

Self-perceptions: influence of other role identities. Some participants came into the PD institute with role identities other than that of their teacher role already in place. These other role identities surfaced in the pre-interviews in the form of self-perceptions and then served to influence the PD experience. These influences seemed to come in the form of expectations of the PD experience, self-perceptions of the PD experience, and ultimately, takeaways from the PD associated with the role.

Self-perceptions: collaborations with other teachers. All of the participants experienced positive self-perceptions of their collaborations with other teachers. In particular, it seemed that collaborations among teachers from the same school were

beneficial, perhaps due to the already established comfort level among peers. Participants also enjoyed working with their colleagues in a setting outside of school.

Sense of purpose: goals for the PD institute versus takeaways. Participants entered the PD institute with a wide variety of goals in mind. Each participant accomplished at least some of the goals they came into the PD with; however, most also developed additional goals while at the PD. These newly developed goals also seemed to come in conjunction with their PD experiences and newly developed beliefs.

Sense of purpose: self-related versus student-related goals. The PD experience seemed to serve as a catalyst for teachers developing more student-related goals. However, these varied based on the types of goals teachers entered the PD with and their response to the PD experiences. Increased student-related goals seemed to come from the teachers who were better able to connect their learning to that of their students.

Action possibilities: plans for adding/altering practices. There was a wide variance in the type and depth of plans associated with the PD experience. These action possibilities also seemed to be related to the level of connections teachers made between their role as a learner and their students. And while it only occurred with one participant, it seems that there may be a connection between building PD experiences over time and achieving a critical moment when the teacher is prepared to make larger changes to practices.

Themes surrounding the interplay of model components. It was evident that the four components of the model are co-active and interrelated. This section is also divided into each of the themes discovered in the analysis. It includes a discussion of each theme in relation to overall patterns of change.

Interaction between roles of learner and teacher. Participants made a variety of connections between their PD experience as a learner and as a teacher. There was a wide variance in the amount of these connections. It seemed that those who were more readily able to connect their self-perceptions of the two roles were also more likely to experience changes in their personal epistemology, sense of purpose, and action possibilities as well.

Variability in alignments. Participants also exhibited variability in the type and extent of alignments to their professional identity system. Those who demonstrated more alignment were also easier to understand through the narratives, perhaps because they were better able to describe why they do the things they do. For example, these alignments were evident as teachers explained practices and goals associated with beliefs and perceptions of experiences. Alignments shifted throughout the PD as teachers experienced challenges to their professional identity system. Some left the PD having realigned themselves, and others left with tensions present.

Variability in change. Each of the participants left having changed portions of their professional identity system. The types and extent varied widely. These variabilities may be related to the level of interaction between their roles as learners and teachers and their ability to make connections between their experiences and that of their students. And, similar to the theme associated with action possibilities, there may be a connection between PD that builds over time eventually leading to larger changes.

Dynamic nature of changes. Finally, it was also evident that participants experienced dynamic changes to their professional identity systems as they went through the PD experience. Most of these dynamic changes seemed to begin with self-perceptions

of the experience, which led to developing new beliefs, goals, and plans for altering practices.

Triggers for Change in Professional Identity

Triggers for change fell into two categories, internal and external triggers. Internal triggers involved entering the PD institute with an already established orientation toward seeking opportunities for improvement. These internal triggers may have been based on personal characteristics or previous PD experiences. External triggers included designing and carrying out the field study, the assessment portion, and interactions with colleagues and other teachers. In some cases, there was overlap between an internal and external trigger, and in other cases, only one triggering mechanism was present. It seemed that the combination of an internal and external trigger served to produce more change in the professional identity system.

Perceived Pedagogical Discontentment

Pedagogical discontentment was determined through both the Science Teachers Pedagogical Discontentment (STPD) scale and coded interview data. Each of these is further elaborated on below.

STPD scale. Each of the participants experienced changes associated with their STPD scale scores. These changes seemed to be small in nature; however, there is no established basis for determining relative levels of STPD. The vast majority of their STPD scores indicated that they perceived “no” to “slight discontentment” with the categories of the STPD. Three of the five participants left the PD less pedagogically discontent, perhaps indicating that the PD experience served to negate some of their pedagogical discontentment. The other two participants increased in their level of

pedagogical discontentment. Interestingly, these were also the participants whose narratives were more difficult to understand.

Pedagogical discontentment in the interviews. Participants mentioned several instances related to their pedagogy during the series of interviews. However, most of those instances were of pedagogical *contentment* and plans associated with pedagogy rather than pedagogical discontentment. Contextual discontentment was also a prevalent theme within the interviews, including discontentment surrounding students and the profession. One of the five participants experienced contextual discontentment that seemed to interfere with his pedagogy such that he was unable to see past his discontent with the context in order to look further into his pedagogy.

Comparisons of the STPD scale scores and coded data revealed that some of the post-subscale scores corresponded with plans discussed during the interviews, indicating that there might be a relationship between increased pedagogical discontentment and planning, perhaps to alleviate the discontentment. Overall, however, the STPD scale and coded sections of pedagogical discontentment did little to showcase the underlying causes and meaning behind tensions.

Relationship between Professional Identity and Pedagogical Discontentment

The professional identity model served to fill in some of the underlying causes and meanings behind tensions found in the STPD scale data and coded interview data. Pedagogical discontentment may serve to provide more information as to the what (i.e. discontentment specifically surrounding providing inquiry based learning experiences for students, etc.). However, I argue that professional identity serves to provide the why and how. The four components of the professional identity model allowed for insights into

perceptions and beliefs about aspects of pedagogical discontentment that may have been causing limited goals and action possibilities associated with them. Of note, however, the STPD scale may also serve to help identify tensions and potential changes in less elaborative interviewees.

Theoretical Implications

The findings of this study contribute to developing a more comprehensive model of science teacher professional identity, for which the literature currently lacks a conceptual framework. The professional identity model used in this study (Kaplan, et al., 2012) seemed to successfully capture the professional identities of each of the participants. This included showcasing the interplay between the four components of the model as well as the individual and contextual characteristics that influenced each participant's experience of the PD Institute. In keeping with previous literature, the model highlighted common features of teacher professional identity, including the ongoing process of professional identity, the importance of looking at both person and context, the presence of sub-identities, and the active pursuit of additional learning according to goals (Beauchamp & Thomas, 2009; Beijaard, et al., 2004). The ongoing process of development and changes in professional identity was evident even with seasoned teachers nearing the end of their careers, as was the case with Bill and Barbara, who were both still looking for ideas for their classrooms and willing to engage in exploration of components based on self-perceptions associated with the PD experience. The importance of interpreting professional identity in light of both person and context was highlighted by Tony's lack of connection between the PD and his high school students, which seemed to be due to his perception that the field study was at an undergraduate

level rather than high school appropriate. It could also be seen in Bill's positive perceptions of the PD as being professional as opposed to the majority of other PD's in which he participates, which may have led him to more thoroughly engage in the PD. The presence of sub-identities was also evident in Tony and Bill, whose perceptions of themselves as scientists influenced their experience of the PD, and seemed to serve to limit their connections between the PD experience and that of their students. However, in Barbara, whose perceptions of herself as a professional student also influenced her experience, we found that her sub-identity may have contributed to her making connections between the PD experience and her students. Finally, each participant demonstrated the active pursuit of additional learning according to goals. Many of their goals at pre-PD were met, and with the exception of Tony, everyone experienced changes to their goals as a result of the PD experience.

Triggers for change in participants' professional identity were showcased by both internal and external triggers. Teachers experiencing an internal trigger may have entered the PD Institute already dissatisfied with a portion of their teaching practice and were seeking to make changes. External triggers were the PD experiences that served to trigger ambiguity or confusion, which then provided motivation for professional identity exploration (Flum & Kaplan, 2003). Participants experienced external triggers in the form of the field study, assessment work, and collaborations with colleagues. In complex systems thinking, triggers can be thought of as perturbations to the system from outside sources (Davis & Sumara, 2007). In keeping with complex systems literature, these perturbations seemed to cause fluctuations within the professional identity systems, which prompted the system to respond differently (Davis & Sumara, 2007). These

responses came in the form of altered perceptions, beliefs, goals, and action possibilities. Participants' systems were perturbed by different experiences and in different ways, which is in keeping with the hierarchical structure and self-organizing nature of complex systems (Clarke & Collins, 2007; Davis & Simmt, 2003; McMurtry, 2008). Some participants left with disequilibrium or misalignments, present, which is regarded as a positive, creative tension needed in order to change (Clarke & Collins, 2007; Prigogine, 1977). These triggering events correspond to Smagorinsky, et al.'s (2004) suggestion that tensions can and should be provoked in order to encourage professional identity exploration. And, as with previous literature, these triggers for identity exploration seemed to be aided by the daily written reflections, which some participants referred to during their interviews, conversations and collaborations with colleagues, particularly those from the same school, and by the general sense of safety created at the PD (Flum & Kaplan, 2003; Sinai, et al., 2012). A more longitudinal study is needed in order to better understand the teachers' negotiations of their disequilibrium after the PD experience.

Triggers for change may also be related to pedagogical discontentment, or dissatisfaction with a portion of teaching practice, which Southerland et al. (2011a) purport to be a first condition necessary for teachers to make changes to their practices. They suggest that pedagogical discontentment can be engendered during PD, which may also have happened through the external triggers. However, the STPD scale did not seem to fully capture participants' experiences with pedagogical discontentment. However, the professional identity model seemed to capture the trigger and the processes participants went through to change beliefs, goals, and action possibilities associated with aspects of the STPD. And, although some STPD subscale score did not change, participants may

still have come away from the PD experience having changed their perceptions, beliefs, goals, and action possibilities related to STPD subscales. This supports teachers' personal beliefs as a key component of their response to reform-based initiatives (Crawford, 2007; Johnson, 2007; Jeanpierre, Oberhauser, & Freeman, 2005; Smith & Southerland, 2007). Pedagogical discontentment on its own did not seem to give enough information. However, the professional identity model allowed for a much more thorough understanding by capturing the process they went through when triggered, or not, for change.

The STPD scale was used to determine perceived pedagogical discontentment pre- and post-PD Institute. Participants generally came into the PD Institute with low levels of pedagogical discontentment. Three of the five left the PD Institute with less discontentment than they entered with and the other two increased in their discontentment. The decreases in pedagogical discontentment seen in Penny, Barbara, and Bill could be due to them finding practices that were more in line with reform-based teaching. This supports Southerland et al.'s (2011a) assertion that teachers must experience pedagogical discontentment before they seek change. However, the professional identity model allowed for an inside look at how the participants were negotiating the PD experience and what might have led to their planned changes or a lack thereof. For example, Bill entered and left the PD as the most pedagogically discontent participant. The interviews, however, provided insights into why Bill was pedagogically discontent, and uncovered his contextual discontentment in the form of beliefs about his students and how school works, which heavily influenced his pedagogy. In keeping with Southerland et al.'s findings (2011b), it seems that contextual and pedagogical

discontentment are interdependent, and that increased levels of contextual discontentment can serve to overshadow pedagogical discontentment such that teachers may be unable or unwilling to engage in explorations of their pedagogy.

The STPD scale also provided some useful information about Lisa and Tony, who were less elaborative speakers. Their lack of elaboration during the interviews served to limit the effectiveness of both models in capturing in-depth insights into their professional identity system because they were less inclined to discuss beliefs, goals, and action possibilities. Tony, in particular, did not seem to experience any changes associated with the PD institute based on the interview data, however, his increased STPD post-scores indicate that he left the PD with tension present. This supports Southerland et al.'s (2012) suggestions for the usefulness of the STPD scale in shaping the impact of the PD experience for teachers. Using the STPD scale with interviews coded through the model might be particularly helpful for instances in which the interviewees are less elaborative speakers.

Implications for Practice and Future Research

Understanding teachers' experiences of the PD institute illuminates the complexity of such programming. The teacher professional identity model provides practitioners with a valuable framework to evaluate and understand the impact of their PD programming. Encouraging the adoption of reform-based practices is a continual struggle, and one that researchers are stymied over as to the various causes for lack of or differential rates of adoption (Borko, 2004; Capps & Crawford, 2013; Wilson & Berne, 1999). However, in keeping with a complexity thinking perspective, teachers are unique, and in order to explain their professional learning, they must be considered as individuals

(Opfer & Pedder, 2011). And although we cannot predict teacher change, as complex systems, they are highly patterned, which means that using the model of professional identity allows us to determine emergent patterns (Clarke & Collins, 2007), such as those noted in the summary of findings. Additional research in this area should focus on further developing these patterns through case studies of varied science teachers. It would also be useful to vary the timeframes associated with the research. This study was situated within two weeks, allowing for in-depth views of the PD process. However, longer studies that perhaps include interviews with teachers as they begin and progress through the school year after their PD would be helpful in determining how they negotiate their PD learning, goals, and plans with the pressures associated with daily teaching.

The STPD scale was used on a very small level for this research. Although generalizations cannot be made from the five participants in such a contextualized PD, the study did yield some insights for practitioners wishing to use the scale. First, changes in STPD scale scores over a course of time may assist practitioners in determining the effectiveness of PD in engendering and perhaps resolving pedagogical discontentment, as purported by Southerland et al. (2012). Second, the subscale scores may be useful in pinpointing areas in which a teacher is already experiencing discontentment, or in identifying areas teachers may need to become discontent with in order to change (Southerland, et al., 2012). However, it should be noted that the STPD scale by itself gave limited information about the teachers in this study. The professional identity components served to better capture and allow for discussion of the complexities at play for each teacher and how they negotiated the PD experience. Coupling the STPD with interviews coded using the model components led to a better understanding of science

teachers as individual systems and is suggested for future research. Further, using the STPD scale over a longer time frame may also allow for better understandings of changes in perceived pedagogical discontentment.

Finally, this research showcased the importance of creating opportunities for PD participants to connect the PD experience to both themselves and their students as learners. When these connections did not occur, it seemed to lead to limitations in goals and action possibilities associated with the PD. When the connections did occur, it seemed to cause them to develop more perceptions and beliefs associated with the PD, which led to greater increases in their goals and action possibilities for both themselves and their students. While there are many other factors at play in these teachers, PD developers may want to consider attempts to engender connections to students. This could be done through guided reflections and discussions that explicitly and implicitly focus the PD learning on students and teachers as learners. It is also important to note that Penny's larger-scale plans for changes in her practices may have been influenced by building PD experiences over a course of time. This supports Crawford's (2000, 2007) assertion that training teachers in reform-based teaching practices involves extensive PD and time. It would seem that being open to accepting changes in beliefs, goals, and action possibilities also involves extensive PD and time.

Limitations

Looking at teacher professional identity and pedagogical discontentment over a micro-timeframe comes with benefits and limitations. The two-week timeframe allowed for an in-depth view of participants' experiences of the PD. However, the shortened timeframe also prevented a thorough examination of changes, particularly in action

possibilities, which were expressed through planning only. Perceptions of pedagogical discontentment were limited as well, both due to the timeframe as well as the fact that the PD occurred during participants' summer break. Their perceptions of pedagogical discontentment may have lessened while they were out of school. Varelas, et al. (2004) noted a similar limitation in their examination of the professional identity of pre-service teachers participating in summer science research internships and then experiencing their first year of teaching. Because the two experiences did not overlap, they found that teachers were unable to "reflect in action", which may have led them to make fewer connections between the PD and their teaching.

Another potential limitation was the variation in the level of elaboration expressed by the participants. Bill and Penny gave elaborate descriptions of their perceptions, beliefs, goals, and plans. For example, Bill explained difficulty translating his PD experiences into his classroom by giving examples to support his beliefs. He said, "*I can't take them out to a mudflat for half a day. They're just not going to be focused*". He attributed this to technology, believing that "*we've thrown so much technology at them, they want to be entertained*" (Mid). He went on to describe, in detail, why he believes technology is a problem but also why he uses it in the classroom. An example of Penny's depth of elaboration comes from her discussion of the pressure she feels to cover material prior to the SOL test. When discussing how her plans to do things differently have gotten pushed aside in the past, she said,

"...but once the school year gets started it's like, oh my goodness, we're barely getting through acids and bases before the SOL gets here. I mean, I skim over neutralization, reactions, and titrations and it's like what starts out as us having all these hopes and dreams and goals of doing things differently and being facilitators quickly gets overtaken with, well we've gotta get through this. Let's get that

PowerPoint, let's get that worksheet, let's get them practicing, and you're back into your old routine." (Mid)

Barbara and Lisa were less elaborative than Bill and Penny. Barbara did not respond very much to probing questions other than with yes/no answers, particularly at the pre-interview. This made it more challenging to get an in-depth idea of some portions of her professional identity system such as her goals and practices. For example, although Barbara mentioned students doing "*little projects where they have to do some of the research on their own and having them present in class*" (Pre), she did not elaborate beyond that in order for me to get a clearer picture of the roles both she and her students adopted during the projects. Lisa was less of an elaborator than Barbara, particularly during the mid- and post-interviews. For example, although she left the PD with newly developed goals surrounding assessment and student ownership, she did not elaborate on these goals or share beliefs associated with them. This made it difficult to determine what might have caused the shift in her goals.

Finally, although Tony had very dense interviews, he was not precise in his speaking. Most of what he talked about during the interviews and in his writing had to do with perceptions and beliefs. He gave limited information surrounding his goals and practices. Some of his goals were embedded within his statements about beliefs, but it was often difficult to tell if what he was saying was actually a goal he had for his students, or a belief that he subscribed to but did not necessarily carry over to his students. For example, Tony expressed the belief that science teachers do not let students fail enough. When asked to elaborate, he expressed the belief that this problem stems from grades and teachers needing products in order to assign grades. It was not clear, however, if he

wanted his students to experience failure in his classroom or if he tried to provide his students with opportunities to fail.

It could be argued that the variance in participant elaboration might stem from failure on the part of the interviewer to probe for elaboration. However, the interviewer used the same questions and similar probes with each participant, suggesting that lack of probing was not the reason for this discrepancy. A difference in verbal expression might serve to explain Tony's long interviews with limited explanations, but does not account for the variance between the other participants, suggesting that there were factors beyond this that might account for the differences.

It is also important to note that the STPD scale is a self-report of perceptions of pedagogical discontentment. Previous research has shown that self-report may not give an adequate picture of teachers' practices. For example, teachers have been found to believe that they are teaching science as inquiry and explicitly covering NOS, however, when interviewed, they cannot articulate what inquiry is or give examples of lessons that use either (Capps & Crawford, 2013). This may have been the case with the STPD. If the teachers believe that they are appropriately teaching inquiry and NOS or using alternative assessments, they may be more likely to self-report that they are content with their practices. While this research did not seek to uncover their accurateness of their beliefs regarding the STPD categories, some of the teachers made statements indicating narrow views of inquiry and NOS. Future studies using the STPD should take this into account, and perhaps try to determine if teachers' conceptions of the categories measured in the STPD are accurate in order to better determine their level of pedagogical discontentment.

Finally, the threat of social desirability served as a limitation to the study. The primary researcher tried to make her position explicit by telling the participants that she worked for the university rather than the school system and that anything they said would be kept confidential. However, the PD institute was a district-sponsored event, thus teachers may have perceived that they should respond to questions in a way that coincided with the districts' goals and expectations.

BIBLIOGRAPHY

- Ackerson, V. L., Buzzelli, C. A., & Eastwood, J. L. (2012). Bridging the gap between preservice early childhood teachers' cultural values, perceptions of values held by scientists, and the relationships of these values to conceptions of nature of science. *Journal of Science Teacher Education, 23*(2), 133-157.
- Adams, G. R. (1992). Introduction and overview. In G. R. Adams, T. P. Gullotta, & R. Montemayor (Eds.), *Adolescent identity formation* (pp. 1-8). Newbury Park, CA: Sage.
- American Association for the Advancement of Science. (1993). *Benchmarks for science literacy*. New York: Oxford University Press.
- American Association for the Advancement of Sciences. (1989). *Project 2061. Science for all Americans*. New York: Oxford University Press.
- Anderson, R.D. (1996). *Study of curriculum reform*. Washington, DC: U.S. Government Printing Office.
- Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1-12.
- Beauchamp, C., & Thomas, L. (2009). Understanding teacher identity: An overview of issues in the literature and implications for teacher education. *Cambridge Journal of Education, 39*(2), 175-189.
- Beijaard, D. (1995). Teachers' prior experiences and actual perceptions of professional identity. *Teachers and Teaching: Theory and Practice, 1*(2), 281-294.

- Beijaard, D., Verloop, N., & Vermunt, J. D. (2000). Teachers' perceptions of professional identity: An exploratory study from a personal knowledge perspective. *Teaching and Teacher Education, 16*(7), 749-764.
- Beijaard, D., Meijer, P. C., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. *Teaching and Teacher Education, 20*(2), 107-128.
- Bernstein, R. J. (1983). *Beyond objectivism and relativism: Science, hermeneutics and praxis*. Oxford, UK: Basil Blackwell.
- Berzonsky, M. D. (1992). A process perspective on identity and stress management. In G. R. Adams, T. P. Gullotta, & R. Montemayor (Eds.), *Adolescent identity formation* (pp. 193-215). Newbury Park, CA: Sage.
- Blanchard, M. R., & Grable, L. L. (2009). *SMART for Teachers: Science and Mathematics Achievement through enRiched Technology for Teachers, Phase II*. NC Quest Initiative, U.S. Department of Education.
- Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.
- Borko, H. Jacobs, J. & Koellner, K. (2010). Contemporary approaches to teacher professional development. In P. Peterson, E. Baker & B. McGaw (Eds.), *International encyclopedia of education, vol. 7* (p.548-556). Oxford, England: Elsevier.
- Bullough, R. V. (1997). Practicing theory and theorizing practice. In J. Loughran, & T. Russell (Eds.), *Purpose, passion and pedagogy in teacher education* (p. 13-31). London: Falmer Press.

- Capps, D. K., & Crawford, B. A. (2013). Inquiry-based instruction and teaching about nature of science: Are they happening? *Journal of Science Teacher Education*, 24(3), 497-526.
- Capps, D. K., Crawford, B. A., & Constan, M. A. (2012). A review of empirical literature on inquiry professional development: Alignment with best practices and a critique of the findings. *Journal of Science Teacher Education*, 23(3), 291-318.
- Chambers, D. W. (1983). Stereotypic images of the scientist: The draw-a-scientist test. *Science Education*, 67(2), 255-265.
- Clarke, A. & Collins, S. (2007). Complexity science and student teacher supervision. *Teaching and Teacher Education*, 23(2), 160-172.
- Coldron, J., & Smith, R. (1999). Active location in teachers' construction of professional identities. *Journal of Curriculum Studies*, 31(6), 711-726.
- Crawford, B. A. (2000). Embracing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching*, 37(9), 916-937.
- Crawford, B. A. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching*, 44(4), 613-642.
- Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.) Thousand Oaks, CA: Sage.
- Darling-Hammond, L., & M. W. McLaughlin. (1995). Policies that support professional development in an era of reform. *Phi Delta Kappan* 76(8), 597-604.
- Davis, B., & Simmt, E. (2003). Understanding learning systems: Mathematics education and complexity science. *Journal for Research in Mathematics Education*, 34(2), 137-167.

- Davis, B., & Sumara, D. (2005). Challenging images of knowing: Complexity science and educational research. *International Journal of Qualitative Studies in Education, 18*(3), 305–321.
- Davis, B., & Sumara, D. (2007). Complexity science and education: Reconceptualizing the teacher's role in learning. *Interchange, 38*(1), 53–67.
- Davis, K. S. (2002). "Change is hard": What science teachers are telling us about reform and teacher learning of innovative practices. *Science Education, 87*(1), 3–30.
- Dole, J. A., & Sinatra, G. M. (1998). Reconceptualizing change in the cognitive construction of knowledge. *Educational Psychologist, 33*(2/3), 109–128.
- Donald, M. (2001). *A mind so rare: The evolution of human consciousness*. New York: W.W. Norton.
- Duda, J. L., Smart, A. E., & Tappe, M. K. (1989). Predictors of adherence in the rehabilitation of athletic injuries: An application of personal investment theory. *Journal of Sport & Exercise Psychology, 11*(4), 367–381.
- Eick, C. J., & Reed, C. J. (2002). What makes an inquiry-oriented science teacher? The influence of learning histories on student teacher role identity and practice. *Science Education, 86*(3), 401–416.
- Erikson, E. H. (1963). *Childhood and society*. New York: Norton.
- Erikson, E. H. (1968). *Identity: Youth and crisis*. New York: Norton.
- Erikson, E. H. (1982). *The life cycle completed: A review*. New York: Norton.
- Enyedy, N., Goldberg, J.S., & Welsh, M. (2006). Complex dilemmas of identity and practice. *Science Education 90*(1), 68–93.

- Fyans, L. G., Salili, F., Maehr, M. L., & Desai, K. A. (1983). A cross-cultural exploration into the meaning of achievement. *Journal of Personality and Social Psychology*, 44, 1000-1013.
- Feldman, A. (2000). Decision making in the practical domain: A model of practical conceptual change. *Science & Education*, 84(5), 606-623.
- Freese, A. (2006). Reframing one's teaching: Discovering our teacher selves through reflection and inquiry. *Teaching and Teacher Education*, 22(1), 110-119.
- Garner, J. K., Kaplan, A., & Richardson, T. (2013). *The emergence of (re)organization in pedagogical reflections: A complexity approach to studying processes and outcomes of science teacher professional development*. Presented at the Annual Meeting of the Eastern Psychology Association, New York, NY.
- Garner, J.K., Whittecar, R., Kaplan, A., Loney, M., & Frank, G., et al., (2012). *Learning enhanced through the nature of science (LENS): An interdisciplinary, sustainable professional development model for high school science*. Virginia Mathematics & Science Partnership.
- Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, 38(4), 915-945.
- Gibbs, G. R. (2002). *Qualitative data analysis: Explorations with NVivo*. Maidenhead: Open University Press.
- Glesne, C. (2011). *Becoming qualitative researchers: An introduction* (4th ed.) Boston, MA: Pearson Education.

- Golden, B., Enderle, P., & Southerland, S. A. (2010). *Describing the effects of research experiences for teachers (RET'S) on science teachers' knowledge, beliefs and practices*. Paper presented at the annual Meeting of the National Association for Research in Science Teaching, Philadelphia, PA, March 20–24, 2010.
- Goodson, I. F., & Cole, A. L. (1994). Exploring the teacher's professional knowledge: Constructing identity and community. *Teacher Education Quarterly*, 21(1), 85-105.
- Gregoire, M. (2003). A challenge or a threat? A dual-process model of teachers' cognition and appraisal processes during conceptual change. *Educational Psychology Review* 15(2), 147-179.
- Guastello, S.J., & Gregson, R.A.M., (Eds.), (2011). *Nonlinear dynamical systems analysis using real data*. Boca Raton, FL: CRC Press/Taylor & Francis.
- Hathcock, S. J., Garner, J. K., Kaplan, A., & Davidson, Y. (March, 2013). *Investigating the impacts of teachers' professional development through change in professional identity*. Presented at the annual meeting of the Eastern Psychology Association, New York, NY.
- Hays, D. G., & Singh, A. A. (2012). *Qualitative inquiry in clinical educational settings*. New York, NY: The Guilford Press.
- Helms, J., (1998). Science and me: Subject matter and identity in secondary school science teachers. *Journal of Research in Science Teaching* 35(7), 811-834.
- Howe, M. L., & Lewis, M. D. (2005). The importance of dynamic systems approaches for understanding development. *Developmental Review*, 25(3-4), 247–251.

- Jeanpierre, B., Oberhauser, K., & Freeman, C. (2005). Characteristics of professional development that effect change in secondary science teachers' classroom practices. *Journal of Research in Science Teaching*, 42(6), 668-690.
- Johnson, C. C. (2007). Whole-school collaborative sustained professional development and science teacher change: Signs of progress. *Journal of Science Teacher Education*, 18(4), 629-661.
- Johnson, S. (2003). *Mind wide open: Your brain and the neuroscience of everyday life*. New York: Scribner.
- Kaplan, A., Baris-Gunersel, A., Vorndran, P., Etienne, M., Heath, A. & Barnett, P. (2012a). *Teacher professional identity in higher education: An emerging conceptual model*. Presented at the Annual Meeting of the Eastern Educational Research Association, Hilton Head, SC.
- Kaplan, A., Katz, I., & Flum, H. (2012b). Motivation theory in educational practice. Knowledge claims, challenges, and future directions. In T. Urdan (Ed.), *APA Educational Psychology Handbook, Vol. 2: Individual differences, cultural considerations, and contextual factors in educational psychology* (pp. 165–194). Washington, DC: American Psychological Association.
- Kunnen, E. S., & Bosma, H. A. (2000). Development of meaning making: A dynamic systems approach. *New Ideas in Psychology*, 18(1), 57-82.
- Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*, 29(4), 331-359.

- Lederman, N. G. (2007). Nature of science: Past, present, and future. In S. K. Abell & N. G. Lederman (Eds.) *Handbook of research on science education* (pp. 831-880). Mahwah, NJ: Lawrence Erlbaum Associates.
- Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners; conceptions of nature of science. *Journal of Research in Science Teaching*, 39(6), 497-521.
- Leedy, P. D., & Ormrod, J. E. (2010). *Practical research: Planning and design* (9th ed.). Boston, MA: Pearson.
- Lichtwarch-Aschoff, A. van Geert, P., Bosma, H., & Kunnen, S. (2008). Time and identity: A framework for research and theory formation. *Developmental Review*, 28(3), 370-400.
- Lincoln, Y. S., & Guba, E. G. (1995). *Naturalistic inquiry* (2nd ed.). Thousand Oaks, CA: Sage.
- Lindholm, J. A. (1997). Secondary school physical education teacher motivation: an application of personal investment theory. *Journal of Teaching in Physical Education*, 16(4), 426-439.
- Loucks-Horsley, S., Love, N., Stiles, K. E., Mundry, S., & Hewson, P. W. (2003). *Designing professional development for teachers of science and mathematics* (2nd ed.). Thousand Oaks, CA: Corwin Press.
- Luehmann, A.L., (2007). Identity development as a lens to science teacher preparation. *Science Education* 91(5), 822-839.
- Maehr, M. L. (1984). Meaning and motivation:

- Toward a theory of personal investment. *Research on Motivation in Education*, 1, 115-144
- Maehr, M. L., & Braskamp, L. A. (1986). *The motivation factor: A theory of personal investment*. Lexington, MA: Lexington Books.
- Maehr, M. L., & Nicholls, J. G. (1980). Culture and achievement motivation: A second look. *Studies in Cross-Cultural Psychology*, 3, 221-267.
- Marcia, J. E. (1966). Development and validation of ego identity status. *Journal of Personality and Social Psychology*, 3(5), 551-558.
- Marcia, J. E. (1980). Identity in adolescence. In J. Abelson (Ed.), *Handbook of adolescent psychology* (pp. 159-187). New York: John Wiley.
- Marcia, J. E. (1988). Common processes underlying ego identity, cognitive/moral development, and individuation. In D. K. Lapsley, & F. C. Power (Eds.), *Self, ego, and identity: Integrative approaches* (pp. 211-225). New York: Springer-Verlag.
- Marcia, J. E. (1993). The ego identity status approach to ego identity. In J. E. Marcia, A. S. Waterman, D. R. Matteson, S. L. Archer, & J. L. Orlofsky (Eds.), *Ego identity: A handbook for psychosocial research*. New York: Springer-Verlag.
- McComas, W. F., Almazroa, H., & Clough, M. P. (1998). The nature of science in science education: An introduction. *Science & Education*, 7(6), 511-532.
- McInerney, D. M. (2008). Personal investment, culture and learning: Insights into school achievement across Anglo, Aboriginal, Asian and Lebanese students in Australia. *International Journal of Psychology*, 43(5), 870-879.

- McInerney, D. M. (2012). Conceptual and methodological challenges in multiple goal research among remote and very remote indigenous Australian students. *Applied Psychology: An International Review*, 61(4), 634-668.
- McMurtry, A. (2008). Complexity theory 101 for educators: A fictional account of a graduate seminar. *McGill Journal of Education*, 43(3), 265-281.
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.
- National Research Council. (2000). *Inquiry and the national science education standards*. Washington, DC: National Academy Press.
- National Science Teachers Association. (1998). *The national science education standards: A vision for the improvement of science teaching and learning*. Arlington, VA: NSTA.
- Opfer, V. D., & Pedder, D. (2011). Conceptualizing teacher professional learning. *Review of Educational Research*, 81(3), 376-407.
- Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.) Thousand Oaks, CA: Sage.
- Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal*, 44(4), 921-958.
- Prigogine, I. (1977). *Self-organization in non-equilibrium systems: From dissipative structures to order through fluctuations*. Wiley: New York.

- Roehrig, G. H., & Kruse, R. A. (2005). The role of teachers' beliefs and knowledge in the adoption of a reform-based curriculum. *School Science and Mathematics, 105*(8), 412-422.
- Roehrig, G. H., Kruse, R. A., & Kern, A. (2007). Teaching and school characteristics and their influence on curriculum implementation. *Journal of Research in Science Teaching, 44*(7), 883-907.
- Sachs, J. (2005). Teacher education and the development of professional identity: Learning to be a teacher. In P. Denicolo & M. Kompf (Eds.), *Connecting policy and practice: Challenges for teaching and learning in schools and universities* (p. 5-21). Oxford: Routledge.
- Saka, Y. (2013). Who are the science teachers that seek professional development in research experience for teachers (RET's)? Implications for teacher professional development. *Journal of Science Education & Technology, 1*-18.
- Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education, 88*(4), 610-645.
- Settlage, J., Southerland, S. A., Smith, L., & Ceglie, R. (2009). Constructing a doubt-free teaching self: Self-efficacy, teacher identity, and science instruction within diverse settings. *Journal of Research in Science Teaching, 57*(1), 1-22.
- Sinai, M., Kaplan, A., & Flum, H. (2012). Promoting identity exploration within the school curriculum: A design-based study in a Junior High literature lesson in Israel. *Contemporary Educational Psychology, 37*(3), 195-205.

- Smagorinsky, P., Cook, L., Moore, C., Jackson, A., & Fry, P. (2004). Tensions in learning to teach: Accommodation and the development of a teaching identity. *Journal of Teacher Education, 55*(1), 8-24.
- Smith, L. K. (2005). The impact of early life history on teachers' beliefs: In-school and out of-school experiences as learners and knowers of science. *Teachers and Teaching: Theory and Practice, 11*(1), 7-38.
- Smith, L. K., & Southerland, S. A. (2007). Reforming practice of modifying reforms: Elementary teachers' responses to the tools of reform. *Journal of Research in Science Teaching, 43*(3), 396-423.
- Southerland, S. A., Nadelson, L., Sowell, S., Kahveci, M., Saka, Y., & Granger, E. M. (2012). Measuring one aspect of teachers' affective states: Development of the science teachers' pedagogical discontentment scale. *School Science and Mathematics, 112*(8), 483-494.
- Southerland, S. A., Sowell, S., Blanchard, M., & Granger, E. M. (2011a). Exploring the construct of pedagogical discontentment: A tool to understand science teachers' openness to reform. *Research in Science Education, 41*(3), 299-317.
- Southerland, S. A., Sowell, S., & Enderle, P. (2011b). Science teachers' pedagogical discontentment: Its sources and potential for change. *Journal of Science Teacher Education, 22*(5), 437-457.
- Southerland, S. A., Smith, L. K., Sowell, S., & Kittleson, J. (2007). Resisting unlearning: Understanding science education's response to the United States' national accountability movement. *Review of Research in Education, 31*(1), 45-77.

- Sugrue, C. (1997). Student teachers' lay theories and teaching identities: Their implications for professional development. *European Journal of Teacher Education*, 20(3), 213-225.
- van Geert, P., & Steenbeek, H. W. (2005). Explaining after by before: Basic aspects of a dynamic systems approach to the study of development. *Developmental Review*, 25(3-4), 408-442.
- Varelas, M., House, R., & Wenzel, S. (2004). Beginning teachers immersed into science: Scientist and science teacher identities. *Science Education*, 89(3), 492-516.
- Volkman, M. J., & Anderson, M. A. (1998). Creating professional identity: Dilemmas and metaphors of a first-year chemistry teacher. *Science Education*, 82(3), 293-310.
- Wilson, S. M., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. *Review of Research in Education*, 24, 173-209.
- Woodbury, S., & Gess-Newsome, J. (2002). Overcoming the paradox of change without difference: A model of change in the arena of fundamental school reform. *Educational Policy*, 16(5), 763-782.
- Woolhouse, C. & Cochrane, M. (2010). 'Now I think of myself as a physics teacher': Negotiating professional development and shifts in self-identity. *Reflective Practices*, 11(5), 607-618.
- Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: Sage.

Appendix A

Science Teachers' Pedagogical Discontentment Scale

Science Teaching (Dis)Contentment

We all have aspects of our teaching practice that we feel we do particularly well, that make us particularly effective as a teacher; we are content with these aspects of our teaching. On the other hand, there are often aspects of teaching that we feel that we are not particularly good at, that prevent us from being as effective as we can or should be; we are discontented with these aspects of our teaching. This questionnaire asks you to reflect upon your current science teaching and to think about the level of contentment and discontentment you hold about a number of science teaching practices. In this questionnaire, we want you to consider if your performance of these practices *help* you to reach your teaching goals. Too, we want you to consider if your performance of these practices *prevent* you from reaching your teaching goals. Through this instrument, we hope to gain some understanding of your personal state of contentment or discontentment with your science teaching.

Years of teaching experience:

Grade level(s) and subject(s) currently teaching:

I. General Job (Dis)Contentment

Before we focus on your teaching practices, it is important to note significant things about your teaching situation—the environment in which you practice. Are there things about your current teaching environment or situation with which you are experiencing discontentment—that prevent you from teaching effectively? If so, explain.

II. Specific Science Teaching Discontentment

Read each statement below and indicate your *level of discontentment* in terms of your own science teaching. In other words, how discontent are you *currently* with these aspects of your daily science teaching? Next to each item, circle one of the following choices:

- 1 = no discontentment
- 2 = slight discontentment
- 3 = moderate discontentment
- 4 = significant discontentment
- 5 = very high discontentment

1. Teaching science to students of lower ability levels.
2. Balancing personal science teaching goals with those of state and national standards.
3. Monitoring student understanding through alternative forms of assessment.
4. Orchestrating a balance between the needs of both high and low ability-level students.
5. Preparing students to assume new roles as learners within inquiry-based learning.
6. Using inquiry-based teaching within all content areas.
7. Assessing students' understandings from inquiry-based learning.
8. Assessing students' nature of science understandings.
9. Including all ability levels during inquiry-based teaching and learning.
10. Teaching science to students from economically disadvantaged backgrounds.
11. Planning and using alternative methods of assessment.
12. Having sufficient science content knowledge to generate lessons.
13. Teaching science to students of higher ability levels.
14. Teaching science subject matter that is unfamiliar to me.
15. Integrating nature of science throughout the curriculum.
16. Having sufficient science content knowledge to facilitate classroom discussions.
17. Using assessment practices to modify science teaching
18. Developing strategies to teach nature of science.
19. Ability to plan successful inquiry-based activities/learning.
20. Balancing personal science teaching goals with state/national testing requirements.
21. Balancing the depth versus breadth of science content being taught.

Appendix B

PD Institute Participant Pre-Interview Protocol

Pre-institute Interview (quiet room, speaker phone, audio recorder, notepad and pen)

Interviewer: *Hi, <name>. My name is <name>. Thank you for agreeing to talk with me today. I'm part of the team that is evaluating the PD project and conducting research on the changes people may experience as they participate. The purpose of our meeting today is to better understand the people who are participating, and what they hope will happen in the upcoming Institute. So, the focus of today's interview is your personal perspective.*

The online survey you took included an informed consent statement at the beginning. This told you about the project, confidentiality, and how the information will be used. The interview data will be used to understand participants' experiences in the project, in order to inform ways to provide effective professional development experiences for science teachers.

One part of the informed consent statement indicates that interviews will be recorded. This allows me to pay attention to what you say rather than try to write it all down. The recordings are going to be kept completely confidential and will not be connected to your identity. Recordings will be transcribed by a research team member and transcripts will be used for analysis. We remove any identifiable details, so when we present our report there is no way to know who said what. Is it OK if I record the interview? (If they say no, continue but take notes and review/revise them afterwards).

Additional information available if questions arise: *Information will be used in such a way to protect individuals' identities. Data we gather will be kept securely in password protected folders on a secure computer drive. Only individuals who are involved in gathering the data will be able to access it. In compliance with standard University procedures, data will be stored for up to 7 years. The evaluation of the PD project was approved by Old Dominion University's Institutional Research Board. Participation is voluntary and you do not have to answer any questions that you do not feel comfortable answering. You can see a copy of the transcript if you wish.*

1. How did you decide to participate in the PD project?
2. Please tell me about how you became a <self-defined role within PD*>
3. What were the most meaningful experiences you had in your role? Why were they so meaningful?
4. Can you think of other experiences that were meaningful, perhaps in a different way?

5. What provides you most satisfaction now as a <self-defined role within PD>?
6. What dilemmas and challenges do you have as a <self-defined role within PD>?
7. Where do you imagine yourself in the future?
8. What are your hopes and expectations from participating in the Institute?
9. Which is a more prominent part of how you think of yourself as a <self-defined role within PD>: generalist or specialist?

* Cohort 1 and leadership team members may have a clearer self-defined role within PD than Cohort 2 or the middle school teachers. Probe for how they came to hold this role. Probe for motivation to adopt a professional role within a particular subject area if the participant emphasizes it in their response, “e.g. I was always fascinated by Biology.”

Possible probes during the interview:

1. You said “...”, can you please elaborate?
2. Can you please elaborate about what happened?
3. What did you mean when you said “...”?
4. Can you give me an example of what you said?

Interviewer: *Thank you very much for speaking with me today. I would like to talk with you again after the Institute. Let’s schedule a date and time that is convenient for you. It will take about an hour. [Schedule the mid- and post-interview]*

2013 PD Institute Participant Mid-/Post-Interview Protocol

Mid-/Post-institute Interview (quiet room, speaker phone, audio recorder, notepad and pen)

Interviewer: *Hi, <name>, it’s <name>. Thank you again for agreeing to talk with me today. The purpose of our meeting today is to better understand your experience of the Institute. So, the focus of today’s interview is your personal perspective.*

Just a reminder that about the informed consent statement you signed. This told you about the project, confidentiality, and how the information will be used. The interview data will be used to understand participants’ experiences in the project, in order to inform ways to provide effective professional development experiences for science teachers. Is it OK if I record the interview? (If they say no, continue but take notes and review/revise them afterwards).

Additional information available if questions arise: *Information will be used in such a way to protect individuals' identities. Data we gather will be kept securely in password protected folders on a secure computer drive. Only individuals who are involved in gathering the data will be able to access it. In compliance with standard University procedures, data will be stored for up to 7 years. The evaluation of the PD project was approved by Old Dominion University's Institutional Research Board. Participation is voluntary and you do not have to answer any questions that you do not feel comfortable answering. You can see a copy of the transcript if you wish.*

Q1: Could you please tell me about your experiences in the Institute? Please start from the beginning.

Q2: What were the most meaningful experiences you had in the Institute? Why were they so meaningful?

Q3: Can you think of other experiences that were meaningful, perhaps in a different way?

Q4: How do you think these experiences relate to who you are as a science teacher?

Q5: What dilemmas and challenges did the experience in the Institute highlight to you?

Q6: What might you take from this experience to your science classroom over the course of the next year?

Possible Probes:

1. You said "...", can you please elaborate?
2. Can you please elaborate about what happened?
3. What did you mean when you said "..."?
4. Can you give me an example to what you said?

Appendix C

Professional Identity Case Summaries

Professional Identity Interviews Summary: Barbara

Barbara is a 57-year-old woman with 21 years of teaching experience. She has a bachelor's degree in interdisciplinary studies, an endorsement in earth/space science, and a masters' degree in educational leadership. She is pursuing an Ed.D. in educational leadership. She was teaching oceanography at the time of the interviews, but previously taught earth science. She was asked to attend the PD in order to form a consortium from her school.

Pre-Institute Summary

Self-perceptions. Barbara wanted to teach since the second grade. She perceives that her interest in education grew from having a teacher she “*really really adored*” because of “*her mannerisms and how we were always learning different things and moving about and just getting to know people and how they interact*” (Pre: 75-76).

Barbara initially majored in physical education because she considered herself to be a “*jock*”. However, after learning that the state would provide incentives for certifications in various sciences, Barbara decided to pursue earth/space science due to her “*science background with physical education*”. She felt “*excited*” by going outside and on field trips for her earth/space science endorsement, and particularly enjoyed experiences during which she could “*see*” evidence of things like crustal movement.

Barbara said that she continues to teach because she is “*trying to get it right*”. One of the things she is trying to get right is the learning environment she creates. Her perceptions of good learning environments for herself include those in which she can take

an active role. She said, *“I find that when I’m able to construct my own meaning from learning, I retain the information longer”* (Pre: 181-182). She perceives that she tries to bring a similar style of learning to her students, saying, *“I don’t like having to just tell them stuff”*. She perceives that her tendency to have students *“explore”* leads them to tell her she is *“not a real teacher”*. She said that her response to them is, *“Well, I’m never going to be a real teacher because I think the joy of learning is discovery”* (Pre: 188).

Barbara also entered the PD feeling some frustration with technology. Her district allows students to bring technology such as iPads and iPhones into the classroom. She said, *“I haven’t really learned to implement it so that it works to my advantage”*. Although she has attended technology PD sessions offered by the school system, she does not feel comfortable implementing much technology in her classroom.

Barbara sees herself as a generalist because she feels like her subject matter *“incorporates a lot of different things, not just one specific thing”*. She considers this to be a positive because she does not want to *“get stuck in one hole”*, which she perceives can happen when people specialize. She perceives that if she were a specialist, she would have moved to teaching *“beyond high school”*. She plans to remain in the profession for four more years, saying *“I’m going to be there 25 years. That’s long enough for me”* (Pre: 297). She is presently pursuing her Ed.D. in educational leadership, which she considers to be her *“lifelong learning”*. She said, *“I love school, so I’ve always gone to school. If I had the money I would just be a professional student...I’m already a professional student”* (Pre: 330-331). Barbara has no desire to work in an educational leadership context or go back into the public school system after she retires. She is hoping that her Ed.D. will lead to part time work at the college level.

Personal epistemology. Barbara believes that earth science “*incorporates a lot of different sciences as opposed to one science*”. Her enjoyment of the subject was initially fueled by her experiences seeing different crustal movement and other earth science concepts come to life. She believes that her school district is in the “*boring part of the state*” because there is no “*visual evidence*” of similar phenomena. However, she believes that her city is a good spot for oceanography because “*those are the things that they can see. They can go to the ocean, they can see some of those movements*” (Pre: 93-94). She believes that if she were able to take her students to the western portion of the state, they “*could really get them*” because they would be able to see the coastal plane and “*get those aha moments*”.

Barbara believes that “*the joy of learning is discovery*” (Pre: 188). However, she also believes that her students seek “*instant gratification*”. Because of this, they do not like to “*look at things or study things outside of class*”. Rather, they just want her to “*tell them the answers, and I have a problem with that*” (Pre: 198-199). Barbara tries to have her students do research and present their work in class. She said that at first, the experience is “*like pulling teeth*”. This is based on her belief that:

“some students really like it, but then there are other students who are not very sure of themselves and see they don't want to make a mistake because they don't want to be wrong” (Pre: 213-215).

Barbara also expressed some beliefs about assessment. She is “*not real crazy*” about multiple choice exams because she believes that those types of tests give her students a “*chance to guess*”. She does not allow her students to use PowerPoint for projects because she believes that with PowerPoints, her students just “*cut and paste information*”. She seems to believe that having students make movies and develop Prezi's

encourages them not to cut and paste.

Barbara believes that many of her students are not prepared for “*higher level work*”. She believes that her students should come to oceanography knowing some earth science concepts, but she finds that they do not. This causes her to spend time “*reteaching things that they should already know*”. She believes that her remediation efforts are only about 50% successful. Barbara also believes that her students do not take ownership of their learning. Since oceanography is not a tested subject, Barbara believes like her students “*don't take it very seriously*”. She believes that her students take the course because they “*need a 3rd science to graduate, and oceanography is it because they will not have the math background to take the chemistry or physics*” (Pre: 275-276). Regardless of these issues, however, Barbara is glad not to have an SOL-tested course “*because I don't want my abilities reflected by my students*” (Pre: 284). She believes that most of her students do not “*see the relevance*” of oceanography. She attributes this to her belief that the majority of her students “*don't have visions of college*”, which prevents them from developing “*work ethics*”.

Perceived purpose. Barbara's perceived overarching purpose is student achievement. She said, “*student achievement is basically what I'm interested in*” (Pre: 130). Associated goals consist of “*helping students understand*” what she is trying to teach them. She is looking for her students to:

“...get those aha moments. When I can see it on their face that they actually get it or they can tell me something that lets me know that they actually got it, you know, that they actually understood what I was talking about” (Pre: 110-112).

Barbara hopes her students will “*connect or give me an example or produce something that lets me know that they understand it*” (Pre: 163-164). She feels that one of the

purposes of student understanding is to give her “*some gratification*” because she can tell she is “*doing a halfway decent job*”.

Barbara also has the goal of being “*more of a facilitator*”. She would also like her students to “*become self-directed learners*”. She would also like to be able to implement technology “*so that it works to my advantage*”. Barbara was asked to attend as part of a “*consortium*” from her school, and is interested to “*see what it was all about*”. She is hoping that the PD will give her “*tools I need to help my students become life-long learners and self-directed learners*” (Pre: 336-337).

Action possibilities. Barbara says that she enjoys “*presenting information and helping students understand it*”. She gave the following example of what this practice might look like in the classroom, saying, “*I teach them something about plate tectonics and they can connect or give me an example or produce something that lets me know that they understand it*” (Pre: 163-164). She also discussed having to “*spend a lot of time on basic things*” because her students enter the class without conceptual knowledge she feels they must have.

Barbara also discussed practices involving her students doing “*little projects where they have to do some of the research on their own and having them present in class*” (Pre: 207-208). Examples included giving her students opportunities to “*present information as a teacher*”, “*work in small groups*”, and trying to implement “*project based learning*”, in which students have to “*create*” things in order to determine their level of understanding. She is trying to “*get away from things like PowerPoints*”. Instead, she tries to “*get them to make short movies or some of them are starting to use Prezi and some of those other presentations*” (Pre: 176-177). She also mentioned boat field-trips for

her classes. Barbara does not feel the multiple choice assessments meet her needs, so her assessments also include “*conversation and applications*”.

Alignment. Barbara demonstrated a few areas of alignment. Barbara believes that “*the joy of learning is discovery*”, which aligns with her preferences for her own learning, including being able to “*construct my own meaning*”. These perceptions and beliefs align with her goals of becoming more of a facilitator and helping students become self-directed, life-long learners. While Barbara says that she does not “*like having to just tell them stuff*”, and wants them to “*explore*”, she also said that she enjoys “*presenting information and helping students understand it*”, indicating some misalignment. However, she also has the goal of becoming “*more of a facilitator*” indicating that she is seeking new practices that might be better aligned with her beliefs, perceptions, and goals.

Summary. Barbara entered the PD with perceptions as a life-long learner who considers herself a “*professional student*”. She prefers to construct her own meaning from learning situations, and would like for her students to do the same. She holds some negative beliefs about her students, such as their apathy and desire for instant gratification, but she still seems to believe that they are teachable. Her overarching purpose is student achievement with associated goals of students becoming more self-directed, life-long learners like herself. Her practices, however, seem to be fairly teacher-directed and focused on her presenting information and her students demonstrating that they understand that information. She would like to become “*more of a facilitator*”, and is hoping that the PD will give her some tools to help her students become more self-directed, life-long learners.

Mid-Institute Summary

Self-perceptions as a Learner. Barbara did not initially want to attend the PD, but after the first week, she said, “*I’m glad that I didn’t miss it, and I think that it’s a good opportunity for me as a learner*” (Mid: 9-10). She perceives that the PD has allowed her to put herself in the role of a student, which has allowed her to see things “*from a learner perspective*”. She considers herself to be a self-directed learner, and felt “*engaged*” during the PD. She perceives that the experience has been meaningful to her, “[*b*]ecause it helps me to construct my meaning rather than for someone else to tell me” (Mid: 130). She gave an example of having to “*think outside of the box, and then you’d have to think, wait a minute, does this make sense or can I do it this way or can I do it another way*” (Mid: 40-41).

Barbara said that the data collection was “*the most fun for me*”. She perceived that the experience was “*out of the box*” for her. She said:

“[b]eing in a situation where I am out of control, I don’t have total control is kind of odd for me because I like to have everything...I like to always be in a position of control. But being out there, it makes you kind of vulnerable to nature, so it was quite different for me” (Mid: 82-85).

She perceived that her group’s data “*got a little bit skewed*”, so they are planning to collect additional data during the second week of the PD. They are hoping that their “*mistakes*” did not have an effect on their data collection, and that the problems they are seeing are something that they “*don’t have control over*”.

Barbara perceived that the LabQuest training was a “*positive learning experience*”. She was not very familiar with the LabQuests, and perceived that the experience gave her the opportunity to become familiar with the equipment. Barbara also found the concept mapping to be a “*positive experience*” because she was able to see the

different ways in which people were able to represent their ideas. Barbara found that time was a factor for her during the first week. She had a few meetings scheduled throughout the week that caused her to miss some of the PD. She feels like things will be better the second week “*because I won't have all of these other variables, so I think I'll be able to concentrate better on what I want to do next week*” (Mid: 243-245).

Self-perceptions as a Teacher. Barbara made some connections between the daily reflection and another PD course she was taking that deals with reflection. She perceived that the daily reflections are helping her to “*kind of step back*” and “*put things in perspective*”. She also perceives that the PD is “*helping*” her think about things she might want to try in her classroom. Barbara said, “[*t*]he challenge for me is working with other people” (Mid: 209). However, she perceives that working with her group members and the PD facilitators has been a positive experience. She perceives that having group members “*who are familiar with what you encounter on a daily basis*” has made the process “*a lot easier*”. Although she knew her group members prior to the PD because they teach at the same school, she had not personally worked with them, and is finding their collaboration to be a good experience. She also perceives that her group members have the “*common goal*” of student achievement.

Integration of Self-perceptions within Roles. Barbara's self-perceptions as a learner and teacher demonstrate some integration. She perceives that the PD experience is placing her in the role of a student, which she feels is helping her see things from their point of view. She also seems to be making connections between herself as a learner and teacher through the daily reflection prompts.

Personal epistemology as a Learner. Barbara believes that, “*as a teacher you*

sometimes forget that you're still a learner and you see things differently" (Mid: 10-11).

She further believes that being in a "*learning situation*" allows teachers to "*see things from a student perspective*". Barbara also expressed some beliefs about science and NOS. She believes that oceanography is different from other sciences because it is composed of so many different sciences. She said:

"I kind of don't think of oceanography as one of the hard sciences because I kind of think of it as a hodge podge; I don't think of it as a specialty. I think I look at it that way because it incorporates so many different sciences" (Mid: 173-176).

Ultimately, though, she believes that oceanography allows for more creativity, and, "*people don't usually think of science as being creative*" (Mid: 181-182). She elaborated on this belief by saying:

"sometimes you think of science as a vacuum, but it's really not science in a vacuum because scientists basically collaborate with other scientists anyway. Even when they're doing research, one scientist may find something and then they may articulate that to another scientist who may help them see things from a different perspective. So as a collaborator, you get more than one perspective on a concept" (Mid: 186-190).

She also expressed a belief about how scientists work based on her field study experience. She said that doing the field study allowed her to see that:

"scientists don't always get what they're looking for the first time around and that's why they may have to conduct a series of investigations or experiments to find out why or they may even have to rewrite their hypothesis because the data does not support it" (Mid: 109-111).

Finally, Barbara expressed the belief that the facilitators have done a nice job of not projecting a know-it-all attitude. She said:

"[t]hey're guiding and asking questions to make you think about stuff, but they're not putting themselves, just because I'm the expert, I know this is what's going to happen, or I know this is not going to happen, this doesn't make sense kind of thing" (Mid: 222-224).

Personal epistemology as a Teacher. Barbara believes that reminding teachers of

what it is like to be a learner will ultimately make them better teachers because:

“we will better be able to sympathize with our students and kind of help them capitalize on their strengths rather than, you know, going through the process of making them learn things, we can now go through the process of getting them to want to learn things” (Mid: 12-15).

She also believes that when students are allowed to “*find your own meaning*”, their learning becomes more “*relevant*” to them.

Barbara came to the belief during the first week of the PD that the labs she implements are of the cookie-cutter variety. She said, “*the objective is already there, they already know what procedures to take, so they're just kind of basically following somebody else's structure*” (Mid: 51-52). She wants to use more inquiry in the classroom because she believes that having students “*develop their own investigation*” is “*more engaging*” and “*more relevant*” to them. She believes that engagement will lead students to be more self-directed learners. She also expressed the belief that her students are “*at risk*”. Because of this, she believes that her students “*need a lot more nurturing and guidance than a lot of other students*”. However, she does not believe that this will prevent her from implementing inquiry within her classroom.

Barbara also expressed some changing beliefs about the value of concept maps. She has not previously used concept maps in her classroom because she “*thought that there was a simple route*”. She related this to driving, saying that she believed that concept maps would allow her students to just choose the “*quicker*” route. Her experiences with developing her own concept map and then looking at others' maps allowed her to see that, “*it doesn't matter where you go as long as everything connects*”. She now seems to believe that concept maps are more complex and that they would be a useful way to formatively assess her students.

Barbara also expressed beliefs about the LabQuests. She said that after learning how to use them, *“I know that there are some other things that we need in the classroom to help our students learn how to use the technology”* (Mid: 61-63). She believes that technology experiences will help her students be *“better learners and prepare them more for global society if they're able to use the technology or at least know what the technology is for”* (Mid: 63-64).

Finally, Barbara expressed her belief that everyone at the PD is *“trying to get to the same place”*. She believes that everyone there wants to become *“better facilitators and to help our students become higher achievers or better prepared in the sciences at least. Or at least in the science that you're teaching them”* (Mid: 229-231). She acknowledges time constraints, but believes that, *“time is always a factor, even during the regular school day because we have all these other variables coming into play anyway”* (Mid: 245-246).

Integration of Personal Epistemology within Roles. Barbara demonstrates integration between her beliefs that being in a learning situation such as the PD is allowing her to *“see things from a student perspective”* and her belief that these types of experiences will ultimately make teachers better. She believes that teachers who have been placed in a student-like learning experience can better sympathize with their students and are better equipped to help them *“capitalize on their strengths”*.

Perceived purpose as a Learner. Barbara's group is planning to go back into the field during the second week of the PD with the goal of looking for additional data and getting the project finished without making mistakes. She perceived that the facilitators' goals for the teachers as learners were to *“make you think”*. She also perceived that the

purpose of the daily reflections was to help her to “*reflect on what you’re doing and think about what you may do in the future*” (Mid: 196-197).

Perceived purpose as a Teacher. Barbara expressed several goals for her students. One of her goals as a teacher is to get her students “*to want to learn things*”. She would like for her students to become “*more self-directed learners rather than wait for me to give them the answers*” (Mid: 131-132). She would also like for them to “*develop those higher level thinking skills*”, and specifically wants them to be at “*the evaluation stage*”. She feels that this may be accomplished through inquiry experiences that allow her students to “*construct their own meaning*”. She leaves with the goal of helping her students “*develop those inquiry skills*” and “*use more inquiry*”. A goal associated with this is for her to “*become more of a facilitator*”, which would involve her “*stepping out of the way*”. Her goal for facilitating student experiences is “*guiding them to find their own answers rather than telling them my answers or what they should think*” (Mid: 141-142). She related this to students developing their own hypothesis, although she did not express that as a goal.

Barbara is also considering using technology such as the LabQuests, with the goal of making them “*better learners*” and preparing them for a “*global society*”. Lastly, she is considering using concept maps as a formative assessment. Her goals associated with that are to determine what she might need to “*reteach*” and to “*reflect on how I can make it more meaningful for students*” (Mid: 272-273). She would also like for her students to collaborate more. Her goal associated with this is for them to “*try to see things from more than one perspective*” (Mid: 191).

Barbara also leaves the first week of the PD hoping for more opportunities to

collaborate with her group members during the school year. She feels that her group shares the “*common goal*” of student achievement, and is hoping that she can use something in her classroom that she has learned from her group members and they are learning from her. She is also hoping to continue collaborating with her group members to perhaps “*develop a professional learning activity for our school, or at least for our science teachers*” (Mid: 163-164). She sees the purpose of the reflection as also allowing her to “*put things in perspective*” and to “*maybe change things*” or “*improve on things*”.

Integration of Perceived Purpose within Roles. Barbara does not express many goals as a learner, but her goals as a teacher integrate well with her goals for her students. Her goal of becoming a “*better facilitator*” integrates with her perceived purpose of developing more “*self-directed learners*”. Her desire to step “*out of the way*” integrates with her goal of using “*more inquiry*” with students. Lastly, her goal of having students collaborate more integrates with her hopes for collaborations with her group members during the school year.

Action possibilities as a Learner. Barbara worked with her group to design their field study and then collect data. Her group was planning to return to the field site during the second week of the PD to collect additional data. At the time of the interview, she expressed that she had been thinking about writing up her group’s procedures and materials for their field investigation.

Action possibilities as a Teacher. Barbara is planning to implement several ideas from the first week of the PD. She is planning to have her students collaborate more. She is also making plans to use concept maps as a formative assessment tool with her students. Barbara is also making plans to add “*more activities where students have to use*

inquiry". She is planning to "*prepare*" her students for inquiry by going over some "*basics*", but wants to "*start helping them develop those inquiry skills*" by the second week of school. A more concrete plan she mentioned was, rather than using "*already established labs*", she is planning to "*let them come up with their own*".

Barbara and her group members have been discussing plans to "*develop some activities that all of us can do*". These activities may include developing a "*professional learning activity*" for her school or for the other science teachers at her school.

Integration of Action Possibilities within Roles. Barbara's action possibilities as a teacher integrate with the experiences she has had during the first week of the PD, including adding more inquiry, using concept maps, collaborating, and having students design their own labs.

Mid-Alignment. Barbara leaves with first week of the PD with alignment in several areas. First, she perceived that her learning experiences at the PD allowed her to construct meaning and to feel engaged. This aligns with her beliefs about the relevance found when you "*find your own meaning*" as well as her belief that having her students do a similar type of experience would lead to engagement and relevance for them. This aligns with her action possibilities of developing inquiry activities for her students, and her associated goal of having students "*construct their own meaning*". Her perception that she was placed in the role of a learner aligns with her belief that reminding teachers what it is like to be a student is beneficial for them because they are better able to sympathize with their students.

Barbara also demonstrated alignment between her positive perceptions of collaboration with her group, her perception that the group shared a "*common goal*" of

student achievement, and her desire and plans to continue working with her group members to develop activities for their students as well as other teachers. Her plans and goals surrounding students collaborating more aligns with her belief that scientists' collaborations leading to multiple perspectives. Barbara's perceptions and beliefs surrounding the value of reflection were also aligned. She felt that daily reflections at the PD served the purpose of making her think about what she was doing and connect it to the future. Lastly, Barbara's perceptions of the concept mapping activity as being a positive experience align with her altering her beliefs about concept mapping. She used to think that concept maps were "*simple*", but now believes that they are complex and allow for different ways to connect things. This further aligns with her plans to begin using concept maps as formative assessment for her students, as well as her goals of using the data inform her teaching.

Mid-Summary. Barbara felt that the first week of the PD placed her in the role of a student again. She believes that this experience will serve to make her a better teacher because she can sympathize with her students and help them capitalize on their strengths. She enjoyed her learning experiences, perceiving that they were engaging and allowed her to construct her own meaning. She also enjoyed working with her group members. Although she believes that her students need more nurturing due to their at risk status, Barbara leaves with the goal of trying to help her students become more self-directed. She is planning to implement some activities similar to those she experienced at the PD, such as having students design their own labs.

Post-Institute Summary

Self-perceptions as a Learner. Barbara's group went back into the field during the

second week of the PD. She said, *“having the chance to go back out and reevaluate the situation and consider some other things that may have affected that outcome was interesting”* (Post: 36-37). She found the second round of data analysis to be *“a lot more thought provoking”* than the first. She perceived that this was because her group was *“able to ask ourselves some questions that we had not considered”* during the initial data analysis. She also found that creating the poster was a useful experience. She said that she *“kind of got away”* from using posters recently because of the push to use technology; however perceived that the poster forced her group to carefully consider *“what you’re going to put in that small space”*. She considered the poster presentations to be a *“capstone event”*. She felt that the groups were both excited and anxious. She perceived that she gained more sophistication in her understanding as she presented, and her group even began considering things that they *“had not even considered in the investigation”*. Ultimately, Barbara perceived that her PD experience gave her *“more respect from a student perspective”*. She feels that everyone there was reminded that *“we’re all still learners”* and perceived that the *“lifelong learning aspect was important for me”*.

Barbara also discussed perceptions about a few of the second week activities. She found the assessment portion of the PD to be *“good, but it was too much information in a short time. It was overwhelming”*. She said that although an hour and a half *“seems long”*, she does not think that they were able to get into the *“nuts and bolts of it”*. Barbara *“enjoyed”* the NOS discussion, saying that it gave her the opportunity to reflect about things that *“you just don’t normally consider on a regular basis”*.

Self-perceptions as a Teacher. It seemed that the most salient experience for Barbara was the reflections. She was enrolled in another PD course specifically dealing

with reflection; however, Barbara felt that *“the [PD] program is better preparation for reflective teaching in the classroom for me. It just brings it home”* (Post: 62-63). She found it useful to be able to reflect at different points during the day, saying, *“we started the day with reflection and then we got a chance to reflect in the afternoon because that we you were able to add some components that you hadn't considered in the morning or the day before”* (Post: 67-69). She also perceived that she is able to *“relate it more to science now that I could before”*. She perceives that most of the PD she takes gives a *“broad overview”* and uses examples from subjects other than science. She feels that she has not ever had *“models as science teachers that we can use or develop”*, however, she perceives that the PD *“provided the models that we needed in science”*. She also made connections with other PD courses she had taken over the summer. One was about reflection, another was about assessment, and the third involved taking students outside. She said, *“it's funny how all of these things are related and I had not planned it that way”*.

Barbara found it meaningful to work with colleagues from her school. She does not often get a chance to work with the other oceanography teacher at her school, and was glad to have some other connections within the science department. She said that they are *“starting to talk”* about doing some things together, *“which is good, because we never talked before”*. Barbara also found it meaningful to get to know other teachers within the city and to make connections and *“get that feedback”* from the college facilitators.

Barbara said that she has been thinking about *“[m]aking the decision to get out of that traditional four walls”* since she got stuck in the mud during the first data collection

day. She perceived that the experience of *“not being in control and allowing yourself to have fun while you learn”* was important, and although she has not made any plans, she leaves the PD thinking that she would like to bring similar experiences to her students. She perceives that her schedule would allow for this because she is not *“crunched for time”* like the SOL-tested courses.

Integration of Self-perceptions within Roles. Barbara's self-perceptions as a learner were integrated with her self-perceptions as a teacher. The PD has made her think of herself as a learner, which she perceives has given her more *“respect”* from the students' perspective. Her experiences at the PD have also made her begin to think of ways she might alter her classroom.

Personal epistemology as a Learner. Barbara expressed the belief that teachers are still learners. She believes that teachers tend to *“take yourself out of that student mode”*. She believes that *“we're always learning; it never stops”*. Barbara also expressed some beliefs about the NOS based on participating in the activity. She believes that teachers do not think about NOS and the outside influences affecting science. She said:

“we do science so much, we never really think about the NOS and how it's impacted by a lot of things. Because we don't even think about science is affected by culture and political views or we don't really think about it but we know it's happening because we're affected by finances which are affected by whoever's in power at the time” (Post: 26-29).

She also expressed beliefs about research. She believes that, *“whatever topic you're thinking about, somebody, somewhere has started some research on it. So nobody ever actually solves the problem; they just add to the body of knowledge”* (Post: 110-112).

This belief has shifted how she thinks about research, and she now believes that *“you're not going to solve this problem today. All you can hope to do is add to a larger collective*

body of knowledge for this particular investigation” (Post: 113-114).

Personal epistemology as a Teacher. Barbara's beliefs about “*adding to the body of knowledge*” also led her to emerging beliefs about best practices for her students and her role as a teacher. She said:

“it made me realize that's probably what my students need to do too rather than just giving them something that's already prepared, let them do the preparation. You know, I know I have to teach them the concept, but let them do more investigative work rather than them deciding right away what it should be or should not be” (Post: 118-121).

Barbara also discussed emerging beliefs about reflection and giving students time to consider things. She believes that reflection is not used enough in the classroom. Her experiences with going back into the field during the second week of the PD led her to believe that “*all conclusions don't have to take place in one class period*”. She sees value in allowing “*time for reflection*”, saying, “*I think if we give the students more time for reflection like we had, by having the opportunity to revisit the site, and reevaluate our hypothesis, was a better teaching moment*” (Post: 44-45).

Barbara also expressed some beliefs about technology. Although she “*got away*” from using less technologically advanced things such as posters for student products, she now believes that those types of products might better serve her students. She believes that when students do PowerPoints, they “*generally cut and paste, they don't actually synthesize the material, so they're not really getting to that point where we want them in the evaluation stage of learning*” (Post: 86-87). However, with posters, she believes that her students “*have to think about what you put on that board and you have to make sure that what's there connects*” (Post: 332-333). She believes that this process will “*help students remember the concepts a lot better*”. She further believes that the having

students present their posters make them “*more responsible for what they learn; they have ownership*”.

Barbara also expressed beliefs about the value of field trips. Although the school system will not pay for field trips, she believes that a trip on the boat she went on at the PD would be “*very beneficial*” to her students because it would allow them to see the instruments and learn more about oceanography. However, Barbara also discussed some negative beliefs about her students and her teaching context. She reiterated the belief that her students are only taking her class to get their third science in order to graduate. She also believes that class sizes might prevent her from taking her students outside. She said:

“*[w]ell, some classes have 30 or more students in them and sometimes it can be a challenge trying to keep everybody on task outside. You know, you want to take them outside, but then the challenge of keeping everybody focused because the classes are so large*” (Post: 194-196).

Integration of Personal Epistemology within Roles. Barbara's belief that research is about “*adding to the body of knowledge*” integrates with her emerging beliefs about letting students “*do more investigative work*” rather than her telling them what to do. This also integrates with her beliefs about the value of allowing time for her students to reflect and reconsider what they are doing rather than moving them along quickly.

Perceived purpose as a Learner. Barbara's perceived purpose as a learner was to reflect on what she was doing and prepare for “*reflective teaching in the classroom*”. She gave several examples of opportunities to reflect, including the daily reflections, other times throughout the day, as well the time she had between data collections. Her group did a second round of data collection and analysis during the second week of the PD. Their goal was to “*reevaluate the situation and consider some other things that may have affected that outcome*” (Post: 36-37).

Barbara perceived the purpose of the poster session was to make “*connections*” within their learning. She actually did outside research on her group's project with the goal of adding to the “*body of knowledge*”. She also perceived that one of the goals of presenting their work was to “*become more sophisticated*” in their knowledge and connections as they repeated their presentations.

Perceived purpose as a Teacher. Barbara leaves the PD with the goal of giving her students experiences with “*learning and having fun at the same time*”. Her experiences led her to the goals of letting her students “*do the preparation*” for their labs and letting them “*do more investigative work*”. She also wants to “*give the students more time for reflection*”, which includes her being “*a little bit more open*” to letting her students reevaluate hypotheses or revisiting data collection. She would like to take her students on the boat with the goal of them seeing the “*scientific tools that they can use for actual data collection*”. Although her students may be familiar with some of the tools, the boat field trip would give them the opportunity to see how the tools are “*actually used*”. She is also hoping her students will “*get more practical applications and see the relevance of oceanography*” because one of her goals is for her students to see oceanography as more than just their 3rd science to graduate.

Barbara is making plans to have students do presentations as “*some type of capstone event*”. Ultimately, her goal is to get her students to the “*evaluation stage*” of learning. She also discussed plans for using an activity she learned right after the PD with the goals of reviewing work, helping students “*focus on what we learned in class*”, and assessing every seven days. Barbara also leaves with the goal of being a more reflective teacher. She is hoping to continue collaborating with her PD group as well as the science

faculty she worked with at the PD.

Integration of Perceived Purpose within Roles. Barbara's perceived purpose of learning to reflect integrated with her goal of becoming a reflective teacher. She felt that she was given many opportunities to reflect, including their second round of data collection. She comes away with the goal of trying to be a "*little bit more open*" and allowing her students the time to do the same, including reevaluating situations. Barbara's felt that one of the goals of the poster session was to increase her level of sophistication. This integrates with her desire to give her students opportunities to "*do the preparation*", "*do more investigative work*", and ultimately, to learn and have fun at the same time.

Action possibilities as a Learner. Barbara's group went back into the field during the second week of the PD to collect additional data because their original data was inconclusive. They then worked together to design and present a poster about their field study. She also learned about assessment practices and NOS principles.

Action possibilities as a Teacher. Barbara was planning to have her students create posters and do presentations. She is also planning to incorporate reflections into her classroom practices. She also shared her plans to include "*10, 24, and 7*", which she explained as giving students 10 minutes of review in class, then 24 hours of review, which includes homework, and finally, a 7 day review, which would be an assessment. She is also looking into the possibility of taking her students on the boat. Barbara was thinking of giving her students additional time for some activities such as reflection and reevaluating hypotheses. While she had not yet made any concrete plans, she said, "*so at least I think I'm going to try to be a little bit more open*" (Post: 38). She was also thinking of giving her students more control in the classroom, including allowing them "*to*

do...rather than just giving them something that's already prepared" (Post: 118-119).

Integration of Action Possibilities within Roles. Barbara's action possibilities as a teacher integrate with her experiences as a learner to some degree. While she does not seem to be planning a field experience, she is making plans to incorporate many of the elements of the PD learning experience into her classroom, including reflection, posters, presentations, and perhaps even a field trip on the boat. Ultimately, it seems as though Barbara may be considering allowing her students to "*do*" instead of preparing everything herself.

Post-Alignment. Barbara leaves the PD with alignment in several areas. First, her positive perceptions of the learning experiences at the PD and feeling that she had more "*respect*" for her students' perspectives as a result aligns with her belief that learning never stops, as well as her belief that her students need the opportunity "*to do too*". She seems to feel conflicted about some of her current practices, perhaps seeing the misalignment between them and her new conceptions. She leaves with action possibilities of trying to "*be a little bit more open*" and giving her students more control in the classroom as well as her goal of giving her students experiences in which they can learn and have fun "*at the same time*", which represents the potential for aligning her practices with her beliefs.

An associated example of alignment is Barbara's positive perceptions about creating the poster and presenting with her group. This aligns with her belief that these experiences would encourage higher level thinking and ownership. She is planning to have her students do posters and presentations as a "*capstone event*" with the goal of getting her students to the "*evaluation stage*" of learning.

A third example of alignment is Barbara's positive experiences and perceptions of reflection. This aligns with her emerging beliefs about the value of reflection. This alignment is also present in her goal of incorporating reflection into the classroom, both for herself and her students. There are also alignments present between Barbara's positive perceptions of the group work and her hopes of doing more collaboration with her group after the PD. Lastly, she demonstrated alignment between her beliefs of the benefits of taking students on a boat trip and her goal of them seeing practical applications and relevance of oceanography.

Post-Summary. Barbara seemed to feel that her learning experiences at the PD were helping her become a better teacher. She continued to enjoy and value her learning experiences and opportunities to collaborate with teachers from her school. Beliefs emerged concerning the value of reflection and of the higher level thinking and ownership involved in creating and presenting. Although she did not discuss very many concrete plans, Barbara leaves the PD wanting to be a more reflective teacher and wanting to give her students opportunities to "*to do too*" and says that she is "*going to try to be a little bit more open*".

Overall Change. Barbara entered the PD already considering herself to be a "*lifelong*" learner because of her perception that she is a "*professional student*". Her experiences with the PD put her in the role of learning that more closely mimicked her students' roles. The experience left her feeling that she had "*more respect from a student perspective*" and the belief that she would now be better able to "*sympathize*" with her students, which she believes will make her a better teacher.

Although Barbara entered the PD with the goal of being “*more of a facilitator*”, it seemed that she was unsure of what that role might entail. Her preference for constructing her own meaning in learning experiences was misaligned with her teacher-driven practices for her students. Her experiences at the PD served as a model for her to envision what facilitation and better student experiences could look like, and led her to want to give her students experiences that were similar to those in which she had participated. She became conflicted about some of her current practices, realizing, for example, that the labs she implements are cookie-cutter. She left the PD having changed her beliefs about good practices, and seeking opportunities for her students to “*do*” things, which might better allow them to construct their own meaning. Although she still believes that she will have to “*teach them the concept*” and had not made any concrete plans, she did express a desire to be “*more open*” to those types of experiences and perhaps let her students “*do more investigative work*” rather than her telling them the exact steps.

Barbara also experienced a shift in her perceptions about group work. She had previously had negative experiences working with other teachers at PD sessions. At the PD, however, she perceived the group work to be very positive and meaningful. She attributed this to having group members from her school “*who are familiar with what you encounter on a daily basis*”. She leaves the PD with the desire to collaborate more with her group members, and hopes to work on activities for their classrooms as well as for other teachers at their school.

Barbara did not mention reflection during the pre-interview, so it is unclear what her perceptions and beliefs regarding the value of it were prior to the PD. However, the

daily reflections and continual reflection opportunities throughout the PD were the thing that Barbara brought up most often during the mid- and post-interviews. This was most likely influenced by a PD course she had just taken about reflection. However, Barbara felt that the PD was a “*better preparation for reflective teaching*” because of the continual opportunities to reflect the focus on science. Barbara left the PD with very positive views and beliefs about the value of reflection and goals and plans to include reflection in her teaching practice for herself as well as for her students.

Overall Alignment. Barbara demonstrated several areas of alignment. She entered the PD perceiving that good learning experiences for herself involved being able to construct her own meaning. She seemed to believe that she was providing those types of experiences to her students through her practice of allowing them to research some on their own, present as a teacher, and make presentations. These practices aligned with her perceived purpose of student achievement and goal of helping them understand. Her experiences with a more authentic learning environment at the PD aligned with her perception of a good learning environment for herself, but it also served to cause some misalignment in her beliefs about best practices for her students. She perceived new “*respect*” for her students’ perspectives. She realized that her labs are cookie-cutter, which was misaligned with her emerging goal of implementing more inquiry and better understanding of the role of a facilitator. She left the PD moving toward re-aligning her practices with her new beliefs and purposes. Although she did not have concrete plans in place, she was planning to “*try to be a little bit more open*” to giving her students opportunities to “*do*”. Barbara also developed perceptions and beliefs about the value of reflection during her time at the PD. These aligned with her perceived purpose of

becoming a “*reflective teacher*” in the classroom and her associated goal of giving her students more time for reflection.

Overall Summary. Barbara entered the PD with a good understanding of her own preferences for learning and the belief that she was providing those experiences to her students. She was seeking to become “*more of a facilitator*”. Her experiences at the PD placed her in a role similar to her students, and gave her a new appreciation and “*respect*” for their position. Through her experiences and reflections, she came to realize that she would better serve her students by facilitating experiences in which they could construct their own meaning, which would involve them doing more of their own learning and her “*stepping out of the way*”. Barbara left the PD with the desire to include reflection in her classroom and some abstract plans for giving her students opportunities to “*do*” things and to “*try to be a little bit more open*”.

Professional Identity Interviews Summary: Bill

Bill is a 57 year old man who entered the PD Institute with 26 years of teaching experience. He was teaching oceanography at the time of the interviews, but had previously taught earth science and physics. Bill has undergraduate degrees in geology and environmental science and a masters’ degree in earth science. Prior to teaching, he spent several years working in the oil industry. He also teaches earth science courses part time for the local community college. Bill joined the PD Institute because his school was looking for someone from earth science to participate. His prior experiences with earth science and curiosity about the project led him to volunteer to represent earth science at the PD Institute.

Pre-Institute Summary

Self-perceptions. Bill feels that he was “*always kind of a teacher*”. He seems to pride himself on this, and gave examples of teaching in the boy scouts and when he is on vacation. He said that there were too many teachers when he originally graduated from college, so he spent several years in the oil industry before becoming a professional teacher. He currently takes vacations centered on his subject area, and brings back pictures and videos of him doing things like swimming with sharks to share with his students. His degrees, prior experiences, and current science-related vacations lead him to see himself as a “*scientist who teaches*” because he “*actually does these things*”.

Bill perceives that he is very capable of explaining concepts to his students due to his experiences. He said:

“The kids usually understand it when I explain most things because having been in the field, you don’t necessarily give the textbook definition; you can explain it other ways” (Pre: 105-107).

He considers himself to be a “*special generalist*”, which seems to stem from his interest in scientific phenomenon in general rather than one specific subject within science.

When discussing this, he said: “*I am a specialist, but like I’ve said, I taught all the sciences. When I teach them, I guess that becomes my specialty*” (Pre: 297-298). He finds that he has a tendency to “*get overwhelmed*” in whatever subject he is currently teaching.

Personal epistemology. Bill seems to believe that he is better able to explain concepts and has more authority with his students than many of his peers. This belief stems from his time spent working in industry as well as his continuation of science experiences through his vacations. He values experience over “*just study[ing] the book*”. He elaborated on this by saying:

“...if a student knows that you actually did those things...when you teach them, you’re teaching more from authority than just from textbooks, so they tend to ask questions that are a little more real world sometimes because they know you did it, so they’re asking” (Pre: 67-70).

Although he values experiences in the field, Bill believes that it is very difficult to get his students out into field. This is based, in part, on his belief that his students are apathetic toward learning, which causes them to get bored easily and avoid work. He also considers student misbehavior as an issue. These classroom challenges limit some of the things he believes he can do with his classes, such as focusing on more finite details of the subject area, or taking his entire class on a field trip. However, Bill also believes that his students respond better to “*real-world*” information. These beliefs lead him to bring things back into the classroom, which seems to serve as his compromise to allow everyone to have experiences.

Perceived purpose. One of Bill's goals for teaching is to “*bring the real world in*”. One of his purposes for bringing his trips back into the classroom seems to be to show his students “*first-hand*” experiences and, “*...actually show them that I was standing right beside the ones that are mentioned in the textbook*” (Pre: 78-79). He also wants his students to leave his class with an understanding of the science he taught, which to him does not necessarily mean a high grade, but rather, for them to see the relevance of science to their lives.

Bill's purpose for attending the PD is to “*present better science in class*”. He says that he is “*always looking for something*” and trying to “*find a new way*”. Bill is also looking for ways to do more with his students, saying, “*I want to do that more with the kids. I’m always looking for ways to do that*” (Pre: 267-268).

Action possibilities. The majority of practices Bill discussed involve him bringing “real-world” things into the classroom for students to view and discuss. Many of the things he brings in come from his personal vacations. He seems to want his students to see him doing science. He brings in pictures and videos of him doing things such as swimming with sharks or standing beside rocks in the Grand Canyon. He also brings live animals into the classroom for students to identify.

Although it seems that the majority of Bill's practices involve bringing things in for students to see, he also mentioned taking small groups on trips. He discussed taking a small group of students on a boat. This was the only instance during which he discussed his students doing anything. This experience started with Bill doing the work, but ended with his students becoming actively involved. He said:

“I just picked things up and hold them in my hand and they were all squeamish, but when they actually got a closer look, they forgot about all that and in 20 or 30 minutes, everybody was picking stuff up and they were all trying to identify it and figure out what each one was” (Pre: 114-117).

When discussing this experience, Bill seemed to see himself and his students in different roles than they normally take. He said:

“When I looked back, it was like I didn’t even need to be there; they just had all the fish out of the bucket and they were collecting them and trying to identify everything” (Pre: 117-119).

Bill also discussed his assessment practices. He does not focus heavily on the test, which allows students who perform well on class assignments to pass the class even if they do not pass the tests. He said:

“It’s a combination of the test and how they work on whatever project we do. Things are different, so as long as they have an understanding on either side, they’re usually doing OK. I have kids that may never pass a test, but they’ve done all their work and understand it from the other part and they still pass the class” (Pre: 168-171).

Bill seeks out and participates in a lot of professional development (PD). He typically attends far more PD than is required for recertification. He also volunteers with some local organizations such as the Chesapeake Bay Foundation and the Virginia Aquarium, both to receive and test PD options for teachers.

Alignment. Bill demonstrated alignment between his beliefs about not being able to take students into the field and his practice of bringing his vacations into the classroom in the form of photos, videos, and discussions. This also aligned with his purpose, which was to “*give everybody experiences*”. He echoed this alignment by referring to his perceptions of himself as a scientist as well as his belief that he had more authority in discussions due to his experiences and photo and video proof of those experiences. Bill also demonstrated alignment between his beliefs about assessment, his goals for his students, and his practice of giving them multiple opportunities to show understanding.

Summary. Bill entered the PD Institute with conceptions of himself as a “*scientist who teaches*” due to his prior experience working in the oil industry as well as his current experiences taking vacations centered around oceanography. While he relishes his personal experiences and seems to value “*real world*” experiences for his students, he also seems to believe that he cannot take his students into the field due to group sizes and apathy. Because of this belief, he has taken to bringing his experiences into the classroom, and seems to believe that his students’ seeing him doing these things suffice as quasi-experiences for them. Bill is, however, looking for ways to “*present better science in class*” and to do more science with his students. He’s looking forward to the PD Institute, and seems to be going into the experience with excitement and an open mind.

Mid-Institute Summary

Self-perceptions as a Learner. Bill enjoyed the data collection portions of the first week in particular, calling data collection “*fun*” and commenting that he “...*always like[s] doing that kind of stuff. I don't know what else to...I mean I can get immersed into it.*” (Mid: 80-81). He perceived that the group work was going well and discussed the week in a positive light.

Bill's conception of his fellow PD teachers seemed to have changed at the mid-institute interview, perhaps due to their shared learning through the field experience. When talking about working with his group, he said classified them all as scientists, saying, “[w]e're scientists; we just work together” (Mid: 66). His discussions of group work seemed to indicate that he perceived himself as the leader who “*drug*” his group along to look at something he was interested in studying.

Self-perceptions as a Teacher. Bill's perception of himself as a “*scientist who teaches*” coincides with his experiences at the PD. When asked how the experiences he was having relate to who he is as a science teacher, Bill said, “*That's who I am (laughs). You know, I tell people, yeah, I'm on the boat again. I've been on boats all summer long, off and on, doing stuff like this*” (Mid: 147-148). Although he seemed to be changing his conception of the other teachers, Bill still seemed to see himself as different from those around him. He said that being out on the boat (and perhaps doing field work in general), “...*is normal, which is strange (laughs) for other people. I get used to it*” (Mid: 162).

Integration of Self-perceptions within Roles. Bill's perception of himself as a learner and a teacher demonstrate some integration. His view of himself as a “*scientist who teaches*” coincides with his perception that the PD fieldwork is “*normal*” for him.

While he began grouping the other PD teachers in as scientists, perhaps due to their shared learning experiences in the field, he continued to set himself apart. This may be due to his perception that he seeks out science experiences, which he considers to be “*strange*” to other teachers.

Personal epistemology as a Learner. Some of Bill's beliefs about scientists emerged when discussing group work. He believes that, “*scientists generally work together well*”. He also believes that “*scientists always like to look at things*”, which he finds to be helpful for collaboration due to his belief that scientists tend to see each other's side, leading to good ideas. He also discussed scientists' looks, which are in keeping with stereotypical views (c.f. Chambers, 1983):

“...most of us don't care how we look, you know, it's funny that the typical scientist has got messed up hair and glasses and a lab coat but that's typical. Now there are atypical scientists and we've seen some of them this week too” (Mid: 72-74).

Bill explained that his group experienced some difficulty with their initial data collection efforts due to the location and loudness of the boat. When discussing his group's plan for the second week of the PD Institute, Bill commented, “*I get the impression that nobody cares if we fail just as long as we try to do something, which is nice*” (Mid: 32-33). This comment provides insight into his beliefs about learning. It seems that the process-oriented style of learning he participated in at the PD differs from what Bill generally experiences as a learner.

Personal epistemology as a Teacher. Although Bill was enjoying the freedom to explore as a learner, he was having trouble thinking of how to translate the PD experience into his classroom due to his beliefs regarding instruction. He commented, “*I wish we could afford*” to allow students to have similar experiences of being able to try, even if

they fail. However, he seemed to believe that he could not do more inquiry-based activities because, "*normally I don't have time to waste for them not to get something*" (Mid: 34-35). This suggests that although he may believe that his students would benefit from a more process-oriented style of learning, he feels constrained to teaching via direct instruction to ensure that his students come away understanding the material in a timely fashion.

Bill was also experiencing difficulty translating his PD experiences into his classroom because of his belief that, "*kids want to see the big stuff*", whereas, the data associated with his PD field study does not include "*dramatic changes*". This corresponds to his beliefs about students' lack of focus and boredom. He said, "*I can't take them out to a mudflat for half a day. They're just not going to be focused. I might get one kid that's focused, but the problem is I have 30*" (Mid: 141-143). He attributes this lack of focus and boredom to technology, believing that "*...we've thrown so much technology at them, they want to be entertained...*" (Mid: 179-180). While he believes that "*technology takes the fun out of research*", he also tries to use a lot of technology in his classroom because of his belief that technology is, "*part of the entertainment factor that they need*" (Mid: 195). This also corresponds to his belief that bringing his vacations into the classroom through short video clips serves as a quasi-experience for them because, "*...that's the only way I'm going to be able to teach them, just little blips. They can't focus on anything for very long*" (Mid: 204-205)

Interestingly, although Bill feels that he cannot take his students on large field trips, he also seems to believe that a short field trip within his school yard is not a good option either. When discussing the possibility of doing so, he said, "*...that's a small*

thing...that's a 10 minute discussion in your class. It's a mini-field trip, but it's not a whole lot" (Mid: 260-261). This suggests that although he believes that his students would be bored 30 minutes into a longer field trip, videos of him on science-related vacations would better serve students than giving them shorter experiences.

Integration of Personal Epistemology within Roles. Although Bill finds the PD institute to be a good fit for him as a learner, he is struggling with connecting the more open-ended style of learning he is experiencing with his teaching due to his beliefs about instruction and his students' lack of focus and boredom.

Perceived purpose as a Learner. Bill's purpose as a learner during the first week was to "*check something out*", with the ultimate goal of trying to find, "*...anything that I can see a small change in that ties to something that the kids could see*" (Mid: 45-46). Although his group was "*trying to do small*" for his students, Bill seemed to also want to "*have huge humongous amounts of information*".

Perceived purpose as a Teacher. Bill perceives that his purpose as a teacher at the PD Institute is, "*to do something we can get the kids involved with*". One of Bill's goals for his students is, "*to get them to do something, to think*", which he is trying to accomplish by connecting learning to his school yard.

Although Bill feels like he could bring a small group of students into the field, he is struggling with meeting all of his students' needs through field experiences. This leads him to try to, "*find ways to bring other things in*" to his classroom, which ties to his purpose for bringing his vacations back into the classroom. He said:

"That's one of the things I'm trying to do when I take my scuba diving vacations. I'm taking videos; I'm just trying to find a good program. I just want to make little 5 minute clips on different things like fish identification, fish camouflage, you know, things that I could show little blips in the class" (Mid: 201-204).

Integration in Perceived Purpose within Roles. Bill demonstrated some integration between his perceived purpose as a learner and teacher when discussing his goal of finding something his students can see. He is struggling with this goal because he is not seeing the changes he wants to see, and he feels pressure to meet the needs of all of his students. His goals for himself as a learner, which includes gathering vast amounts of data, and his goals for his teaching, which are to find small changes and “...make little 5 minute clips on different things...” that he could then share with his students lack integration.

Action possibilities as a Learner. Bill and his group members worked together to collect data on the boat trip. They experienced difficulty getting some of their samples due to the weather and loudness of the boat. This led to his group deciding to change their data collection plan to look at plankton rather than fish. He discussed their plans for collecting additional data during the next week, which also included the potential for wet weather.

Action possibilities as a Teacher. Bill was beginning to make plans for bringing some of his PD experiences into his classroom. He was struggling with the fieldwork portion, saying, “...I don't know how I can translate walking across the mud flat to get the kids to get it” (Mid: 136). This comment was followed by a discussion of some of his practices surrounding bringing things back into the classroom rather than taking his students out into the field. He also discussed technology that he uses in the classroom, which included PowerPoints, videos, and the overhead document camera.

While Bill liked the location of his field study because it did not require a boat for data collection, it seemed as though he was referring to the prospect of him collecting

samples to bring back into the classroom rather than taking students out. However, he also discussed the idea of taking his students into the school yard, perhaps to put wells in to look at rainwater and drainage issues, which he referred to as a “*mini-field trip*”.

Integration in Action Possibilities within Roles. Bill did not demonstrate integration between his action possibilities as a learner and as a teacher. As a learner, he was seeking authentic experiences, which included grappling with difficulties in data collection and altering practices based on experience. However, he was struggling with translating these experiences to his teaching. He is reticent to take his students out in the field, thus he is looking at the field study site as a good fit for a place he can come to collect data to take to his students, which he seems to see as a good substitute for authentic experiences.

Mid-Alignment. Bill showed some alignment between his perceptions of himself and his fellow PD teachers and his beliefs regarding scientists. He seemed to alter his perception of the other teachers at the PD after the first week of the Institute. He originally felt that he was different from them due to his past experiences in industry and present experiences with science-oriented vacations. However, in the mid-interview, he referred to everyone as scientists, perhaps due to their shared experiences with field work. This aligned with his beliefs about scientists being able to work together because they are “*purposed*” on science rather than their appearance, etc. However, Bill still set himself apart from the others with comments that the field study was “*normal*” for him, which was “*strange*” for others. Bill also maintained his alignment between his beliefs about his students and his purpose and plans for translating his PD experiences back into the classroom by bringing something in rather than taking students out. Although he

discussed the possibility of a mini-field trip, he did not seem to believe that it would be very useful.

Mid-Summary. Mid-way through the PD Institute, Bill was enjoying his time spent collaborating with other teachers, particularly with the field study portion. He seemed to begin thinking of the other teachers as scientists. He was beginning to try to figure out how to translate his PD experiences back into his classroom, but was struggling with the thought of taking students outside due to his beliefs surrounding their lack of focus or interest. Based on this, he was looking for ways to bring science back into the classroom.

Post-Institute Summary

Self-perceptions as a Learner. Bill's group had planned to go back into the field during the second week of the Institute; however, the weather was uncooperative. One of the scientists went out in a kayak and collected the samples they needed. Bill said that the data analysis portion made him feel like he was “*going back in time*” and considered it to be “*fun actually doing the work*”. He was glad that the scientists made his group narrow their focus because otherwise his group would “*get carried away*” and still be working on their project. Bill enjoyed the interactions he had with other teachers at the PD. He found that “*meeting other people and making friendships*” was an important part of the Institute. He perceived that the poster presentation was a sort of “*fun busy work*”. However, he also found it “*kind of nice*” to get to see the other groups’ projects during the poster session because each group had a “*different perspective on what we were trying to accomplish*”.

Bill initially had negative perceptions about the Cornerstone Assessments because he felt that they had “*not been presented very well over the past couple of years*”. He had

been on the “*Cornerstone Committee*” when it was first established, but said, “*I don’t think anybody knew what the questions were supposed to be like back then*” (Post: 14-15). When the Cornerstones were first brought up at the PD, Bill said, “*there were some eye rollers...I think I was one of them*”. However, he left the PD feeling like he had a good understanding of the Cornerstones and was glad for the experience. This led to a discussion of district PD, which he feels is a waste of time. While he found the PD to be very intense and felt “*burn out*” toward the end of the second week, his perception of the PD was that it was “*professional*”. He said:

“[w]e went someplace, we sat in nice chairs, we were treated nice, except for the mudflats (laughs), we were treated nice and given food and treated like professionals and we got a chance to toy around and learn with stuff” (Post: 354-356).

Self-perceptions as a Teacher. Bill said that he found the PD interesting because, “*being a science teacher, you don’t always get a chance to be a scientist*” (Post: 9-10). He felt that the PD related to who he was a science teacher because it “*just reminded me what I like to do*”. He left the Institute feeling “*motivated to find little ways*” of infusing the PD into his classroom. He felt like it was going to be a “*learning experience*” to try to infuse the PD into his classroom, however, he said, “*I’ve got 30 more years to figure it out*”.

Bill was happy to have made a connection with a fellow group member who would be teaching Oceanography at another school within the district. He had shared his lesson plans, and was looking forward to having someone to “*communicate with during the year and connect with*”. Bill also discussed having a good relationship with the other Oceanography teacher at his school, saying that they “*work together pretty well*”. He

finds that, “*a lot of times we’re thinking for each other before we even open our mouths*” (Post: 147-148).

Bill also elaborated on his perceptions about district PD. When asked about PD, Bill first wanted assurances that the interviewer was not employed by the school system. He then discussed his perceptions regarding the poor quality of PD offered to teachers. He seemed somewhat nervous to be talking about it, saying that teachers are “*afraid*” to discuss it. This fear is based on his perception that, “*[i]f we rock the boat, we get bad assignments*” (Post: 373). He likes his current teaching assignment, which keeps him from speaking out against the district’s PD. He said, “*[w]hat I’ve got right now is what I like and it’s perfect and so I’m yes sir, no sir when I have to be so I can keep it*” (Post: 373-374).

Integration in Self-perceptions within Roles. Bill demonstrated some integration in his self-perceptions as a learner and teacher. He perceived that the field study was “*fun actually doing the work*”, which corresponded with his comment that the PD related to him as a science teacher because it “*just reminded me what I like to do*”. His learning experience left him feeling “*motivated*” to make some changes in his classroom, however, it seemed that these would be on a small level based on his comment that he wanted to “*find little ways*”. While Bill seemed to miss the parallel of him as a student, he did make the distinction between science teachers and scientists, finding that the PD left him feeling like a scientist.

Personal epistemology as a Learner. Bill left the PD believing that every science teacher should participate in a PD similar to the PD Institute. He said, “*they need to do this for all science teachers every summer, just something that allows them to get their*

feet a little dirty every once in a while" (Post 132-133). He further explained this belief by saying, *"a lot of science teachers have been out of school 10-15 years and they don't get the chance to do that"* (Post: 166-167). Bill believes that the majority of the PD offerings given by his school district do not allow teachers to get *"too sciency"* because of the length of time allotted and the *"canned"* nature of the activities. He believes that this leads teachers to just *"go through the motions"*, and they forget what it is like to do actual science. He believes that while the school system calls it professional development, *"it's not professional at all"*. In contrast, Bill felt that the PD was worth his time due to the content as well as the way in which it was run. He believes that the information was *"interrelated and we could see one piece fitting with the other piece and there was time to communicate and it was nice to have lunch and talk some more"* (Post: 351-352). This led to his belief that the PD was *"professional"*.

Personal epistemology as a Teacher. Bill believes that he is required to make all of his classroom activities *"canned"*. He said, *"we have to do the cookbook stuff. We have to make everything canned. We know what the kids are going to get regardless of what we tell them we don't know, but we know"* (Post: 23-24). This belief seems to stem from the pressures associated with the context in which he teaches, including time and the perceived abilities and interest of his students.

Bill believes that the NOS discussion *"refocused the way we look at things"*. He believes that he was already aware of each of the tenets of NOS, but that the way in which they were *"repackaged"* allowed teachers to make sure the information does not get lost. He was having difficulty determining how he might bring NOS into his classroom due to his belief that his students would not read the information.

Bill was also thinking of working with the Cornerstone Assessments. However, he was struggling with his belief that teachers should be able to modify the tests “*because not everybody teaches the same*”. He did not seem to understand the purpose of the Cornerstones as a tool to look at changes in student growth over a district, but rather was thinking of them in terms of his classroom only.

Although Bill discussed ideas for bringing the PD back into his classroom, much of the discussion was punctuated with his beliefs regarding his students' inabilities. He believes that he would need to give his students small pieces of PD-like problems to work with because “*they'll just freeze*” with a larger problem. He explained that he is “*dealing with the lower end*” of students, calling them the “*curdled cream of the crop*”. Although he does get some “*really smart kids*”, he believes that the majority of his students are the “tail end”. He explained that most of his students take Oceanography due to science requirements for graduation, saying, “*everybody kind of knows that it's a lower end science because of who's taking it*” (Post: 273-274).

Integration in Personal Epistemology within Roles. Bill demonstrated a limited amount of integration between his personal epistemology as a learner and teacher. He seemed to make a slight connection between his belief that science teachers learn best by doing science and his desire to give his students some actual science experience. However, this was framed by his beliefs regarding his students' inabilities. These beliefs coupled with his general beliefs about how school works seem to lead him to think that he has to make all of his classroom experiences “*canned*”. Bill's belief that PD for teachers should be more authentic and professional also differed from his beliefs regarding student learning. It was unclear whether or not he believed that students should

get more authentic experiences, but regardless, he seems to feel that it is not possible to give them those types of experiences due to the way school works and his students' inabilities.

Perceived purpose as a Learner. Bill perceived that his group's purpose was to have an authentic experience. His group "*actually had to do it, calculate the math, do it out*", which he seemed to feel should be the purpose of PD. However, his experiences with what he felt was "*horrible*" PD left him feeling that his typical purpose for being there was only to get his Continuing Education Credits to keep his license. He was also hoping to have additional experiences like the PD as a learner.

Bill felt that the purpose of creating the poster was to summarize his group's experience into a "*brief snapshot*". He found the poster session to be useful for seeing the other group's work. While he had heard some information about what the other groups were working on, the poster session gave him the opportunity to see "*exactly what they were doing*".

Perceived purpose as a Teacher. Bill perceived that his purpose as a teacher at the PD was to gain ideas of things he could do in the classroom to get his students to "*think*". A goal associated with this was to, "*find ways that are small that allows them to think through it and then they can take a little ownership in what they did*" (Post: 190-191). He was looking to give his students "*something that they're following and then have a place where they're stumped and they've gotta figure out how to fix it*" (Post: 193-194). Ultimately, he would like for his students to "*figure out a solution on their own*" and "*let them take some ownership*". However, rather than trying to accomplish this through more authentic learning experiences, Bill seemed to leave with the goal of making something

to show his students the “*real stuff*” he had done at the PD. He said, “*I’ll create something and use that as a way to get my kids to see the real stuff*” (Post: 28-29). He seemed to be thinking of this in terms of very small things his students could do in the classroom. For example, Bill was considering bringing plankton into the classroom, similar to his field study. However, his goal for his students would be to “*teach them a bit about math*”. He seemed to feel that the activities he created would have to be “*canned*” so that he could be assured that his students can “*get it done*”. He was struggling with how to “*get the kids to want to do the same thing*” that he had done at the PD. However, he was also going into this thinking that he would “*start implementing little problems for them to solve and then see how it goes*” (Post: 270-271). So if Bill experiences some success with implementing small changes, perhaps he will be more inclined to try larger changes.

Integration in Perceived Purpose within Roles. Bill’s perceived purpose as a learner was to actually do science. He seemed to have a similar goal for his students at the outset, wanting to give them “*ownership*” and have them find a “*solution on their own*”. However, this type of talk was juxtaposed with discussions of him creating things to allow his students to “*see the real stuff*”. He left with the goal of implementing small changes in his classroom, but he felt that the experiences would have to make them “*canned*” rather than more authentic.

Action possibilities as a Learner. Bill’s group focused on analyzing data collected during the second week of the Institute. While his group would have liked to have collected additional data, he also understood that they needed to focus on a smaller study. Bill’s group also created a poster and participated in the poster presentation session. Bill

also interacted with others, including his group members, scientists, and other PD teachers. He mentioned advising another teacher who was going to be teaching Oceanography in the fall.

Action possibilities as a Teacher. Bill was planning to create some classroom activities based on his experiences at the PD. He was planning to do something similar to the plankton study his group came up with, but on a smaller scale. He was intending to have his students work in lab groups, and have them discuss ways to solve the small problems he would come up with. His plan during that time would be to have them “figure out a solution on their own”, so while he would be walking around to the groups, he would be “acting like an idiot” and not giving answers.

Bill was also planning to make a poster of the NOS tenets. He was planning to make it picturesque, and wanted to refer back to it throughout the school year. Bill was also making plans to create Cornerstone Assessment questions for his tests. He did not detail his reasoning for this other than to say that “it is a part of the way of thinking”. He was hoping to eventually get to the point of having up to half of the test being written in the Cornerstone style.

Integration in Action Possibilities within Roles. Bill demonstrated some integration between his action possibilities as a learner and teacher. As a learner, he wanted to do more, including collecting additional data and having additional experiences similar to the PD. As a teacher, he was making plans to provide his students with similar experiences; however, his plan was to do so on a much smaller scale. He perceived that his action possibilities were limited due to his students’ abilities and level of engagement.

Post-Alignment. Bill seemed to feel rejuvenated as a learner and teacher due to the PD. His perceptions of the experience align with his beliefs about what good PD should be and left him with the belief that all science teachers should have similar experiences. This also aligns with his goal of having additional PD-like experiences as a learner. While he enjoyed the authentic experience the PD provided for himself as a learner, his beliefs about his students' inabilities continue to lead him to feel that he cannot provide similar experiences to them. He believes that he must make everything "*canned*" due to time constraints and students' lack of ability to solve problems. He seems to believe that his students will not be able to handle much more than small problem solving tasks. These beliefs align with his plans to try to infuse some of his PD experiences into the curriculum in small ways.

Post-Summary. Bill leaves the PD feeling satisfied as a learner. He enjoyed and valued his experience and believes that all science teachers should have a similar PD. He is making plans to infuse his PD experiences into his curriculum in small ways due to his beliefs regarding his students' inabilities. These beliefs seem to overshadow Bill's purpose and action possibilities, limiting what he feels he can do with his students.

Change throughout the PD. Bill entered the PD with the perception of himself as a "*scientist who teaches*" and the belief that he is different from other teachers because he "*actually does these things*" rather than just reading them in a book. He shifted his perceptions at the mid-interview to include all of the PD teachers as scientists, perhaps due to their shared experiences with fieldwork. However, he still saw himself as different because the experiences he was having were "*normal*" for him and "*strange*" for others. His perception seemed to shift again at the post-interview. While he still seemed to see

himself as a scientist, he discussed his belief that, “*being a science teacher, you don’t always get a chance to be a scientist*”. Rather than looking down on other teachers as he had at the pre-interview, he wanted all science teachers to have the PD experience, which he felt was “*professional*” as opposed to the types of PD experiences typically provided by the school system.

Overall Alignment. Bill entered the PD with beliefs about students' inabilities aligning with his practice of bringing things into the classroom with the goal of giving all of his students experiences. He maintained this alignment throughout the PD, and although he leaves the PD with plans to make small changes to his lessons to provide his students with ownership, he still feels that these experiences must be product-oriented and “*canned*”. Further, although he talked about giving students some opportunities to come up with solutions on their own, it seemed as though these opportunities would be part of something he would create in order for his students to “*see the real stuff*” rather than providing them with authentic experiences.

Bill’s beliefs about his students continued to lead to limitations in his perceived purpose and action possibilities. Throughout the series of interviews, he maintained his belief that he cannot give his students more authentic learning experiences. This was based on his beliefs regarding their inabilities, including apathy, misbehavior, and them “*being on the lower end*”. While he desires more authentic science opportunities for himself as a learner, and perhaps sees the value of these types of experiences for his students as well, his beliefs about what he can and cannot do with his students lead him to feel that he must create canned activities and bring things into the classroom.

Overall Summary. Bill enjoyed and found value in his PD experience. The experience seemed to serve to reiterate his perception of himself as a scientist who is different from other teachers. However, it also allowed him to see that teachers do not get to act as scientists and led him to group himself in with those teachers. While he enjoyed and found value in his PD learning experiences, he found it difficult to translate those experiences to his students. His beliefs regarding his students interact with his beliefs about learning, purpose as a teacher, and action possibilities. Although he seemed to think that his students might benefit from more authentic experiences, his beliefs about their apathy, need to be entertained, and lack of ability to problem solve caused him to feel that he could not give his students an experience similar to the PD. He left with plans to make some small changes, however it seemed that these changes would only include him providing his students with “*ways to see the real stuff*” rather than actually experiencing the “*real stuff*”.

Professional Identity Interviews Summary: Lisa

Lisa is a 30-year-old woman with seven years of teaching experience. She has bachelor's degrees in biology and geology and a masters' degree in curriculum and instruction. She was teaching biology at the time of the interviews, but has previous experience teaching earth science and oceanography. She was representing earth science at the PD because the current earth science teacher at her school was unable to attend. She had heard positive things about the PD from a friend who is part of the first cohort. She was asked to attend the PD by her department head.

Pre-Institute Summary

Self-perceptions. Lisa professes a love for science, saying, “*it's very interesting to me*”. Her love of science goes back to childhood, when she “*was always the kid kind of asking why why why*”. She perceives that this love of science was further developed in high school by her teachers and courses, saying,

“I had a really good geology teacher and I had a really good biology teacher and they just definitely influenced me, they made me interested in the subject and I was able to take really cool classes at the academy and that's kind of why I went” (Pre: 45-47).

She double majored in biology and geology in college. She initially wanted to become a doctor, but an experience shadowing a doctor left her feeling that it would not be as “*fulfilling*” a career as she had thought, so she decided to go into teaching.

Lisa seems to teach due to her love of the subject as well as her love of students. She especially enjoys the interactions she has with students, saying, “*I love the connections. I love seeing them smile. I love seeing them succeed. I love seeing them love the subject and ask me questions. Truly, the kids themselves make everything worth it*” (Pre: 147-148). Lisa assigns her students a reflection letter at the end of each school year, in which they discuss their initial expectations of the class and how their perceptions of it changed over the course of the year. She finds that she “*just love[s] reading those letters*” because of the positive things her students say as well as the “*hugs and smiles*”.

Lisa actually prefers geology as a subject matter, saying, “*I love geology, love it, love it, love it*”. However, she feels that her students enjoy biology more, saying that they are, “*more willing to dive into biology with me, which makes that more fun, rather than earth science*” (Pre: 295-296). This perception leads her to feel satisfied with teaching only biology. She perceives that she is both a generalist and a specialist because she feels like she can teach general things such as the scientific method and critical thinking skills,

as well as specialized things such as the rock cycle. She envisions herself staying at the same school, teaching the same thing in future, and says she has no desire to come out of the classroom because, *“I love being a teacher; I love the kids”*.

While Lisa loves her job, she feels frustration with a few aspects of teaching. First, she feels constrained due to lack of money. She said, *“as a teacher, I am forking over thousands of dollars every year and I just can't afford to pay for things myself”* (Pre: 99-100). She related an experience that occurred a couple of years ago in which she applied for and received grant funding for a project she wanted to implement with her students. However, after several months, several emails, and a change in leadership at the administrative level, she was told that the funds were already spent. She joked about hoping to *“win the lottery”* so she could fill her classroom with great equipment and animals.

Lisa also feels frustrated with some of the PD offerings available to her. She appreciates being able to choose when to take PD, and having a lot of options available. However, she finds some of the offerings, such as those in which teachers *“listen and stare at a PowerPoint for 2 hours”* to be boring and not worth her time. She said, *“[s]ome of them have been really really good, like just beyond...I left so motivated. And then some of them, I felt, were very redundant, like I've taken the same class every year, it's just now called a different thing* (Pre: 206-206). She finds that PD courses that allow teachers to actually do things instead of just listen are more useful to her.

Personal epistemology: Lisa expressed some beliefs about science in her pre-interview. She believes that science is *“very dynamic, and when we think we've got it, it changes, and then we kind of get a new perspective”* (Pre: 33-34). She also believes that

science is connected to technology, and considers it to be a “*growing field*”. Finally, she also believes that there are basic principles of science, such as critical thinking and the scientific method, which are the same across disciplines.

Lisa believes that her students learn best when they “*get to put their hands on*” things. She also believes that her students enjoy experiences in which they have some choice, are able to be creative, and come up with their own products. Lisa believes that her students respond well to guest speakers who back up the information she has previously given them in class. For example, she discussed bringing in field scientists and college professors to discuss what they do and “*why we should care about the environment*”. She believes that her students' reactions reinforced that, as a teacher, she “*knows what she's talking about*” and that it helped them envision different options for their future. Lisa requires her students to do community service for her class. She believes that while her students do not at first appreciate the experience, “*at the end of the year they look back and appreciate that they had teachers force them to do things*” (Pre: 324-325).

Lisa also expressed some beliefs about PD and how she feels teachers learn best. Her beliefs about how teachers learn best seem to coincide with her beliefs regarding how her students learn best. She said,

“I think teachers are just as bad as the students in that we have really short attention spans. And if it's something we can do, something we can think on our own, something we can collaborate, I think teachers come away with a lot more when they're able to work together versus just being told things through a PowerPoint” (Pre: 239-242).

She gave examples of PD experiences that she felt were less useful because the instructor only talked about the strategies. She compared these types of experiences to those in

which she was able to experience the strategies and observe the instructor implement the activities.

Having taught both SOL-tested courses and non-SOL-tested courses, Lisa believes that there are distinct differences between the two. She seemed to believe that she could do many more “*projects*” with her students when she taught oceanography, which is not tested. However, she seemed to lump teaching an SOL-tested class with budget cuts, saying, “*the unfortunate thing is there are so many time constraints that I'm unable to, I guess, have as much freedom to do all those different field trips, especially now with budget cuts*” (Pre: 90-91). She finds that many of the things she would like to do with students are not possible, “*because everything is always about money and we don't have money for that*”.

Lisa also believes that teachers are asked to a lot of things “*outside of the classroom*”. She seems to believe that responsibilities outside of actual teaching limit what she can accomplish inside the classroom, saying, “*teachers are kind of asked to do a lot of other things besides teaching that take away from just being able to teach*” (Pre: 154-155). She gave several examples of these duties outside of the classroom, including PD for Continuing Education Credits, collecting, analyzing, and reflecting on student data for her annual evaluation, IEP meetings, and parent/teacher conferences. She said, “*it's a lot, but everyone handles it and we all know it's part of the profession*” (Pre: 199).

Perceived purpose. Lisa's perceived purpose as a teacher is to share her love of science to future generations. Some of her goals for teaching are to give her students experiences in nature and to help them make connections between what they are learning in her class and the outside world. She also values giving them the opportunity to

“explore their own interests”, “do their own research”, “show their creativity”, and to “produce their own products”.

Lisa's perceived purpose for coming to the PD is to assist her school and colleagues by representing earth science. Since the earth science teacher at her school was unable to attend, one of Lisa's goals is to bring the information back to her, but she also hopes to be able to connect what she is doing to biology, which she currently teaches. There are other teachers coming to the PD from her school, and Lisa hopes to collaborate with them as well as others. She seems to be interested in ready-made activities that will *“fit within the time constraints and the budget”*, saying that she would like *“to get resources that I can use right away in the class without having to buy certain software or having to jump through 82 hoops for an activity that will last 30 minutes”* (Pre: 266-267). Lisa's discussion of her goals for the PD relates with her goals for PD in general. She hopes for and values PD experiences in which she gets to be actively involved in learning and is able to see how the activities might be implemented so she can get an idea of *“the setup and the takedown and what it takes and how long it takes”*. She also longs for PD experiences during which she receives activities that can be used for *“any curriculum, any topic, any subject, any day”*.

Lisa would like to be able to focus her job only on things such as lesson planning and curriculum writing. She does not seem to see the purpose of other parts of her job such as assessing herself through a yearly evaluation. She discussed having to collect and analyze data and reflect on goals for her evaluation. However, she did not seem to connect that with bettering teaching through reflection, but rather, as just additional work.

Action possibilities. Lisa gave examples of activities she implements in class such

as students designing and building remotely operated vehicles (ROV), and taking students outside to photograph items and connect them to what they learned in class. She gave an example of her students coming into her class with an understanding of cell division and mitosis. Rather than re-teaching the concepts, she had her students create a product that demonstrated their understanding. She said,

“...they just kind of like went with it, and it was really cool and very meaningful to them because instead of me teaching them something they already knew, they've learned it like 82 times, they were able to kind of use their creativity to show me that they understood the different phases of mitosis and how we get from one cell to the next and why we need cell division” (Pre: 128-132).

She discussed using rubrics for grading these types of activities, but did not go into detail about what those rubrics might look like.

Lisa also discussed strategies she has used to try to get her students more interested in science. She tries to get her students to make connections between what they are learning in her class and the outside world. One way she does this is by having her students summarize media such as articles, podcasts, or videos, they find that relate to the topics they are studying in class. She also requires a community service element to her courses. Lisa discussed requiring her students to do community service as well as summarizing media that connects to what they are learning in class. Lisa also gave examples of bringing people into the classroom to speak to students about their jobs and conduct labs with the students. This included scientists and professors as well as taking students to the zoo.

Lisa feels that some of her practices are limited due to funding and time constraints associated with teaching an SOL-tested course. She gave examples of practices she was able to implement when teaching a non-SOL-tested course, which

seemed to include a more project-based learning approach. She said:

“I was able to do so many environmental projects. Like we grew dune grass. We were able to plot it into a swampy area later in the year. We did oysters, and my kids raised the baby oysters and we monitored and measured them throughout the year. We did boat trips. We went out and planted dune grass” (Pre: 80-83).

Now that she teaches an SOL-tested course, and there is less money in the budget, Lisa is looking for alternatives to some of the activities she no longer considers as options.

Alignment. Lisa demonstrates alignment in a few areas. Her beliefs about the ways both teacher and students learn through doing rather than listening seem to coincide with her practices involving having students do project-type activities in class. Lisa is also very positive about her students, which coincides with her practices of taking them outside and allowing them more freedom within the classroom. She feels constrained by time and money, which aligns her beliefs about teachers being asked to do a lot of things outside the classroom. This also aligns with her goal of finding ready-made activities that she can immediately use in her classroom that do not require purchasing a lot of materials.

Summary. Lisa entered the PD as a teacher who loves science, teaching, and her students. Her beliefs about appropriate learning for students correspond with how she likes to learn in PD's. She feels frustrated with lack of funding and the time constraints associated with teaching SOL-tested classes. She is hoping that the PD will provide her with opportunities to collaborate with other teachers, and seems to be seeking ready-made activities that she can easily implement in her classes.

Mid-Institute Summary

Self-perceptions as a Learner. Lisa perceived that the process of developing and implementing her group's field study was a good experience. She worked with three

teachers from her school, saying that it was *“nice to collaborate with teachers that are my friends and I see them every day, but I never truly get to work with them and now I’m able to”* (Mid: 118-119). Her group was composed of two chemistry teachers, one of whom was representing physics, and two biology teachers, which included Lisa, who was representing earth science. Lisa found the process of determining the group’s research question and hypothesis to be *“frustrating because we each had a different point of view to attack kind of the same problem”* (Mid: 37-38). Lisa perceived that the subject matter each group member was coming from heavily influenced what they perceived as the focus of the field study. The group had trouble determining the focus of their research until they sought guidance from the community college faculty members, which helped them to *“combine all of our different expertise into one so that we had one idea that we could all bite into and feel like we brought our expertise to that area”* (Mid: 49-51).

Lisa found the data collection portion of the PD to be *“interesting and funny”*. While her group felt that they had an *“idea as to what to expect”*, they had to *“modify”* some of their plans based on what they found at the field site. She perceived that the *“hard part was picking exactly what area we wanted to test”*, but after doing so, she found the data collection and group dynamics to be good.

Lisa perceived that the data analysis portion of the PD was *“eye opening”* and *“different”*. She said that she and the other biology teacher were unaware of the *“technical skills”* that went into analyzing soil salinity. She thought it would be a *“really simple protocol”* and that the group would be *“done in like 10 minutes”*. However, she found that the chemistry-intensive data analysis was quite rigorous. She said, *“[l]ittle did we know how precise it had to be, how accurate, and then they wanted to repeat it, so we*

did all the samples 3 different times and it ended up taking the entire day” (Mid: 46-47). While she found it to be a “whole other realm and world” from biology data analysis, she said that both she and the other biology teacher were “open to that now”. Ultimately, Lisa found the field work portion of the first week to be meaningful because she feels that “[a]nything that I’m able to get my hands on and specifically do has more meaning to me” (Mid: 100). She finds that hands on experiences allow her to “connect to it and make memories to it”. When discussing her past experiences with her students, she finds that the “highlights are the field work experiences”.

Lisa found the interactions with scientists to be useful. She expressed that since she has been teaching biology for so long, she perceives that she has become “*narrowed into biology*”. She found conversations with the scientists to be helpful because it “*kind of reopens my eyes to all the different fields of sciences*”. Lisa also found it useful to interact with colleagues outside of her school group. She perceived that these interactions were helpful when her group was “*in our problem and then another teacher will hear us talking and say, oh, well why don’t you guys try this or I do this and this lab*” (Mid: 106-107). Finally, Lisa found that the PD environment fits in with her perception of a good learning environment. She said:

“[I]t’s been nice kind of being in an environment that fosters different point of views coming together and people questioning different things and, well I don’t really know if that’s how you do it, and we’re able to all approach things differently” (Mid: 145-147).

Self-perceptions as a Teacher. Lisa said that she has not “*been in the field since college*”. She found the field work “*eye opening*” because it caused her to rethink how she teaches experimental design. She has typically focused on having an “*ideal situation*” for experimental design in which you can have a control group, repeated trials, and

random sampling. However, her group's field study served to challenge this. She said:

"[W]hen we went out into the field, I was like, oh my gosh, we're not random sampling or we don't have a large enough population size or we don't have a control group and my group members were like, Lisa, that is an ideal" (Mid: 167-169).

Lisa perceived that the daily reflections were a meaningful part of the PD. She appreciated the opportunity to reflect on a daily basis *"as opposed to writing a reflection two weeks from now when I forget and I'm exhausted from the week"* (Mid: 132-133).

Integration of Self-perceptions within Roles. Lisa's self-perceptions as a learner and teacher demonstrate some integration. She made at least one connection with her learning and her students' learning, and realized that experimental design looks different outside of ideal situations based on her experience with the field study.

Personal epistemology as a Learner. Lisa's experiences with the field study led her to express some beliefs about biology. The chemistry-intensive portion of the data analysis led her to contrast it with biology data analysis. She believes that biology is *"more of an observational thing...it's qualitative, like this dirt is darker than this dirt, I called this dark gray and that's gray kind of thing"* (Mid: 52-53). Her experiences talking with scientists from fields other than biology led her to make connections among the sciences. She now believes that *"all the disciplines are overlapping...they kind of all connect together; they're not so separate"* (Mid: 86-87). Lisa also expressed the belief that many of the PD's she participates in are *"cookie cutter"*. She finds that these types of PD experiences are *"not very applicable to all different fields, all different people, all different students"* (Mid: 155).

Personal epistemology as a Teacher. Discussing the daily reflections led Lisa to express some beliefs about teaching. She believes that teachers are limited by their *"fast*

paced pacing guides", which causes them to "go at 50 mph all year long". Because of this, she believes that the only time to reflect is during the summer. However, she does not find as much value in summer reflections because she believes that the time frame is "too late because what you're reflecting on are things that you would have done in the past and now, the next year gets to experience it, but it's kind of like a year late" (Mid: 129-131).

Lisa also expressed some beliefs about her students. She was beginning to make plans to implement open-ended questioning and labs with her students. She believes her students will be frustrated with this more open-ended approach because they do not want to have to think. She said, "this generation of students is very much, just tell me what to do. And if you don't tell them in 5 minutes, they get angry and then sit out" (Mid: 195-196). However, she also believes that she can help her students "get used to it" by modeling and helping them walk through things, saying "it'll take practice". She also expressed the belief that her students "go through these labs that we do and they just do it to do it" (Mid: 216-217).

Integration of Personal Epistemology within Roles. Lisa demonstrated some integration between her personal epistemology as a learner and teacher. Her beliefs about the value of reflecting soon after her experiences seem to coincide with her plans and beliefs involving having students reflect on their lab experiences. While she does talk about beliefs about the challenges her students will face, she also seems to feel that she can overcome those issues by modeling and assisting them through it a few times.

Perceived purpose as a Learner. Lisa's perceived purpose as a learner was to work with her group to design and conduct a field study. She felt that having group

members from each discipline allowed each person to bring their “*expertise*” into the project. The group then worked together to “*combine*” all of their perspectives for the field study. While in the field, Lisa’s group had to modify their plans based on the location and tide. They also had to “*do some trial and errors*” with their study. She felt that their purpose was to “*work together and help one another to figure out, like what we wanted to test and how we wanted to test it*” (Mid: 34-35). She also felt that the group served to “*check*” each other to ensure they got all of the data collected. Lisa perceived that the purpose of working with scientists was to get “*each different perspective*”. She found that it made her think of the different sciences in new ways, and helped her “*see how all the disciplines are overlapping*”.

Perceived purpose as a Teacher. One of Lisa’s perceived purposes as a teacher is to get her students to “*think critically*”. She asks her students “*to see, kind of, all sides of everything and not take things at face value, but to research it, look it up, don’t just believe it*” (Mid: 144-145). Ultimately, she hopes that her students will “*approach things differently with of course the same outcome in mind*” (Mid: 148-149). She perceives that the classroom environment she has created mimics what she experienced at the PD because it “*fosters different points of views*” and encourages her students to “*approach things differently*”.

Lisa’s experiences at the PD have led her to want to try to implement more open-ended question prompts with her students. Her goal is to have the students design their own experiment in which they determine the procedure, variables, etc. Ultimately, she is hoping her students will “*collaborate and work together and maybe do some research and figure out what they could do and how they could do it*” (Mid: 189-190). Her goal as

a teacher will be to “*guide them*” as they go through this process. She was also planning to alter how she teaches experimental design with the purpose of helping her students understand that having a control group, repeated trials, and random sampling is part of an “*ideal situation*” and may not be possible in actual field studies.

Lisa is also thinking of having her students reflect on their labs. Her goal associated with that is to determine if her students understand the “*main objective*” of the labs. She is hoping that they “*see the big picture*” and “*take ownership of what they’ve done*”. These reflections will then allow her to determine if the class is “*getting the point of the lab*”. If they are not, she will then plan to “*talk about it as a whole*”. Finally, Lisa perceived that the purpose of the daily reflections was to allow her to “*gather my thoughts together*”. This allowed her to think of her experiences and how she could “*apply that to my classroom or teaching in general*”.

Integration of Perceived Purpose within Roles. Lisa’s perceived purpose as a learner and teacher demonstrate some integration. Her experiences with her group in combining their different disciplines and perspectives aligns with her goal of having students “*approach things differently*” but try to come to the same end goal. Further, her group’s perceived goal of designing and implementing the field study connects with her goal of engaging her students with more open-ended questions. She was able to make some connections between her experiences at the PD and her goals for teaching due to daily reflections.

Action possibilities as a Learner. Lisa worked with her group to design and implement a field study. Their experiences in the field included modifying some of their plans and expanding their sample area. They then spent a day analyzing their soil salinity

and other data. Throughout the week, Lisa also created a concept map and met with scientists from different disciplines.

Action possibilities as a Teacher. Lisa was planning to take the chemistry data analysis ideas back into her biology classroom as a discussion point. When talking about salinity in the oceans and organisms, she was thinking of asking her students, “*what if we went on to land, what do you think or how do you think we could take the salinity of soil*” (Mid: 66-68). She was also planning to alter her teaching of experimental design to “*highlight the importance of having constants and variables and so forth*”, but to point out that it would be in an “*ideal situation*”.

Lisa was also planning to give her students reflection questions associated with their labs, which she seemed to be thinking of as a formative assessment to determine their understanding. Finally, she was planning to bring more open-ended questions into her teaching, and seemed to be thinking of taking more of a facilitator’s role. She gave the following example:

“So maybe instead of saying, let’s test how temperature is going to affect yeast fermentation, maybe I’ll say, you guys come up with an experiment that we can test on yeast fermentation and let them pick the variable, let them pick the procedure, let them pick whatever they want. And I will kind of model that with how you guys did that with us where I’ll give them the big picture and then let them collaborate and work together and maybe do some research and figure out what they could do and how they could do it and guide them through it” (Mid: 185-190).

Integration of Action Possibilities within Roles. Lisa’s action possibilities as a learner and teacher demonstrated some integration. She made some connections between her learning and teaching, including wanting to ensure that her students were aware that the way in which she taught experimental design was for an “*ideal situation*”. She was also making plans to translate some of her PD experiences to her students, such as

wanting to give them more open-ended questions and providing them with reflection associated with labs.

Mid-Alignment. Lisa demonstrated some alignment at her mid-interview. Her experiences as a learner were positive and somewhat enlightening to her. She perceives that she has a better understanding of other disciplines and how they connect with one another. This aligns with her purpose of combining perspectives as a learner and her goal of having students “*approach things differently*”. She did not elaborate on what that might look like, however, it might coincide with her plans for using more open-ended questioning with her students and desire for them to gain more ownership. Lisa’s belief that the daily reflections were valuable and useful for her coincides with her plans for having students reflect on their labs in order for her to get a better understanding of what they are taking away from the labs. Lisa expressed beliefs about her students’ desire for answers rather than trying to do things themselves, however, she also discussed plans for facilitating her students and seemed to understand that it would take time.

Mid-Summary. Lisa had positive learning experiences during the first week of the PD that allowed her to make connections between the various disciplines represented and feel that she was able to bring her background in biology and earth science to the table, calling it “*expertise*”. She was beginning to make some plans to translate her PD experiences to her classroom in small ways. She would like to give her students experiences with more open-ended questioning, reflecting on their labs, and ultimately have them take more ownership of their projects.

Post-Institute Summary

Self-perceptions as a Learner. Lisa’s group did not need to collect additional data

during the second week of the PD. Lisa perceived that the data analysis portion of the PD was “*pretty easy*” for her group. She attributed this to one of her group members, who “*really enjoyed looking at data and analyzing it*”. He put their data into spreadsheet form, which Lisa felt “*made things a lot clearer*”. She also perceived that developing the poster was “*good*”, saying that the “*hardest part*” was determining the color scheme. She felt that while each group member had a “*different personality*” and “*different vision*”, they were able to “*find a way to talk it out and agree to compromise on one idea*” (Mid: 42). She enjoyed being able to interact with other teachers from her school, saying, “*[s]ometimes during the school year, we all have our different classrooms and we kind of stay in those different areas, so it was nice being able to interact with one another*” (Post: 71-72). The poster presentation was “*good*” for her as well. She perceived that she gained confidence each time she presented, and at the end, “*you just kind of know your stuff*”. She also found it “*nice*” to be able to see and hear what other groups did.

Lisa enjoyed looking at the NOS principles and “*put[ting] them in our own words*”. She also appreciated being able to “*hear other people’s ideas*”. She perceived that her post-PD concept map “*wasn’t that different*” from her pre-PD map. She found the major difference to be that she was able to add concepts from her field study experience such as salinity. She found it interesting to look at other people’s concept maps because it allowed her to “*see how different people fit pieces of the puzzle together*”, which she felt was based on their discipline. Of note, Lisa’s experience of the second week of the PD may have been influenced by her perception that she had gotten Lyme disease when she was in the field during the first week. She was bitten by something during the first week and her doctor put her on a round of antibiotics as a precaution. However, Lisa

maintained the perception that she had contracted Lyme disease and mentioned it during the post-interview, saying, “[w]hat would I change about the institute? Um, not getting Lyme disease (laughs)” (Post: 143).

Self-perceptions as a Teacher. Lisa perceived that being amongst peers was a beneficial portion of the PD. She found that being able to “*bounce ideas off each other*”, even during the meal breaks, was nice because they do not often get to do that. However, she would have liked to have had more interaction with the first cohort of PD teachers. She was able to gain some insight as to what they were working on because some of her former colleagues were in that group. This made her feel that “*other people would have benefitted*” from hearing about their experiences.

Lisa enjoyed the assessment presentation, especially the points about test reliability and validity. She also found value in the NOS discussion because people shared what they were doing in their classes. She said, “*even though it wasn’t a part, like the think-pair-share thing, it kind of turned into everybody saying, oh, I do this, I do this, and then we were able to collaborate together and get some ideas*” (Post: 34-36).

Integration of Self-perceptions within Roles. Lisa demonstrated some integration in her self-perceptions as a learner and teacher. She enjoyed learning with her colleagues as well as being able to discuss practices with them. She did not seem to make many connections between her experiences as a learner and her role as a teacher. The one exception being that she perceived that the NOS discussion fit with her as a learner because they were able to put the principles into their own words and hear others' ideas. She then connected that to the teachers sharing how they teach NOS in their classrooms.

Personal epistemology as a Learner. Lisa did not express any beliefs from a

learner's point of view.

Personal epistemology as a Teacher. Lisa expressed some beliefs about science from the viewpoint of a teacher. She believes that all science disciplines have the “*same principles of science*”. She elaborated on this belief by saying, “*science in general is kind of like observations, asking questions, finding ways to answer those questions, and we all do that in each of our subject areas, we just do it in different fields of science*” (Post: 82-84). She believes that these principles are universal to science teachers, but are very different from the focus of other teachers. For example, Lisa said that English teachers “*would focus merely on the punctuation, the grammar, the syntax of the conclusion and results*”, whereas math teachers “*might focus on the data analysis part*”. She believes that all science teachers “*would focus on, where's our question, how did we solve it, and then what is our conclusion*”.

Lisa also expressed some beliefs about NOS. She feels that NOS is what all of the sciences “*have in common*”, saying that it “*applies across the board to every subject*”. She believes that she will be able to get ideas about how to teach NOS from any other science teacher because “*it kind of goes across the board*”. Lisa also believes that she is already covering the NOS principles with her students. She said, “*I'm not worried about hitting the principles because when you read them, everything we do all year focuses on that*” (Post: 95-96). She seems to believe that making her students “*more aware*” of the NOS principles will require only making a poster and referring to it when necessary.

Lisa also expressed some beliefs about assessment. She has been using a test generator to create her assessments, which include multiple choice and true/false questions. However, she has begun to reconsider this practice because she now believes

that these types of assessments are not reliable. She believes her students could receive good scores for “*guessing correctly*”. Finally, Lisa expressed a belief regarding the benefits of having her students do poster presentations similar to the one she did at the PD. She believes that having students create a poster and “*grade*” others posters “*will take the pressure off*” of her.

Integration of Personal Epistemology within Roles. Lisa did not demonstrate any integration between her personal epistemology as a learner and teacher. She did not express any beliefs as a learner.

Perceived purpose as a Learner. Lisa's perceived purpose as a learner during the second week of the PD was to work with her group to analyze their data, form conclusions, and to create a poster to present their findings. One of Lisa's group members put their data into spreadsheet form, with the purpose of helping the group “*tell direct relationships versus indirect relationships, correlations or no correlations*”. He also created a visual, which assisted the group in determining whether or not their data supported their hypothesis. The poster presentations allowed Lisa to “*tap into my own expertise*” as well as see what other groups did and take ideas from each other. Lisa expressed that she would have liked to have had some focused time with first cohort of teachers in order to ask questions about “*what they did, their ideas, what changed*”.

Perceived purpose as a Teacher. Lisa left the PD with the perceived purpose of making some changes in her classroom. Her first goal is to examine and alter her assessments to make them more valid. An associated goal is to begin including each level of Bloom's Taxonomy in her assessments. She said:

“I would like to make sure that I’m hitting all the levels of Bloom’s Taxonomy, from the very simplest level to the most complex level. Maybe not in every

assessment that I do, but at least once every 9 weeks. And then make sure that I check that it's valid and that I'm hitting all the different content areas that I want to. My goal is to do it once a 9 weeks" (Post: 26-29).

Ultimately, her goal is to *"get a better idea of what the students really understand"*.

Lisa also wants to focus on NOS in the coming year. She feels like the NOS principles are inherently covered within her curriculum, so her goal is, *"to make them more aware that that is a NOS principle"* as they come across things in their lessons. Lisa is also considering using more open ended questions with her students. Her goal associated with that is to have the students *"come up with procedures and guide them through their inquiry instead of just handing it to them"* (Post: 115-116). She is also thinking of having her students create and present posters similar to the one she made at the PD. Her goal associated with that is for her students to:

"take ownership of their projects and instead of having one person in the group do the whole thing, if they know that they're having to take turns doing their talk, then they're all going to take ownership of their projects because they're going to have to talk to their peers" (Post: 110-112).

Finally, Lisa is planning to use concept mapping with her students in order to *"see how they connect the ideas"* and determine *"who's really got it and who needs a little work"*.

Integration of Perceived Purpose within Roles. Lisa demonstrated some integration between her perceived purpose as a learner and teacher. Her experiences with the field study left Lisa with the goal of giving her students small portions of that experience, such as open ended questions and creating and presenting posters. She is hoping her students gain more *"ownership"* of their projects, however it unclear if she felt ownership of her PD project. She also leaves with the goal of bettering her assessments based on information she learned at the PD as well as using concept mapping to better determine her students' conceptions.

Action possibilities as a Learner. Lisa's group spent the second week of the PD focusing on data analysis and creating their poster. One of Lisa's group members was able to put their data into spreadsheet form, which helped the group with forming their conclusions and representing their data on the poster.

Action possibilities as a Teacher. Lisa leaves the PD with plans to alter some of her practices. She would like to begin altering her assessments to include questions from each level of Bloom's Taxonomy. She is also planning to work on other facets of the test such as wording. She said, "*I can go back and revisit my assessments and change wordings, I can add things, take things out*" (Post: 135-136).

Lisa is planning to make a poster with the NOS principles to hang in her classroom and refer to when necessary. Lisa also plans to have her students create concept maps. She was also considering, "*having kind of an open-ended question and letting kids come up with procedures and guide them through their inquiry instead of just handing it to them*" (Post: 115-116). She also liked the idea of having students create posters to represent what they have been working on and grading those with a rubric.

Integration of Action Possibilities within Roles. Lisa demonstrated one example of integration between her action possibilities as a learner and teacher. Her experiences with data analysis and creating the poster at the PD mimic what she is planning to do with her students.

Post-Alignment. Lisa again demonstrated some alignment. Her beliefs about quality assessment align with her plans to alter her assessments with the goal of making them valid. Her goal of having students take more ownership aligns with her plans to give them open-ended questions and have them design and present posters about their learning

and her belief that having students do this will take pressure off of her. Her belief that she already covers NOS because “*everything we do all year focuses on that*” aligns with her plan to create a poster with the associated goal of making her students more aware of NOS.

Post-Summary. Lisa seemed to enjoy the second week of the PD, and felt comfortable with her group’s analysis and presentation. She left the PD with some plans to alter her practices based on her experiences. She would like to implement more open-ended questions and have her students create posters of their learning experiences. She is also planning to revise her assessments to be more in line with her newly developed beliefs about quality assessments.

Overall Change. Lisa seemed to enter looking for ready-made activities she could easily implement. She came away from the experience with some of these types of activities, such as creating a NOS poster. However, she also made plans to change some of her practices, including adding open-ended questioning, reflections, students creating posters, and altering her assessments. A corresponding purpose of student ownership emerged during the mid-interview and continued as a theme at the post-interview. She seemed to believe that this ownership could be established through using more open-ended questions and having students design posters. Her pre-interview purpose of sharing her love of science to future generations did not seem to follow her through the PD. She left desiring student ownership and a better understanding of what they know, however, she expressed limited information regarding her reasoning for wanting student ownership and her beliefs surrounding the value of student ownership.

Lisa left the PD with a better understanding of how the various science disciplines connect, which she attributed to her group work. While she expressed some negative beliefs regarding students' abilities, she also seemed confident that she could overcome those problems by guiding them through new experiences a few times.

Overall Alignment. Lisa demonstrated some alignment in her identity system. Her love of students and science aligns with her purpose of wanting to spread her love of science to students. Her beliefs regarding how she learns best aligned with her perceptions and experiences of learning at the PD and her plan to begin using more open-ended questioning and presentations with the goal of developing student ownership. Lisa entered the PD seeking ready-made activities that she could easily implement. Some of her plans at the end of the PD seem to be aligned with this goal. For example, she was planning to make her students aware of NOS principles, which she believed could be accomplished by hanging a poster of the principles in her room. She was also planning to work on making her assessments more valid, which she described as changing wordings, adding things, and taking things out.

Lisa may have also left the PD with some misalignment present. Although she entered the PD with the perceived purpose of sharing her love of science to students, her purpose shifted. She left with the goals of better understanding what her students know through assessment, developing student ownership through poster presentations, and using open-ended questions to guide them through inquiry. However, she did not elaborate much on these goals and did not express beliefs associated with them, so it is not clear why these are her goals.

Overall Summary. Lisa entered the PD seeking ready-made activities that she could easily implement in her classroom. She enjoyed her PD experience and ended up grasping on to some of the more ready-made portions of the PD such as making a NOS poster. However, she was also planning to make changes to her assessments in order to make them more valid and better understand her students. She was also planning to use more open-ended questions and “*guide them through inquiry instead of just handing it to them*”.

Professional Identity Interviews Summary: Penny

Penny is a 33 year old woman who entered the PD Institute with 10 years of teaching experience. She was teaching chemistry at the time of the interviews, but had previously taught biology as well. Penny has an undergraduate degree in biology with a minor in chemistry and a masters’ degree in secondary education. Penny spent a few years teaching in an alternative private school before coming to her current school. She was asked to join the PD Institute by one of her school administrators.

Pre-Institute Summary

Self-perceptions. Penny did not set out to be a teacher, but rather perceives that it “*just kind of fell into place over the years*”. She said that she was “*never very strong*” in history or literature. She felt that science and mathematics were her strongest subjects during her time in school, and always loved science and learning. She chose biology as her college major because she was considering nursing school, but changed her mind along the way. She continued with biology and picked up chemistry as a minor, which she seemed to like more than biology. She got married right out of college and “*had to go*

to work", so she began teaching in a private school while getting her masters' degree in education. She perceives that although she is considered to be a specialist as a science teacher in the district chemistry curriculum, she is a generalist in chemistry itself.

Penny spent her first few years teaching at a private alternative school for students who were learning disabled, gifted, or both. The class sizes were much smaller, and it was "*very focused on kinesthetics*". She perceived that she had "*a lot more freedom as far as how you could assess the kids*" at that school because of their philosophy that "*fairness was giving each child what they needed, not assessing them all the same*" (Pre: 208-209). Penny left the private school for her current school system because she "*had an ethical conflict going on internally*" due to perceived pressure from parents to pass students regardless of their actual performance. She perceived that her current school system would have a better salary, benefits, "*professional support*" and she would be rid of the "*internal conflict*".

Penny sees herself as an "*approachable*" teacher who spends a lot time building rapport with her students. She indicated that she loves her job because she loves kids, and finds enjoyment in the different experiences she has with her students throughout the day. She especially enjoys reading positive notes from her students and feels pride when they overcome their circumstances or want to pursue higher education.

Penny teaches at one of the district's lower socioeconomic schools. She expressed sadness that her students were being compared with others around the district with better home lives, but perceives that she is very qualified to help her students. She said, "*I otherwise feel like I could provide everything for them that I need to for them to be successful*" (Pre: 244-245). She also perceives efficacy with her classroom management

skills.

Penny perceives that her students' struggles are her own, thus she feels a great deal of responsibility to help them achieve success. She spends a lot of time tutoring her students after school hours, and seeks out experiences that will help her promote a love of learning and love of science in her classroom. Even though she "*hate[s] to just lecture*", she perceives that often has to do so in order to cover the curriculum prior to the SOL. She said, "*I think I enjoy the time after SOL much more than I do during the year*" (Pre: 88-89) because she is able to branch out from her curriculum and do things that she feels are more interesting to her students.

Penny is unsure of her future in teaching. Although she says that she "*loves*" it, she has "*considered doing other things*". She finds that her thoughts at the end of the school year tend to be negative toward continuing to teach, saying, "*towards the end of the year, it can get very...it's work for sure*" (Pre: 83-84). After the summer off, however, she feels that she can continue to teach another year. She thinks that this a common issue for teachers, calling it, "*the cycle of the life of a teacher*".

Personal epistemology. Penny believes that the constraints associated with the SOL necessitate her adopting a lecture style of teaching sometimes. She said, "*you just have to have some of those days in order to get through so much information before the SOL*" (Pre: 92-93). Penny believes that her students enjoy lab and computer work more than other work in class. She believes that these types of experiences allow her to see her students in a different light because they get "*excited about learning*". While she does labs throughout the school year, she believes that her students enjoy the labs they do after the SOL tests more, even when they are covering similar topics. She attributes this

primarily to student choice, saying, “...*they have a choice in what we want to do next as opposed to me being like, here's stoichiometry*” (Pre: 116-117). She also believes that her students get excited when they are able to “*divert from the curriculum*”.

Penny believes that a “*significant*” number of her students struggle with algebraic skills such as isolating variables, and reading comprehension. Although she believes that this can “*hold back a class*”, she also believes that she cannot take class time for remediation. This leads her to offer tutoring after school in order to better meet her students' needs. She believes that her students should attend these sessions when she advises them to if they “*even want a little hope to be successful*”. Penny also believes that her students are “*very needy*”, saying, “...*things they could answer for themselves, they're calling my name, sometimes 5 times in 30 seconds*” (Pre: 291-292).

Perceived purpose. Penny's perceived overarching purpose is student success, which she says is not gauged by just one thing, like a test. Rather, she sees success as being based on each student's goals and needs. She hopes to help students succeed while also creating an environment that focuses on building excitement about the process of learning in general. She said:

“I think that the kids having opportunities to be successful and then being successful and getting...not only knowing the material, where they've grown in their knowledge, but they're excited about learning also; they feel successful also, like they could do anything.” (Pre: 136-139)

To that end, Penny's goal seems to try to create an active, student-centered learning environment focused on choice and students “*actually doing things instead of just kind of sitting*”. She wants her classes to feel “*like a family*” that supports one another and for her students to come to her when they are experiencing problems. Another goal Penny has is to cover the curriculum prior to the SOL.

Penny's goals for the PD institute include gaining more strategies for her “*teacher toolbox*”. She wants her students to develop a love for learning and for science, and she says that she is willing to implement anything that will help facilitate this. She is also looking for ways to enable her students to be more autonomous learners, though she does not seem to have a firm idea of what this might look like. Her goal for herself is to know that she is making “*a difference*”.

Action possibilities. Penny tries to create opportunities for her students to “*really get to like dive in and learn on their own*”. However, she finds that student autonomy is an issue. While she used to feel that part of her job was to walk them through everything, she has shifted her approach from helping by assisting to trying to facilitate them to take steps on their own. She said:

“And I'll tell them, you know, it used to be that I was like, oh I need to be helpful, I need to be a good teacher, but now I'm just like, you can do this, you can do it on your own. I've given you all the tools that you need to be successful” (Pre: 292-294).

As previously mentioned, Penny finds that her post-SOL time with students is more enjoyable. She gave several examples of how her labs differed pre- to post-SOL. The post-SOL labs seemed to include more of a focus on students doing, creating, and having choices. She said:

“We do an alloy and copper/zinc lab where they get to take a copper penny and turn it into brass. We do a polymer lab where they actually get to make a polymer. We call it the slime lab...I do a titration. We've talked about titrations before but there's just not enough time to get it in before the SOL. But after the SOL, I do a titration with vitamin C where they get to use the burettes and they get to use the phenothaline indicator and it changes into a pink. It's just the hands-on, fun stuff where they're still learning but it's just more exciting for them” (Pre: 100-105).

Penny recently participated in a PD initiative emphasizing field investigation and inquiry-based learning. Based on that experience, she developed an activity for the

beginning of the school year in which her students designed their own experiments. This included hypothesizing and identifying dependent and independent variables. She spoke very highly of the results, saying that her students did “*really well*”, and that they were “*excited*”. However, even with the success of that experience, it seemed as though that type of activity had not been repeated or extended upon as the school year progressed.

Penny also discussed her assessment practices. While she mentioned tests and quizzes, Penny focused the discussion more on formative assessment tools such as exit tickets and simulation-style software that allows students to manipulate and interact with concepts. Her goal of developing a “*safe environment*” has led her to be able to do formative assessments in which she can gauge student understanding as well as comfort level. She also continually strives to meet her students’ remediation needs by staying after school for tutoring three times a week.

Alignment. Penny demonstrated alignment in several areas. Her self-perception as an “*approachable*” teacher who loves her students aligns with her goal of creating a safe learning environment with a family atmosphere and her practice of formatively assessing students in order to gauge their level of understanding and comfort. While she does place some focus on the end-products associated with her course, she also seems to want her students to learn to enjoy the process of learning and to feel that they can learn anything. This aligns with her belief and desire that her students feel comfortable in the environment she has created and her hope that students will come to her when they experience problems. Her perception that her students’ struggles are her own aligns with her goals of wanting students to know the material, grow in their knowledge, feel excited about learning, and feel successful. This further aligns with her practice of offering after

school tutoring.

Penny values a more student-centered, inquiry-based approach to teaching. She believes that this type of instruction allows her to see her students in a different light because they are actually “*doing things*” and that both she and they find the class more enjoyable. However, she also believes that the pressure to cover the material prior to the SOL test forces her to adopt a direct-instruction approach to teaching more often than she would like. These perceptions and beliefs align with Penny’s practice of doing post-SOL labs that are more “*hands-on, fun stuff where they’re still learning but it’s just more exciting for them*” (Pre: 104-105).

Summary. Penny entered the PD Institute with self-perceptions as an approachable, student-oriented teacher who loves teaching and cares deeply about the success of her students. To that end, she attempts to create a safe learning environment, perceives that her students’ struggles are her own, and spends a great deal of time remediating through after school tutoring. While she believes that her students respond better to and enjoy a more hands-on learning experience, she feels pressured to cover material prior to the SOL, which causes her to do a lot of direct instruction. She is hoping to gain more strategies that would help her instill a love of science, learning, and autonomy in her students.

Mid-Institute Summary

Self-perceptions as a Learner. Penny was “*pleasantly surprised*” with the first week of the PD Institute. She expressed excitement about her group being able to design their own experiment, which she said she had never actually done, even in college. She perceived that the process of developing their own field investigation was “*grueling*”;

however, she felt that the group got a lot out of it. Penny said she was reminded of “*what it’s like to be a student again, what it’s like to be in the learning process*” (Mid: 18-19), and that “*it’s been so long since I’ve been the student*”. She found it meaningful to meet other people, including the scientists and teachers from other schools as well as “*getting to work with your co-workers in a different way*”. She was particularly impressed by how the scientists responded to her group’s questions, which was by asking additional questions rather than giving answers. She felt that this coupled with time allowed her group to “*kind of explore on our own and come about the answer ourselves*”, which she found to be very beneficial. Penny perceived that her group was able to “*take ownership*” of their field study, which led to them learning “*so much more*”. She said, “[w]hen we got out into the field, it was our experiment, you know...this is our project, our thing” (Mid: 34-35).

Penny felt that executing the data collection portion of her group’s experimental design was “*extremely challenging*” due to the muddy condition of the site. She said that it “*took everything we had*” to collect the samples. They ended up abandoning some of their planned data collection such as longitude and latitude. However rough the experience may have been though, Penny’s perception was that her group was “*in it together*”. She said that the experience was “*so much fun*”, and reminded her that “*learning can be fun*”.

Penny perceived that the Vernier LabQuests training and work was also very beneficial to her. While she had been to “*several*” professional development training sessions for the LabQuests, she had never felt “*confident*” in using them, thus she had never tried to implement them with her students. She related her learning experience with

the LabQuests to that of developing the field study, saying that her group was allowed to “*kind of figure it out on our own*”, but with enough time and an experienced person there to help or “*validate*”, if needed. Although she experienced some frustration with calibrating the probes, she felt that it was “*such a good learning experience*” because her group was then able to use the LabQuests during their data analysis.

Self-perceptions as a Teacher. Penny perceived that her experience designing and implementing the field study had given her “*so much more confidence*” facilitating this type of activity with her students. She further perceived that she would be able to use the LabQuests with her students, and is “*really excited*” about implementing them in her classroom. She perceived that the connections she made will be very helpful in her teaching because she feels “*a great deal of support*”. The first week of the PD Institute left her with the perception that she could reach out to the teachers and college faculty she has gotten to know to ask for advice or help. She said:

“To have that team behind you that, hey, this is what we’re about, hey, this is what we want to do, like, we’re here to help, just give us a call or email if you need anything, is really important to me.” (Mid: 164-165)

Although Penny felt very excited and supported, she also acknowledged perceived challenges associated with trying to implement a more inquiry-based curriculum. In particular, she feels that there will be pressures associated with time based on her prior experiences. She discussed how her plans have gotten pushed to the side in the past, saying:

“...but once this school year gets started it’s like, oh my goodness, we’re barely getting through acids and bases before the SOL gets there. I mean, I skim over neutralization, reactions, and titrations and it’s like what starts out as us having all these hopes and dreams and goals of doing things differently and being facilitators quickly gets overtaken with, well, we’ve gotta get through this. Let’s get that PowerPoint, let’s get that worksheet, let’s get them practicing, and you’re

back into your old routine.” (Mid: 195-199)

Penny said that her experiences in the PD were making her “*reevaluate my teaching philosophy, so to speak, on what’s more important*”. She realized how much the pressure of the SOL affects her teaching. While she perceives that many of the activities she implements are “*student-centered*”, she also said, “*I feel like as much as I try to make the students the center of my lesson planning, time is still the one that overtakes everything*” (Mid: 215-217).

Integration of Self-perceptions within Roles. Penny’s perceptions as a learner and teacher show a great deal of integration. She perceived that the PD experience placed her in the role of being a “*student again*”. She felt supported in her role as a student, which may have led to her perception that she would have a support network in place for trying experiences similar to this in her classroom. She expressed feelings of ownership for her group’s project, and was reminded that “*learning can be fun*”. She connected this to her teaching by saying that she tries to act as a facilitator and make her lessons “*student-centered*”. However, she acknowledged the pressure she feels from the SOL, which causes her to go back into her “*old routine*”.

While Penny felt ownership for her project and perceived that her group learned “*so much more*” because of the way the field study was facilitated, she was struggling with perceived issues regarding time constraints and pacing. This is causing some misalignment between her perceptions as a learner and teacher. However, she is making the connection that the benefits of doing a field investigation outweigh the time needed to do one.

Personal epistemology as a Learner. Penny believes that the way in which the PD

was set up allowed for better learning. She believes that having the ability to try something, perhaps fail, and then adapt and try again was a much more powerful learning experience than being told what and how to do something. She called the experience “*opportunities for growth*”. Penny also believes that working as a team was beneficial. She said, “*working in a team and doing things together is so much more beneficial to the learning process because we could bounce ideas off of each other*” (Mid: 77-78). She believes that teamwork, adaptability, and resilience are part of 21st century skills, and believes that it was very useful for her to have gone through that type of process with her group. She believes that being in a team and being around the scientists created a very supportive environment.

Personal epistemology as a Teacher. Penny left the first week of the PD believing that her students needed to be doing work similar to what she had just experienced. She said, “*we’ve gotta get the kids out into the field; we’ve gotta get these kids designing their own experiments, like there’s so many great benefits to them going through this process*” (Mid: 191-193). She believes a field study would allow her students to learn the same 21st century skills she did, including autonomy, teamwork, adaptability, and resilience, which she believes would help them succeed in the future. She also believes that letting her students “*kind of explore*” and not directly answer questions would be beneficial because then they would figure out the answers their own questions. She is “*reevaluating*” her teaching philosophy, and asking herself questions about what is more important, such as, “*is it spoon feeding the information so that it all gets in their brains before the SOL or is it...?*” (Mid: 213). While Penny believes strongly that her students should be designing experiments and doing fieldwork, she also discussed her belief that time is a “*real issue*”

for all teachers who have an SOL test. She believes that, “*what drives our lesson planning is that we have this much material to get through in this amount of time*” (Mid: 184-185).

Penny also believes that there is always a “*learning curve*” associated with trying new things. So when thinking about implementing a PD-type activity with her students, she is concerned with getting her students through the learning curve with the LabQuests. One of her group members commented that he could not do a field study with students because of the potential for misbehavior. However, Penny believes that this would not be an issue for her because of the subject she teaches, saying, “*thankfully I teach chemistry, so I get a lot of the students who are more academically focused*”.

Penny believes that having a “*team environment*” and feeling supported by both her group and the scientists was an important part of her experience at the PD. She is hoping to plan more with the other chemistry teachers at her school as well as the members of her PD group, however she believes that, “*the year just goes by so fast and everybody just gets so busy*” that co-planning is not likely to happen.

Integration of Personal Epistemology within Roles. Penny's beliefs regarding how great the learning experience associated with the PD was for her integrate with her belief that a similar experience would be beneficial for her students. Penny is beginning to question her teaching philosophy and is experiencing a shift in her beliefs about what is appropriate for her students. Her beliefs regarding time and its effect on teaching, however, are causing some misalignment in her belief system. She recognizes that there is an issue, and seems to believe that she should change her practices, however, she also believes that making changes is a difficult task due to time constraints.

Perceived purpose as a Learner. Penny perceived that the purpose of the first week of the PD was to allow each group to design their own field study, which included time to explore, refine, and take ownership. This ownership was very important to her, leaving her feeling that if something broke, the group had to fix it. If they were not sure of the next steps to take, the group had to figure it out. She appreciated that the scientists let her group “*kind of figure it out on our own*” with them being present if the group needed to ask a question. One of Penny’s goals was to learn how to use the LabQuests so she can then use them with her students. She said:

“I really wanted to accomplish that because I really feel like we could do so many things with Boyle’s Law or pH or all of those things...I mean, I could use those things in class so much if I just felt confident enough to do it” (Mid: 227-229).

Penny perceived that the purpose of being working in a team was to allow them to “*bounce ideas off of each other*”. After data collection, her group then focused on trying to “*make sense*” of their data in an unbiased fashion. They wanted to see if their hypothesis was correct. Their new goal is to take what they have learned and do additional data collection the following week and perhaps add to their conclusions.

Perceived purpose as a Teacher. Penny’s experiences with designing and carrying out her own field study left her with the perceived purpose as a teacher of giving her students a similar experience. She left the first week of the PD Institute with the goal of “*allowing kids to design their own experiments*”. Penny perceives that the purpose of students designing their own experiments is, “*not only to learn, but ultimately, it builds character. They learn to collaborate and be resilient and be adaptable and be those things that will help them be more successful in the future*” (Mid: 178-180). While she had some previous success with a smaller version of this style of activity, she now feels

more confident with facilitating a similar experience herself.

Penny is conflicted due to her other perceived purpose, which is to “*get that information to the kids before the SOL*”. She is trying to focus more on activities that will “*build and make sense to the student*” rather than “*spoon feeding*” information. She says that she has been trying to make the students the “*center*” of her lesson planning, but that she feels a lot of pressure from the SOL. She left the first week of the PD Institute feeling like she should spend more time focusing on planning what “*would be best for the students*” well as getting covering the required curriculum.

Integration of Perceived Purpose within Roles. Penny's perceived purpose as a learner and teacher show a great deal of integration. Being able to have ownership and explore their field study has left Penny with the perceived purpose of giving her students a similar experience. She felt that her group learned a lot of 21st century skills, and feels that her students would do the same if they were given the opportunity.

Action possibilities as a Learner. Penny worked with her group to design and then execute their field study. They were unable to collect all of the data they wanted due to the muddy conditions at the site. Upon analyzing their data, they found that it was inconclusive. Based on this, Penny's group was planning to go into the field again the following week to collect some additional data, including elevations, latitude, and longitude associated with each of their sample sites.

Action possibilities as a Teacher. Penny said that her experience at the PD was making her “*reevaluate and reflect*” on her teaching philosophy and lesson planning strategies. Based on this, she was beginning to make plans for translating some of her PD experiences back into the classroom. The confidence she gained with using the

LabQuests led her to plan to implement them with her students to look at things such as Boyle's Law or pH. She was also making plans to “*take the time*” to have her students design and conduct a field investigation. If she cannot get a field trip, she is thinking of using the small lake on her school campus. She reiterated this desire a few times, saying, “*I want to do it. I'm going to do it*” (Mid: 276). She was also making plans to collaborate with the other teachers in her group, perhaps with taking the students on a field trip or reviewing and planning for using the LabQuests.

Integration of Action Possibilities within Roles. Penny's action possibilities as a learner and teacher were integrated. Her experiences as a learner translated into her planning as a teacher. She seemed to see the value and importance of what she was doing as a learner, which caused her to want to give her students' similar experiences.

Mid-Alignment. Penny demonstrated a great deal of alignment. Penny said she had never designed and conducted a field study before, and felt that the experience placed in the role of a student again. This led her to make connections between what she was doing and what she would like for her to do. Although she considered herself a “*student-centered*” teacher, she felt that the PD was making her reflect on her teaching philosophy and practices, and she was realizing that her students needed to experience the “*process*” of designing and conducting their own field study. She left the first week of the PD with a strong desire to help her students gain 21st century skills like autonomy and resiliency, which she believes can be accomplished by them developing their own field studies.

Penny also demonstrated some misalignment. While she was hoping to make changes and understood the value of doing so, she was also feeling a lot of pressure from the SOL. Her perceived purpose of preparing students for the test led her to adopt direct

instruction strategies much more often than she would like. She seemed to be struggling with her newly developed beliefs about the value of a PD-like experience and her perceptions and beliefs about the pressure she feels to cover material prior to the SOL and how that affects her teaching. She was beginning to plan changes to her practices regardless of the time-constraints she felt because she saw the value in having her students design and conduct their own field study after having experienced it herself.

Mid-Summary. Penny felt that the first week of the PD placed her in the role of a student again. This led to her altering some of her beliefs about how her students should learn, and was causing her to reflect on her practices and philosophy of teaching. Based on this, she was planning to give her students a similar experience, which she felt would better prepare them for the future than “*spoon feeding*” them information. Penny was also very aware and reflective of some of her current practices and beliefs regarding teaching to the test. While she believed that these practices were wrong, she also felt that the pressures associated with testing could easily prevent her from adopting new practices. However, she was feeling that the benefits of doing a field study outweighed the amount of time it would take to do one.

Post-Institute Summary

Self-perceptions as a Learner. Penny's group went out for a second round of data collection during the second week of the Institute. She perceived that the process went much more smoothly, and that her group had more focus. She said, “...*not only did we go out there with a goal, but it's like we accomplished it so much more quickly than we did originally*” (Post: 37-38). She found value in the process her group went through, which she said included “*trial and error, and reevaluating, and reflecting*”. She perceived that

the “*pitfalls*” her group experienced actually led them to better understandings. Penny also reiterated her perception that the scientists answering her group's questions with additional questions was useful to her because it allowed her group to fully experience the process of learning for themselves.

Penny also discussed her perceptions of putting together the poster and presenting to her peers. She said she felt like a “*kid again*” because she was reminded of challenges associated with time management, meeting deadlines, and wanting to compare well to peers. However, she found the process to be very useful, and ended up feeling confident in her knowledge. She said, “[a]nd then to talk about it I realized, oh my goodness, I actually know a little bit about this” (Post: 105-106). Penny perceived that her group worked very well together. She felt like each member of the group brought their “*strengths to the table*”, which allowed her group to experience success together. She reiterated her perception that collaborating with other teachers was very meaningful to her.

Self-perceptions as a Teacher. Penny found the PD experience to be an “*excellent opportunity for professional growth*”. She perceived that the PD experience “*reinforced*” that she was doing a lot of things right. However, she also felt that it, “*...kind of illuminated those aspects in my teaching that definitely need to be changed or that have gone on for too long without my giving it the attention that it needs*” (Post: 336-337). She expressed excitement to begin making some changes, saying, “*I know the way I want to be in the classroom*”. She also expressed a desire to “*get better habits*”, including questioning, assessment, and inquiry-based learning. She felt prepared to start making some changes, saying:

"I love coming up with new ways of doing things and designing activities and I really love that piece of teaching. And I really love implementing them in the class. It's not so fun when they don't go according to plan, but it's so cool when they do! And then all it takes is doing it once and you're like, I'm going to do this all the time!" (Post: 374-377)

Penny perceived that several aspects of the second week of the PD were "eye opening" for her as a teacher. She found the assessment discussions very useful, saying that she was unaware that scientific investigation scores were down across the district. She was also reminded of best practice strategies she should continue to incorporate rather than just when her school was on that "bandwagon".

Penny expressed her perception that when she began teaching at her current school, she felt as though she needed to follow the status quo, which was to assess using multiple choice tests with a few short answer questions included. Her focus in recent years has been to shift these tests onto an online platform. However, she has begun to reflect on her assessments and question their value. She would like to make some changes to her assessments. She perceives that the upcoming school year will be a good time to begin making these changes because she is a more seasoned teacher, and there will be new chemistry teachers joining the school.

Integration of Self-perceptions within Roles. Penny's self-perceptions as a learner and a teacher were very integrated at the end of the PD Institute. Her perception that the field study experience made her feel like a student again integrated with her desire to begin making some changes in her classroom. She left the Institute wanting to give her students experiences that would be more in line with her perceptions of the PD learning experience. Penny's perception of her assessments demonstrates some potential misalignment. When she entered her current school, she went with the status quo

assessments. Although she questioned their value, she felt that she could not do anything about them due to her status as a new teacher. She now perceives that she has enough seniority to begin making changes.

Personal epistemology as a Learner. Penny was mostly focused on her role as teacher; however, she did express some beliefs regarding group work. She believes that all teachers like to be in control, which led to some interesting group dynamics at the PD. However, she also believes that the team environment in general was very conducive to learning. She believes that the field study allowed her to better understand scientific investigation because they were “*diving into it*” and “*actually experiencing it to its full extent*”.

Personal epistemology as a Teacher. Penny's beliefs about teaching and students came out more during the post-institute interview when discussing her experiences with the PD. She expressed the belief that “*every experience is valuable*”. She discussed this in light of the problems her group encountered with the field study, but connected it to her classroom by sharing her belief that teachers go into lessons with learning objectives in mind, and when something goes wrong and those objectives are not met, they sometimes consider the lesson a failure. However, she believes that this can be a “*learning experience and an even more valuable one at that*” due to how the process contributes to overall learning. She said:

“I think process actually leads to a better product. Even if there are still unanswered questions, the process has allowed you to gain so much more than had the teacher said, here these are your supplies, this is the procedure, do it.”
(Post: 79-81)

Penny reiterated her belief that the scientists answering questions with a question is a useful practice. She expressed frustration with the way her students, “*ask me and they*

ask me and they ask me again and then finally I just give the answer". She believes that this is a *"terrible way to teach"*. She also believes that she gives her students *"everything that they need to be successful"*, but rather than try everything they know to do before asking her for help, they want her to show them *"exactly how to do it"*. She further believes that learning experiences like that are less valuable *"because they start to depend on me"*. She believes that this *"learned helplessness"* is getting worse each year.

Learning about the Cornerstone Assessments led to Penny expressing some beliefs regarding student prior knowledge. She was informed that students score poorly on scientific investigation portions of the SOL. She considered this as a surprise based on the annoyed way her students respond to having to re-learn about scientific investigation each year. But she now believes that her students respond that way because, *"they're seeing it as it's just this simple steps"* as opposed to her experience with it at the PD.

Penny believes that it is difficult to change teachers' practices because they *"get used to"* what they have done and then feel comfortable with that. She believes that changing some of her practices will be difficult due to constraints on time and her energy level. She also acknowledges that she will need to *"be OK"* with things not being perfect. She believes that the *"challenge"* of changing some of her practices will be in doing it the first time, *"because when it goes well you want to do it again and again and before you know it your bad habits become better habits"* (Post: 379-380).

Integration of Personal Epistemology within Roles. Penny demonstrated integration with her beliefs regarding the field study as actual scientific investigation. While it was surprising to learn that her students struggle with this aspect of testing, upon reflection, she determined that it was because they are only getting to see scientific

investigation as “*simple steps*” rather than the process she was involved in. Penny also demonstrated integration in her beliefs about answering questions with questions, like she experienced at the PD, and her struggle with student autonomy. She believes that engaging her students in more authentic experiences will help them become more autonomous. Finally, the PD learning experience has left Penny feeling that she should make changes to her practices. This also led to her expressing some beliefs regarding generalized teacher change as well as her personal journey.

Perceived purpose as a Learner. Penny's group went back into the field to collect additional data because they “*weren't really finding a relationship between the two variables that we were investigating*”. Based on her group's difficulties with their field study, Penny's perceived purpose as a learner was to “*adapt*”, “*change*”, and “*reevaluate*” their design and hypothesis. The problems they experienced also caused her to do more research and learn more about their topic, which led her to feel that the process her group went through was much more valuable than if they had been told what to do. Penny found that these experiences as well as the poster development and presentation placed her in the role of a student. She found that talking about their poster and experience actually led her to “*realize*” how much knowledge she had gained from the process.

Perceived purpose as a Teacher. Penny leaves the PD Institute with a perceived purpose of developing “*better habits*”. A goal associated with this is building autonomy within her students. She would like for her students to go back through their notes, think about class discussions, and try to solve problems on their own. She also wants them to “*understand that they're not going to get it right away*”, but to persevere in their learning and figure things out for themselves. An associated “*better habits*” goal is to implement

an inquiry-based learning activity in which students design and carry out a field investigation. Another associated goal is to better her questioning techniques to be more in line with how the scientists at the PD used questions to answer her questions.

Penny would like to alter her assessment practices. She said, *“I want to better my assessments and I also want to actually use that information to adjust my teaching”*.

When discussing this goal, she mentioned her time spent teaching at the private school for students with learning disabilities, giftedness, or both. She perceives that she had *“more freedom”* to do alternative assessments there, but thinks that she will have more freedom to alter her assessments this year because of her seniority at her school. She has begun to question her existing assessments with the purpose of determining answers to questions such as, *“...is this a really good test? Is this testing them on what they should know? Is the language that I'm using for their level? Is it testing what I taught them?”* (Post: 283-284). Her ultimate goal associated with altering her assessment practices is to use the data to *“adjust”* her practices.

Penny also has the perceived purpose of learning more about her students' strengths, weaknesses, and interests. After learning that scientific investigation is an issue for her students on tests, Penny said, *“...it gives me more of an incentive to actually spend a little bit more time on that and to invest a little bit more in that area to improve student success”* (Post: 22-23). She's also hoping to use the information she finds to better group her students, which she feels will lead to more success.

Finally, Penny has the perceived purpose of bringing an *“awareness”* of NOS to her students. She found taking the time to *“dissect”* each part of the NOS useful, particularly to, *“...listen to the dialogue and to really understand our place as humans but*

also as scientists and teachers in bringing those NOS principles into the classroom”

(Post: 126-128).

Integration of Perceived Purpose within Roles. Penny leaves the PD with quite a bit of integration in her perceived purpose as a learner and teacher. Her learning experiences at the PD have led her to reflect on her teaching, and she leaves with the perceived purpose of altering some of her practices in order to develop “*better habits*”. Ultimately, she would like for her students to become more autonomous learners, similar to the way in which her group was able to learn at the PD. “*Better habits*” associated with this goal are to alter her questioning techniques to be more in line with the types she experienced at the PD. She would also like to improve her assessments, both to better serve her students, and to use the data to adjust her practices. Finally, Penny would like for her students to get to experience scientific investigation in a more authentic manner, similar to her experiences at the PD.

Action possibilities as a Learner. Penny's group went back into the field during the second week of the PD to collect additional data because their original data was inconclusive. While they were able to get the additional data, they were still left with inconclusive results. Her group also worked together to design and present a poster about their field study.

Action possibilities as a Teacher. Penny said that she made a “*huge list*” of things she wanted to do in the classroom based on her PD experience. This included having the students design and carry out their own scientific investigation, using the LabQuests, and having the students work in groups that she purposefully designs. She is also looking to add some NOS activities such as an observation versus inquiry activity or something

pertaining to creativity in science.

The thing Penny talked the most about however, was working toward her students becoming more autonomous. When discussing this, she related her past practices, which included helping them any time they asked. She has since begun to follow up their questions with questions and help them realize that they need to consult their notes and think about things before coming to her with a question. She has plans to continue to refine her questioning techniques, and hopes that providing her students with a more inquiry-based classroom will further their autonomy.

Integration of Action Possibilities within Roles. Penny demonstrated integration between what she was experiencing at the PD and what she was hoping to bring back to the classroom for her students. She was planning to give her students opportunities to design and implement their own scientific investigation based on her experiences. She was hoping that these types of experiences would help her students become more autonomous.

Post-Alignment. Penny again demonstrated a great deal of alignment. Her experiences with the process of designing, implementing, and then reporting out on her field study led her to want to make changes in her classroom. She viewed the PD as an “*excellent opportunity for professional growth*”, and seemed to feel that it was helping her to better align her beliefs with her practices. Penny said that “*every experience is valuable*”, even failures, and was planning to focus more on bringing that type of process-oriented approach into her classroom. Although Penny expressed challenges associated with trying to change her practices, she also outlined the benefits, and left the PD feeling like the benefits definitely outweighed the challenges.

Post-Summary. Penny's experiences during the second week of the PD reiterated her beliefs and plans for making changes to her practices that she originally discussed at the mid-interview. She was focused on process-oriented approaches to learning that she believed would better serve her students. She was also aware of resistance to change, both on a personal and a general level, and was making plans to ensure that she would be able to successfully change some of her practices.

Overall Change. Penny's experiences with the field study and feeling like a student again led her to want to give her students similar experiences. Although she had previously tried having her students design their own experiment and experienced success, she had not continued to facilitate those types of activities with her students. Going through the process of designing and carrying out her own field study allowed her to gain personal experience with the benefits, which seemed to alter her beliefs regarding how students should be learning. It also heightened conflicts with needing to cover material for SOL, time issues, as well as assessment practices. She left the PD feeling more confident and motivated to make some changes in her classroom based on newly developed beliefs and goals.

Penny seemed to enter the PD with a growth-oriented mindset. Her focus was on a process-oriented approach that would help her students love learning and feel like they could learn anything. That approach was strengthened and refined during the PD due to her personal experiences with the field study and interactions with the scientists. An example of this was the connections Penny made between her students' difficulties with scientific investigation and their very linear understanding of it. She believed that this was caused by them seeing scientific investigation as "*simple steps*" rather than "*actually*

experiencing it to its full extent” as she did through the field study. She was planning to alter her practices to help her students experience scientific investigation as she had at the PD.

Penny’s beliefs regarding how the SOL impacts her teaching were mentioned during the pre-institute interview as a definite constraint. Although she continued with that theme in both the mid- and post-interviews, there was a shift in how she discussed the issue. While her comments in the pre-interview seemed to indicate that she knew she should change her practices, she also felt very constrained by the SOL, perhaps to the point of feeling that she could not change her practices. At the mid-interview, she again knew that she should change her practices, but was able to give many reasons why it would be a good idea. She was also beginning to make plans to do so, even though she acknowledged perceived constraints. Finally, at the post-interview, it seemed to be a foregone conclusion that she would change her practices because she understood the benefits and felt that they outweighed the cost of time.

Overall Alignment. Penny demonstrated alignment in many areas. Her perceptions and beliefs of the benefits of a more authentic, process-oriented style of learning aligned as she went through the PD. Her goals of giving students opportunities to grow, experience success, and feel excited about learning aligned with her belief that students should be doing more in their learning. She also acknowledged potential issues related to time and testing, but felt that the benefits of “*taking the time*” to allow for a process-oriented approach outweighed the costs. Lastly, her goal of helping her students become more autonomous became more aligned with her beliefs about the benefits of designing scientific investigations and her plans to create those opportunities for her students.

Penny was also easily able to connect her roles as a learner and as a teacher. She came into the PD with a desire to learn and a willingness to change. She left the PD with a more process-oriented approach to learning and teaching, concrete and abstract ideas of changes she wanted to make, as well as an understanding that those changes would take time.

Overall Summary. Penny entered the PD seeking ways to enable her students to be more autonomous learners, to love learning, and to experience growth. Her PD experience seemed to do a few important things for her. First, it educated her in an authentic learning context. This led her altering some of her perceptions and beliefs surrounding learning. Finally, she felt driven to make changes in her classroom and was confident in her ability to do so, even given the constraints she felt from the SOL.

Professional Identity Interviews Summary: Tony

Tony is a 29-year-old man with two years of teaching experience. He has bachelor's degrees in chemistry and music, certification in physics, and a masters' degree in education. He was teaching chemistry at the time of the interviews, but was representing physics at the PD Institute. He chose to attend the PD because of interest and availability. At the time of the interview, Tony had just returned from overseas trips with high school students during which they visited developing nations and did work such as building sidewalks.

Pre-Institute Summary

Self-perceptions. Tony perceives that he did not take a “*typical*” route to becoming a teacher. He was considering becoming a doctor, but in his freshman year of

high school, he realized that biology “*didn’t click*”, and “*realized that I didn’t actually want to be a doctor because of the bio aspect*” (Pre: 19-20). He took chemistry during his sophomore year and “*it clicked immediately*”. He perceives that he “*struggled*” in chemistry and physics but he found that those courses were “*always understandable and very logical*”. He perceives that his struggles came from having a “*typical high school boy work mentality, that if it didn’t come immediately, then I didn’t want to do it*” (Pre: 65-66). Although his “*math background was really able to carry a lot*”, he found that taking chemistry and physics courses led him to learn “*a lot about how I needed to work*”, which led to him “*actually do the work and maybe sometimes even do extra work*” (Pre: 69-70). Tony majored in chemistry and music at college, saying that both were “*simple*” and “*logical*” to him.

While at college, Tony spent summer and winter breaks as an intern for an analytical methods laboratory, where he got the opportunity to analyze data and test pharmaceuticals. This experience led him to realize that he did not want to be in a lab, saying that “*[i]t was a big grind. There was not much difference in what happens on a daily basis. There was not much human interaction*” (Pre: 85-86). After he finished college, Tony began working with youth and college students by running after school, weekend, and outreach programs. He found that he was drawn to work with kids because he perceived it as a “*fulfilling experience*”. Tony got married and his wife got a job in his current city. He then pursued his Master’s degree in education and began teaching.

Tony perceives that it would be “*easy*” for him to “*just flat talk at them and hand out problem sets, but that’s not why I’m in the place I am*” (Pre: 258). Rather, he enjoys the “*daily banter*” of working with high school students, including the short

conversations he has with students while the class is getting ready for the day. He further enjoys seeing *“how they start to change their thinking”* and seeing *“those connections being made”* during classes. Tony perceives that he is able to *“create those relationships”* that enable students to feel safe and comfortable in taking risks.

Tony assumes that all of his students are going to college. He perceives that this assumption comes from his background in a family in which not going to college was *“not an option”*. He also attributes this assumption to the school and the subject he teaches, which is not required for graduation. Although his students' responses to his assumption are *“typically”* to nod in agreement, he has also had students say *“You're the first person who's ever said that”* (Pre: 218). He perceives that it is *“incredibly fulfilling and really important”* to open up *“the possibility of that next level”* to some of his students.

Tony co-plans with another chemistry teacher at his school who is also coming to the PD. They *“split the workload and split the planning process”*, which makes him feel as though he is not *“on an island on our own”*. He also likes getting *“immediate feedback over the course of the day”* because they discuss the lessons in between classes. Although there is a third teacher who plans and uses *“common assessments”*, the co-planning occurs only between the two of them. Tony perceives that this is because *“it's just the way we think”*. He feels supported by his assistant principal, who allows he and the other chemistry teacher to turn things in together. However, Tony perceives that his planning process is *“one of my biggest stumbling blocks”*. He tends to *“over plan”* his lessons because he feels that there is *“too much to do”*. He wonders if part of the problem might be his *“delivery”* as well, but says, *“I always feel like I wish I got another 5 minutes”*

(Pre: 230).

Tony seems to perceive himself as being different from other teachers because he comes with “*some very interesting experience*” and did not follow a “*typical way*” to get into teaching. He said, “*I didn’t undergrad major in ed or science and ed and then just knew it was me. It was figuring it out, which was very interesting*” (Pre: 56-58). He perceives that he would not have difficulty teaching other subjects. He said, “*if I were to walk into another classroom, I think I could pick up, with the exception of probably a foreign language, I think I could pick up most things and just teach it with about 10-15 minutes*” (Pre: 308-310).

Tony sees himself as a generalist. This is based on his perception that he teaches students first and foremost. He said, “*I teach students chemistry; I don’t teach chemistry to students*” (Pre: 188-189). However, he also perceives that he could easily become a specialist. He said, “*I understand that I carry an ability that not everyone does, so I see how it would be easy to turn the path into specialist, but the reason I’m in the classroom is because I’m a generalist*” (Pre: 298-300). He wants to go back to school to get a PhD and would like to “*adjunct somewhere with that degree*”. Although he has “*looked at administration*”, he is currently unsure if that is a pathway he wants to pursue. Ultimately, he enjoys the classroom, saying, “*I see myself in the classroom. I found a huge joy in what I do and I do come home happy every day. Even the bad days are still good days*” (Pre: 262-263). He finds many portions of his job “*really inspiring and really fulfilling*”. He said, “*I work probably more hours than most people, and I come home happy and my wife is a little jealous*” (Pre: 59-60).

Personal epistemology. Tony believes that “*passing a minimum proficiency test is*

really not worth celebrating” (Pre: 156). Rather, he believes that it is much more meaningful to be able to “*come up with surface answers as well as deeper meaning and the value of being able to understand why you got to those answers*” (Pre: 159-160).

Tony believes that students can pass his class if they show work. This is based on his belief that “*the work is more important than the answer*” because, “*getting the right answer, as great as it is, is essentially a number guess. But being able to design the work shows the logic in the thought*” (Pre: 169-170). He believes that when students feel safe, they are able to “*take risks in the subject*”. He gave an example of the types of risks students might take, saying that it could be:

“just taking the risk to start a problem and not knowing where they actually are going, but if they follow it through and follow their work that they know that it eventually will work out, that a different, more interesting problem might come up” (Pre: 201-203).

He believes that the process of developing a safe space for students to take risks starts with “*growing connections, growing interpersonal relationships*”.

Tony believes that students will not respond to his teaching unless they see the relevance of it to their future. He said,

“I can talk all day at them about chemistry and even with the passion I have with the subject, if they don't believe that they will be scientists or chemists or have any reason to learn this, then that won't...there just won't be a positive result” (Pre: 190-192).

He believes that “*open[ing] the doors*” for students to see the importance of chemistry and “*how it clicks with them*” is what actually creates an environment conducive to learning. He believes that he gets more from his students when he asks “*direct questions*” and “*bigger picture questions*” and then allows “*time to interact with each other as well as interact with me*” (Pre: 152). He also believes that he is better able to see his students’

personalities when they do labs and interact. He also believes that “*seeing where typical student mistakes occur is really interesting because it defines how people learn*” (Pre: 148-149).

Tony believes that chemistry is “*highly math based*”. He believes that some of his students do not have the math skills necessary for his course. Although his students come into class having taken at least Algebra 2, he does not “*see the number ability*” from some of them. He also believes that his students struggle in different places based on their grade level. He believes that his 12th grade students’ math skills are lower than the 10th – 11th graders he gets in class, however, “*the understanding and the logic process is much further along*” (Pre: 175-176). He believes that this “*essentially flips*” for the 10th graders; their math skills are good, but they are “*still stubborn in what they want to show*”. He also believes that his students come into the course thinking that it will be “*really hard*” because of what their friends have told them. Although he “*understand[s] that college is not the right place for everyone*”, he believes that “*for someone to even take the risk to take chemistry shows something in there*” (Pre: 223).

Tony expressed some beliefs about science and education. He believes that scientific theories often begin in “*art or history or philosophy or creativity and imagination*” rather than “*hard sciences*”. However, he believes that there is a “*lack of connectability between classes*”, which he believes is an “*international issue*”. He said, “*We’re really bad at connecting science to math, science to history, science to philosophy*” (Pre: 238-239). He believes that this lack of connectability is a “*big stumbling block*” and although he “*doesn’t know how directly fixable*” the problem is from where he is at, he believes that “*developing multi-subject collaborations would be a*

way to fix that". He gave the example of using math processes in science and science word problems in math, which he believes would connect a lot of things. However, he believes that connecting the disciplines is "*not becoming a priority*" for a few reasons. First, it does not fit into his district's goals. Second, there is no incentive to work on it, like PDP hours or money. Third, there are many other "*time constraints*" and "*check the boxes*" that teachers "*have to do*". He believes that all of these things cause multi-subject collaborations to be "*pushed down*".

Tony also expressed some beliefs about his supportive assistant principal (AP). He believes that the AP's "*expertise*" is in the classroom. So although the AP might not understand what he teaches, he does understand the importance of it. He believes that the AP's "*encouragement really is important*"

He said that the AP:

"understands the how and the why, not necessarily the what, and I think that allows him to be really good at pushing us to be better because he's not concerned about the subject matter, it's not that he's an expert on it" (Pre: 289-291).

Finally, Tony also expressed the belief that becoming a specialist would take "*probably 3 years of research*". This would involve "*really going through the PhD program and processing into forming your own...and to specialize in it*". It was not clear if he was referring to a specialization in chemistry or education. He also expressed the belief that "*not everyone can teach chemistry*". He based this belief off of experiences with substitute teachers. He believes that they "*sometimes have difficulty with the lesson*" he leaves, including the answers, because "*they can't explain it*".

Perceived purpose. Tony's perceived purpose as a teacher is to prepare his students for their futures. He said, "*I'm not teaching to high school; I'm teaching for the*

future” (Pre: 211-212). Although the short-term goal of his class is to “*pass the SOL*”, his larger goal is to prepare his students for college. He aspires to “*open the doors for them to see how important the subject I teach is or how important it could be*” (Pre: 193-194). Tony wants to have “*true interaction[s]*” with his students and develop “*relationships*”. Another goal Tony has is to see his students’ personalities, “*both in the struggle of grinding out chemistry problems as well as talking about themselves*” (Pre: 137-138). He wants to see his students as people rather than “*just numbers from a test or student ID numbers or names*”.

Tony tries to make his students “*feel comfortable and be able to take risks*” (Pre: 172). Associated goals include getting them to “*think bigger and think deeper*”, “*understand why you got to those answers*”, and be able to “*bring in that next level of thought*”. Ultimately, he would like to be able to “*see their growth*” and to see “*how students can change*”. He tries to “*push them into making a statement in what they believe as opposed to the nod and shake your head*” (Pre: 93-94). His learning experiences involving coming to the understanding that he needed to actually going through the problem sets and do the work lead him to “*try not to over assign work just for the sake of work*” (Pre: 72). He wants his students to do the work in order to learn the material rather than just to “*check the box in the completed assignment category*” (Pre: 73). He also wants his students to drop the “*assumption*” that chemistry is difficult and “*just commit to the time that you’re required to do that*” (Pre: 257).

Tony gave a few more specific examples of goals involving his practices. For example, he discussed doing “*food science*” labs with his students so they can “*check out some of the danger issues as well as add that element of daily life and fun*” (140-141). He

gave an example involving gummy bears and marshmallows that allows students to see “bond angles” and how they change. His ultimate goal with these types of labs seems to be to have students make “connections”.

Tony perceives that the goal of the PD is to develop an “*interdisciplinary concept that could stretch over a student’s high school career*” (Pre: 9-10). His goals for the PD include developing “*further relationships*” with colleagues. His hope is to have a “*stronger collegial community*” both within his school as well as the district. He would also like to leave with a lesson that “*can connect all four years of science*”.

Action possibilities. Tony discussed very few of his actual classroom practices. He mentioned asking students “*bigger picture questions*” and giving them time to “*interact*” with each other and him. He also discussed developing a “*safe space*” where his students can “*take risks*”. He also mentioned “*food science*” labs such as a gummy bear and marshmallow lab for bond angles. He also mentioned his practice of analyzing test data with his students. When doing this, he said, “*I try to not talk throughout the entire class*” (Pre: 149-150) in order to get students to interact with one another and with him. Tony also discussed his practice of co-planning with another chemistry teacher from his school. They split the planning and workload and then meet between classes to determine what they need to modify.

Alignment. Tony demonstrated alignment in several areas. His assumption that all of his students are going to college aligns with his personal background and experiences as well as his purpose of “*teaching for the future*”. This further aligns with his belief that passing the SOL is not worth celebrating and his goal of getting his students to think bigger and deeper. Another one of his goals is for his students to take risks. This goal

aligns with his beliefs about the value of risk taking as well as his practice of trying to develop a classroom in which students can take risks. This further aligns with his desire for and beliefs about interactions with others. He wants his students to have “*true interactions*”, and also desires that for himself. This aligns with his co-planning practices with another chemistry teacher. His past experiences of having to figure out how he needed to work and actually do the work align with his goal for students to grow, change, and learn the material rather than just completing assignments for the grade.

Tony’s practice of using food science for the purpose of adding “*that element of daily life and fun*” and students making connections aligns with his belief that his students need to see the relevance of chemistry to their lives as well as his perception of enjoying seeing students make connections and start to change their thinking.

Summary. Tony entered the PD with conceptions of himself as a generalist who teaches students chemistry rather than chemistry to students. He seems to perceive himself as being different from other teachers because he did not take a “*typical*” route into teaching. He perceives a “*huge joy*” in his job, enjoying the interactions he has with students as well as other teachers. While Tony is focused on his students passing the SOL, he does not consider that to be “*worth celebrating*”. Rather, his goal is to prepare students for college, which he assumes is the path that all of them will take. He is hoping to develop further relationships with colleagues at the PD.

Mid-Institute Summary

Self-perceptions as a Learner. Tony perceived that aspects of the first week of the PD allowed him to put on his “*student hat*”. However, based on his discussions, which are highlighted more later in this section as well as the personal epistemology section, it

seemed that he was thinking of himself as a college student rather than a high school student. He described the experience as “*positive*”, and seemed to enjoy it. He said, “*the hardest part of dipping my toe into the water was right when we started hypothesizing, being able to just go at it and just take the risks. And being around people I trust allowed that to happen*” (Mid: 280-282). He perceived that working with colleagues from his school was “*positive*”. He feels that there is a “*very healthy atmosphere*” at his school. He works very closely with one of his group members, but was less familiar with the other teachers, having only worked with them on small scale departmental things. He felt that it was “*nice to see people in different settings*” (Mid: 383-384). He perceived that his colleagues have “*respect*” for one another and assume that they are at a “*certain advanced level*” based on what they teach. Although they went through a few minutes of “*trying out*” the process of working together, he perceived that the collaboration was “*very fluid from the beginning*” because “*you drop out that first stage of I don’t know how I’m going to be judged because we’re already close as colleagues*” (Pre: 58-59).

Tony’s experiences with the scientists seemed to be positive as well. He perceived that although the scientists “*pushed us to hypothesize more specific*”, they did not “*choose*” the hypothesis for them. He perceived the data collection to be “*fun*”. He felt that although his group “*wound up playing in the mud a little*”, they were very focused. He said:

“so the group I’m in, we have a lot of fun doing what we do, but we’re very aggressive with making sure that we got what we needed to have done quickly, and that time constraint of the field was not really felt. We went during high tide and we needed to make the markings so we went out and did it. We didn’t sit around and twiddle our thumbs and wait and talk, we just went out and did it”
(Mid: 95-99).

Tony perceived that his group “*had the vision*” to collect enough data. Although they may

not know “*how*” they are going to use the data yet, they know that “*it will be important*”. He perceived that they were consistent in their data collection methods, and collected enough data in order to not have to go back into the field the following week.

Tony said that “*it was nice to get back into a lab*”. His group had most recently been working on their “*backend analysis*”, which he felt was “*right in normal life*” from a “*chemistry perspective*”. He perceived that everyone in the group was “*on the same page*” with their instrumentation choices and data analysis techniques. He found the data analysis portion to be meaningful, saying, “*I really like data, so being able to see that data come from raw sample into actual data, being able to figure out what the next process is going to look like is meaningful*” (Mid: 158-159). He elaborated by saying that data analysis is “*very logical to me and it’s very critical thinking, problem solving, as well as creative rather than worksheet filling*” (Mid: 161-162). He found that not having to “*go back to a calculator every time I needed a number*” allowed his group to move quickly through their data analysis. His group worked on data analysis for about four hours, and this amount of time coincided with his perception that it was similar to a lab “*at the undergraduate college level*”.

Ultimately, Tony perceived that the first week of the PD left him with reminders of what he liked and did not like about working in a lab. He said,

“I think it’s bringing it back to, not necessarily why, but how I got started. Being able to have the freedom to hypothesize and be amongst colleagues and amongst similar experiences of backgrounds. I think it is also, it makes me miss the lab setting a little, but it also reminds me why I’m not there in the first place (laughs). So it’s both” (Mid: 232-235).

He was able to “*have access to the instrumentation*” and was “*forced into the grind of post-secondary academia*”. He said, “[*e*]very so often, it’s nice to go back into to both

access to what money can buy and access into being challenged on a journal level" (Mid: 215-217). He also realized that he does not "*remember*" earth science and biology as well he thought. It also "*highlighted*" to him why he is not in an earth science or biology field. Although he enjoys and could see "*how cool it would be*" to be on a boat, he finds that kind of data collection to be "*empty*".

Tony perceived that the concept mapping activity was "*interesting*". He does not organize his thoughts in that way, saying "*I don't write in full sentences. I skip thoughts because of how I think*" (Mid: 13-14). He found himself altering the directions because of this. He said, "*I guess I kind of ignored pieces of the instructions and used the instructions to my benefit*" (Mid: 15-16). He seemed to feel constrained with only having a few colors to use, and would have liked to have had the option of doing it in 3-D.

Self-perceptions as a Teacher. Tony found it meaningful to be able to "*interact with others*" and to know that "*we're not on our own little islands*". He perceived that the PD was a "*safe space*" to explore similarities among colleagues. He felt that the PD experience "*justifies my philosophy of not doing it on my own*" (Mid: 168). He elaborated by saying:

"It allows us to see that the support is there. You don't even have to leave the Intranet to get to all of us. That all of this is so accessible and so proprietary for (school district) that why we don't use each other to the extent that other professions would is both really disappointing and really nice to know that it's there" (Mid: 168-171).

Tony reiterated his perceptions of co-planning with one of his PD colleagues, saying they "*basically run everything together*". They may "*diverge*" for a few classes, "*but we plan together even on our divergence, that we'll come back again*" (Mid: 46-47). He perceives that this is a "*very interesting*" way to work rather than "*out on our own*"

little island". He perceives that his co-planning work will continue and that the PD experience may serve to change how they work together. He also felt that it was "positive" to "make connections" with the scientists and facilitators in order to see the resources available to him.

Tony was part of a conversation about SOL's at lunch one day that allowed him to see where his "thoughts fit compared to others". He perceives that, "[t]he most nervous I am about SOL scores is after they've taken them and before they come back" (Mid: 304). There was a new science SOL this past year, and although Tony's students did worse on it than he expected, he also feels that it was "fairly negligible considering what the rumor is on the rest of the state" (Mid: 315-316). The chemistry teachers' scores at his school were all within 1% of one another, so he feels that being "consistent was also nice". Ultimately, the first week of the PD seemed to reiterate Tony's perceptions of himself as a teacher because "[i]t was what I really feel comfortable doing and I really enjoy the interactions" (Mid: 212).

Integration of Self-perceptions within Roles. Tony's perceptions of the positive group work experience integrate with his "philosophy of not doing it on my own" as a teacher as well as his perceptions about making connections with the scientists.

Personal epistemology as a Learner. Tony expressed some beliefs about science based on his experiences at the PD. When discussing the data collection process his group went through, he discussed some of his beliefs about data collection. He said that the group had to be:

"consistent with methodology and creating a standard operating procedure, just as long as you can define it. It doesn't so much matter what it is, it matters that it fits into that scientific concept, that it's repeatable, that someone else could replicate it and gather data" (Mid: 99-102).

He also mentioned his belief that if data has no correlation, it is still successful. Tony also discussed his beliefs about how chemistry data analysis is different from other types. He believes that chemistry labs are “*repetitive and precise and [use] very classical analytic methods*” (Mid: 138). He also said:

“how we record data was very different than some of the other scientists present. The precision used. We trust the calibrations and through the instruments themselves that they are accurate, but being able to compare data consistently over significant figures and over...so that your end result is not just maybe one number” (Mid: 127-130).

Tony also expressed some beliefs about concept mapping. He believes that having things “*connect through specific action*” is not important. He discussed ideas about doing concept maps in 3-D, however, he also mentioned beliefs about why that would be difficult. For example, he believes that in order to do a 3-D concept map, you would have to “*set it all up before and then plug it in*”. Although he does not like concept maps, he did not rule out the possibility of using them. Ultimately, he believes that the purpose of concept maps is for note taking. He said, “*it's a good note taking technique, is really what the purpose is, and that's a personal...note taking really is personal*” (Mid: 30-31).

Personal epistemology as a Teacher. Tony expressed his belief that science teachers do not let students fail enough. He believes that inquiry-based learning allows for only “*one or two correct answers*” versus real-world issues. He believes that the problem stems from grades. He said, “*[a] final product by the end of a time frame is what forces, you know, failure is good, but not having a product is bad*” (Mid: 89-90). He believes that there is a connection between having a “*failed product*” and “*just taking someone else's and just copying it*” (Mid: 91). He believes that this pressure to have products comes from the system, the profession, and the “*variation in thought*”, which

may be good *“in concept...but not always...the result is not always what the philosophies behind it agree with”* (Mid: 93-94).

Tony seemed to believe that the analysis he was doing at the PD was more similar to college-level labs rather than high school work. He discussed some beliefs about how a lab similar to what he did at the PD would have to be modified for his students. He believes that there is a *“huge difference in just skill set”*, which would cause his students to only be able to do three data analysis points rather than his group's eight and two trials rather than his group's three. He believes that there would be an issue with students' *“mixing of the samples and the balances and the numbers”*, which would cause them to struggle with the lab. Ultimately, he believes that students do not have the *“skill set ingrained in them”*. This includes simple things *“that are in science from day one”*, such as *“if I have a sample, I have to label it. If my sample looks like your sample and we both put it on the desk, we don't know whose sample it is”* (Mid: 243-244). He also believes that his students view labs as a *“reward versus seeing it as teaching”*. He believes that labs are *“absolutely teaching”*. And while he believes that labs can be fun and *“the more fun is the more engaging”*, he also believes that he has to take away the *“fun”* when students are not behaving. He said, *“if a class doesn't hold their standards up to excellence, you can't reward that, so you go from this great plan of a food lab to same thing, just wet chem lab”* (Mid: 226-227).

When discussing labs, Tony also reiterated his belief that students lack the ability to connect their learning across disciplines. He said, *“[w]hen we as teachers try to go back to prior understandings, they might have an understanding, but they don't know why that understanding is with them or where it came from, and therefore, they can't*

draw connections from that past into further back” (Mid: 247-250). He also believes that *“there’s no connection with what you do in a math classroom and what you do in a science classroom”* (Mid: 250-251). While he strongly believes that something should be done about this, he also believes that because it is a *“long-term benefit”* that *“won’t directly benefit students in the next 6 weeks”*, it gets put off much more readily than other issues. While Tony is considering having students design labs, he was thinking of *“doing experimental design without having the experiment to back it”* (Mid: 337-338). He did not give specific reasons for this plan, but did express his belief that it would remove constraints. He believes that *“being in the classroom puts major constraints on what we have and what we can do”* (Mid: 355-356). He seems to view typical high school labs as simulations, and seems to believe that allowing his students to design labs using authentic materials they do not have access to and cannot actually work with would be better than simulations. He said, *“simulations are great, but they’re just that. They’re simulations and they are taken as in the box simulations”* (Mid: 356-357). He believes that in order for his students to do this type of experimental design, they would *“need to find a method, basically a very well-known method that’s published, that’s internet available, that the methodology behind it is available. Otherwise you can’t get through the steps, especially without the ability to experiment”* (Mid: 374-377). However, he acknowledges that the *“flaw”* in this plan is that *“it might stop at YouTube videos”* (Mid: 360).

Tony also expressed some beliefs about teachers and the teaching profession. He believes that teachers are *“very proprietary even though everyone takes from everyone else”* (Mid: 164). He also believes that the teachers at the PD had *“fairly similar”* priorities across disciplines and grade levels. When discussing the potential for

collaborating with his group members on a PD-type project during the school year, he discussed his beliefs about priorities further. He said,

“[f]rom a day to day experience, there are always other things that get forced up higher on the list, and typically where people would justify putting that in is post-SOL, which really defeats the purpose of where you put it at” (Mid: 176-178).

When discussing the possibility of having district chemistry meetings, Tony expressed some views about how teachers would approach that. He said, *“[t]he biggest problem with that is that people bring their baggage to the table and it becomes an ego issue”* (Mid: 393-394). He also believes that whoever is running the meeting would do so based on their own “agenda”. He would prefer for those types of meetings to be “social” in order to set up “relationships”. He said, *“[w]e’re all here together because we teach chemistry, not because we actually want to talk about anything at these meetings”* (Mid: 394-396).

Tony was briefly introduced to the university's U-Teach replication program.

When talking about it, he shared some of his beliefs about developing good teachers. He said,

“that’s the vision that we really do need to have in the profession. If you can pick them out early because they’re the right people, not just anyone, you’ll be able to have a more cohesive, more collaborative concept as we go forward (Mid: 189-191).

He also expressed some beliefs about why people go into teaching versus the hard sciences. Although he seems to believe that “*money is a motivator*”, and details the differences between salaries in teaching and the hard sciences, he does not elaborate on the other portions of the job. He seems to be indicating that a U-Teach model would be a positive because it would allow students to get an idea of teaching as an alternative job possibility. However, they would then have to make decisions, and since money is a

motivator, teaching might be viewed as a job they could fall back on if needed.

Tony reiterated his beliefs about being supported by his administrators. Although the chemistry SOL scores went down this year, Tony believes that his direct administrator “*trusts in what we do*”. He believes that the principal is “*much more concerned because she values the system you’re in*”. He goes on to say, “[*h*]ut I understand why she would be more concerned or at least have the appearance of being more concerned. I think that they are happy in the products that we’re creating, and that allows us some freedom” (Mid: 327-329).

Integration of Personal Epistemology within Roles. Tony does not demonstrate any integration of his personal epistemology as a learner and as a teacher.

Perceived purpose as a Learner. Tony's perceived purpose as a learner during the first week of the PD was to design and execute his group's field study. He wanted to “*go at it and take the risks*” (Mid: 281) as a learner. During the data collection, his group made sure to get “*what we needed*”. Although it was muddy and high tide, “*we needed to make the markings, so we went out and did it*” (Mid: 97-98). Although he teaches chemistry, he was representing physics, so another goal was to “*pull in some of the physics*”. His group was focused on developing a methodology that “*fits into that scientific concept, that it’s repeatable, that someone else could replicate it and gather data*” (Mid: 101-102). His goal during the data analysis portion of the week was to “*think through a methodology that was presented, so we know the methodology is true*” (Mid: 126-127). His group tried to “*compare data consistently over significant figures*” (Mid: 129-130). His goal was also to “*figure out what the next process is going to look like*” based on his data. His hopes for the second week of the PD include seeing “*what other*

people's results are", figuring out "*how to create and how to put all of this data into a logical presentation*" (Mid: 403-404) and getting to know more people.

Perceived purpose as a Teacher. Tony would like for the profession to be more collaborative. His goal as a teacher at the PD was to "*interact with others*". Tony was considering having his students design labs without actually doing the labs. His goals associated with this were to allow them to "*see what's out there*", give them "*an ownership into taking the time to actually look from a science perspective*" (Mid: 349-350), "*develop critical thinking and puzzle solving*", and ultimately, "*force*" them out of their "*comfort zone*".

Integration in Perceived Purpose within Roles. Tony does not demonstrate any integration in his perceived purpose as a learner and as a teacher.

Action possibilities as a Learner. Tony's group worked together to design and carry out a field study. He gave some details about their study, saying that they are

"comparing salinity to ...originally it was percent plant cover, but based on what data we took -- so we took GPS location, we took a horizontal distance from point to point, we took elevation data, we took soil samples for salinity, we took notes on animals present in the quadrants, we took light readings, and probably something else" (Mid: 104-107).

They had begun data analysis at the end of the first week. His group was not planning to go back in the field during the second week of the PD.

Action possibilities as a Teacher. Tony was thinking of taking a few PD-inspired practices back into his classroom. He would like to do more peer collaboration, which might look like "*free discuss*". He was also considering having students do the experimental design without doing the actual experiment. It is not clear if his students regularly do their own experimental design. He explained that having them do the design

without the experiment would be useful for instances when he does not have access to equipment, but knows it is actually available. He described what the process might look like, saying:

“I think it would scaffold over time, that at first you would start with just one step and then what instrumentation might you use and then what hypothesis would you have. And then in a different experiment, what hypothesis would you have and then what would you use. And then go through the research on finding out the instrumentation and what it requires” (Mid: 371-374).

Tony reiterated his practice of co-planning with a fellow chemistry teacher. They *“basically run everything together and when we diverge we...it might be one or two classes where we do something totally different, but we plan together even on our divergence, that we'll come back again”* (Mid: 45-47). He also mentioned that he does a lab every one to two weeks with his students, but did not reveal details of his role or his students' roles in the lab.

Integration in Action Possibilities within Roles. Tony's experiences with the field study at the PD partially integrate with his plans to have students design experiment, however, he is thinking of planning experiments based around materials students do not have access to rather than those they do.

Mid-Alignment. Tony's beliefs about data collection and analysis align with his perceptions of the lab work as being *“right in normal life”* from a *“chemistry perspective”*. This also aligns with his group's actions and goals of developing sound methodology. His perceptions about the concept mapping activity as not being very useful for him align with his belief that having concepts *“connect through specific action”* is not important as well as his belief that the purpose of concept mapping is note taking. His plans for having students do experimental design partially align with his

experiences at the PD. This also aligns with his belief that these designs would have to incorporate “*well known*” methodology. His perceptions of positive social interactions with peers align with his feelings of safety and being able to take risks within his group. This also aligns with his purpose of interacting with others and his plans to have his students do more “*peer collaboration*”.

Tony demonstrates some misalignment as well. Although he perceives that the PD placed him in the role of a student, it seemed to be as a college student rather than a high school student. This has led to a lack of integration between his roles as a learner and teacher. He perceives the PD experience to be at the college level and does not seem to find it appropriate for his high school students, which is limiting his action possibilities and purpose.

Mid-Summary. Tony's experiences at the PD have served to place him in the role of a college student as well as remind him of his time spent in labs. His group work experience has been positive, and he has found that working with colleagues he already knows has allowed him to take risks. His experiences also brought up some of his beliefs about science, including the value of chemistry data analysis methodology. He is considering having his students develop experimental designs but not actually do the experiment, perhaps based on his belief that a PD-type experience is not appropriate for his students. He is looking forward to seeing everyone's results and figuring out how to put his group's results into a logical presentation.

Post-Institute Summary

Self-perceptions as a Learner. Tony considers himself a “*learner, probably every day*” (Post: 316). He enjoyed the data analysis portion of the second week of the PD,

saying, *"I really like data"*. He perceived that interpreting the data *"pushed our group to focus on what either went well or didn't go well as well as how we want to pursue it in the future in theory"* (Post: 17-19). He perceived that his group had *"the vision to have taken a lot more data in the field"*, which was very useful when their expected correlations did not work out. Ultimately he found the field study to be *"really neat"* because it *"definitely puts everyone into a group together"* (Post: 472). He expounded on this perception by saying, *"[w]e've all done the research together and researched different things, so we share similar experiences regardless of what we've had before"* (Post: 472-474).

Tony *"liked"* being able to present to his colleagues in an *"informal fashion"*. He perceived that the two cohorts were *"separate"* for most of the PD, and found it *"really neat"* to see how they were *"able to connect point A to point B"*. However, he would have found it *"really cool"* to have been able to use technology such as the iPad for the final presentations rather than posters.

Tony was *"disappointed"* with the assessment presentation during the second week of the PD. He recently completed a Master's degree in which he covered *"95%+"* of the material presented. He also perceived that the pace of the program was too slow. He said, *"I teach high school; I process significantly faster than most, and my frustration was that the information presented did not move all that fast"* (Post: 36-37). He perceived that the instructor was *"talking at us"* and that it was *"assumed that we were all coming from the same place"* (Post: 46). He also perceived that *"best assessment practices"* were not included in the material presented. He seemed to feel that it was unfortunate that time was taken for this portion because, *"it's rare that we see science people all in one place"* (Post: 49). He perceived that his colleagues felt the same way about the *"processing*

speed”, but perhaps not about the data repetition. Ultimately, even though he perceived that “*just having the conversation was meaningful and especially seeing how teachers who have been doing it for a lot longer than I rethought about things was kind of cool*” (Post: 263-264).

Self-perceptions as a Teacher. Tony perceived that the PD allowed the teachers to “*reconnect to the hard science that we teach*” (Post: 294). He felt that his experiences at the PD “*reminded*” him that his love of chemistry is “*one of the reasons I'm doing what I'm doing*” (Post: 297). He also perceived that being around “*like-minded people is really nice when you come to the end of May and are really frustrated with students being students*” (Post: 298-299). The experience of collaborating with others who teach “*similar to what I'm teaching and how I'm teaching*” (Post: 302) and realizing that they have “*similar experiences*” seemed to validate his feelings. He perceives that other teachers can serve as resources if you know how to get to them, so he found it useful to have made connections at the PD.

Tony perceived that by the second week of the PD “*we were all truly colleagues*”. He based this on their shared field work and data analysis experiences. He said, “*it was different in the respect from walking in the first Monday versus the second Monday, I think, with the people in the room*” (Post: 139-140). Tony also reiterated his perception that one of the things he enjoyed most about the PD was collaborating with other teachers. He said, “*one of the reasons I've come into teaching is that you're not isolated*” (Post: 281-282). He also felt that connecting with others was “*neat*”. He perceives that the “*collegial community*” created through the PD will “*definitely have a huge effect on the classroom*”, and views other teachers as “*resources*”.

Tony perceived that it was meaningful to “*connect things across curricula*”. He felt that he was “*often wearing multiple hats*” because of his dual roles of chemistry teacher and physics representative at the PD. He ended up using much more chemistry than physics because he perceived that their project did not “*naturally*” contain physics, and it would have to be forced. He was the only person representing physics for his cohort, and had limited interactions with the physics teacher from the first cohort and the physics professor present. He also found it “*interesting*” that all of the chemistry teachers present were women.

Tony “*enjoyed*” the NOS discussion as a teacher because he perceived that it allowed him to “*talk philosophy*” with people “*we assume are coming from similar backgrounds*” (Post: 79-80). He perceived that the conversation helped him to “*reaffirm*” some of his beliefs and let him see that there are others “*doing great work*”. He also enjoyed the statistics discussion that occurred during one of the mornings, which he perceived to be a “*bigger picture philosophy*” discussion. He had some conversations with his co-planning teacher about philosophy, but fewer of those conversations with the other PD teachers, including the rest of his group.

Tony does not like Edmodo, which is the site the PD uses for communication. The site “*frustrates*” him, which leads him to perceive that he will not “*invest more time into learning something that I really have no direct need for*” (Post: 386). This discussion led to him expressing some perceptions of his relationship with technology. He considers himself to be “*old school*” with some of his “*paper/pencil philosophies*”. While he has access to various types of technology for his classroom, he perceives “*frustration*” with “*what they think works for me versus what I actually can work with*” (Post: 403-404).

Integration in Self-perceptions within Roles. Tony's self-perceptions as a learner and teacher demonstrate integration in his quest for social interaction. He makes statements from a learner's and a teacher's perspective about his enjoyment of the social interactions he was having through collaboration with his group members as well as the other teachers and facilitators at the PD. He "*enjoys*" the experiences he is having of being among "*like-minded*" people who teach similar subjects. Tony also demonstrates some integration of his self-perceptions of the assessment presentation of the PD. Although he did not enjoy the way the way in which the presentation was made or the topics it covered, he still perceived value in being able to interact with other teachers and learn about their practices.

Personal epistemology as a Learner. Tony's believes that the PD did not naturally contain physics. He said, "*I think that the way this was presented, it was very difficult without forcing it for the physics to come naturally*" (Post: 239-240). Tony believed that the other subjects were naturally a part of the project, which seemed to lead him to discount physics. He said:

"[t]here is so much chemistry directly, there's even more bio, and there's even more earth science in the project that we chose, that a lot of the physics on a one day shot was very difficult to approach. Most of the physics that we might consider would have been long term development stuff" (Post: 240-243).

Tony also expressed the belief that data can be manipulated. He said, "*[y]ou can use it to either support or distract from an argument depending on how you skew it. And the data's still factual, but the interpretation becomes interesting*" (Post: 16-17).

Personal epistemology as a Teacher. Tony believes that "*field work really is a basis for all science*" (Post: 295). He also seems to believe that people who majored in a science field were involved in a lot of field work. However, he believes that teachers "*get*

removed from” field work. Tony expressed some beliefs about science when discussing the NOS activity. He believes that having “*bigger picture philosophy*” discussions is valuable because they “*tend to shape your own, whether it's positive or negative, meaning whether you affirm your beliefs or question your beliefs, both of which are positive things*” (Post: 86-88). He believes that “*science is changing*”, and went on to say that “*the “truths” are just that; they’re not capital T truths*” (Post: 100). Tony disagreed with the NOS discussion about communication, saying that communication can happen in many ways other than what people might consider as “*publication*”. He also seemed to express the belief that there is a “*true scientific method*”. He said:

“I think that if we looked at true scientific method, the most important steps, and this deals a lot with where I’m coming from, is actually the last step, that communication piece. It’s publishing, being able to not keep your own results in your own little world. Publication doesn’t really have to be that. It can be telling your neighbor who’s also doing the same thing. But that communication aspect is, I would say by definition, if we’re counting scientific method, one of those big definitions of science could be inclusive of communication” (Post: 106-111).

Tony believes that NOS is similar for all of the science disciplines. However, he did not discuss NOS with anyone other than his chemistry co-teacher because of his belief that the different subjects are “*totally different*” within the classroom. He said:

“[[from a day to day perspective, our days are so different in chemistry versus bio versus earth science that while the big picture NOS really is entirely similar, what we do on a day to day basis, if you were to ask any of our students, they would say it’s totally different. And we say it’s totally different” (Post: 167-170).

Tony also believes that there is “*no time*” and no “*safe space*” to have these types of “*bigger conversations*”. Tony believes that a person’s internal philosophy “*changes the why you do things, not the how necessarily*” (Post: 155-156) or “*it could change the how and not the why*” (Post: 156-157). He gave the following example:

“if you go directly with IBL (inquiry-based learning), if that’s a philosophy that

seems to make sense on the why, big picture why, it could start changing how you operate on a day to day basis in the classroom. On the flip side, even if it changes that big picture, but you're still able to get across just by tweaking one or two things over the course of the year, and not even necessarily by incorporating 4 IBL's, but by changing things to that philosophy. That could be really really big (laughs)" (Post: 157-162).

Tony also expressed some beliefs about why a PD-style project would be inappropriate for his students. He believes that what he did at the PD is really an AP Environmental Science “*process*”. Because of this, he seems to believe that it would not be appropriate for his classes. He said, “*if we break it down over 4 years of classes, there's no connection made and the skills, while isolated, might be accomplished, they'd be missing the whole reason we're doing it*” (Post: 194-196). However, he is considering having students do presentations. This is based on his belief that it is “*incredibly important*” to be able to “*present and communicate effectively*”. He also believes that doing so would “*take some of the lecture out of*” whatever the students are studying. He gave an example of Heisenberg’s work, which he believes is “*not understood by most*”. He said, “*Heisenberg came up with these fairly incredible mathematical calculations that we summarize to say we either know where the electron is or isn't and how fast it is or isn't moving*” (Post: 208-209). This discussion led him to express his belief that teachers do not do a good job “*nor are we necessarily at the right level for us to teach them how to get through really complex journal information in a way that they can process*” (Post: 214-215). He further believes that the SOL confounds this problem. He said:

“this is actually one of the few places where I strongly disagree with the SOL. I think the SOL oversimplifies it, and if you can actually explain the theory, you will actually lose credit on it sometimes. There's only one correct answer that they will take, whereas if you actually know the theory behind it and have built that correct answer, there are 5 or 6 correct answers in your drawing” (Post: 219-223).

Although he believes that “*oversimplification*” can be good because it “*develops understanding*”, he also said, “*but if that oversimplification wasn't the whole point of the original or the process of the original, it's not a benefit to our kids*” (Post: 227-229).

Tony’s dislike for Edmodo was explained by him expressing some beliefs about the site. He believes that Edmodo “*tries to be a social media site*”, like Facebook. He went on to express his belief that social media sites are built from the ground floor as opposed to Edmodo, which was built from an “*upper level investment*”, which causes him to believe that there is “*no reason to use it*”. He believes that Google Drive would be “*much more applicable*” for the PD teachers to use. This led him to express some additional beliefs about technology. He believes that paper and pencil has been effective in chemistry. He also believes that the “*older generation*” would not consider “*going digital in the classroom*”.

Integration in Personal Epistemology within Roles. Tony expressed the belief that his field study did not naturally contain physics, so as a learner, he found it difficult to bring physics into what he was doing. He believes that there was a lot of chemistry “*directly*”, more biology, and even more earth science. This was reiterated from his role as a teacher when he expressed the belief that the PD was actually an AP Earth Science “*process*”, which made it inappropriate for his class.

Perceived purpose as a Learner. Tony’s purpose as a learner was to work with his group’s field study data. His group made correlations and was able to work with all of the data together. He discussed plotting data and then using it “*creatively*”. His group had to “*focus on what either went well or didn't go well as well as how we want to pursue it in the future in theory*” (Post: 18-19). He was also “*trying to bring in the physics that I have*

in and the chemistry that I teach into the bigger group play” (Post: 234-235).

Perceived purpose as a Teacher. Tony felt that the PD encouraged him to consider “more than just small things”. He said:

“It forced me to go back and begin to question, I guess, my whole reasons that through philosophy and classroom practice, being able to pick up on what others do and why and the benefit in why and how others do allows me to process through what I do and how I do and pick up new material or new methods in how I can make my classroom experience better” (Post: 317-320).

He wished that there had been more time to “actually discuss” the assessment portion “versus almost talk around it”.

When doing the NOS activity, Tony seemed to have the goal of “talk[ing] philosophy” and seeing “different perspectives from that big picture assumption” (Post: 84). He felt that the discussion pushed him to “question my beliefs”. He said, “[i]t pushes you to either affirm your direct stance on it, or go the other way” (Post: 98). He would have liked to have had even more conversations like that, and longs for PD that would allow teachers to “shape” their philosophies. He also feels that internal philosophies should be written down in order to “see if it’s actually worth defending or worth throwing away” (Post: 150-151).

Tony is considering doing a “brain trust concept” with his students with the goal of enabling his students to grapple with “difficult questions that we would never be able to touch otherwise” (Post: 415-416). He said:

“the goal is for it not to be my own investment, that I have an answer, but if through the discussion, I’m forced to think of my answer and make a better answer come up or to make a more applicable” (Post: 421-423).

He would like to better “shape” student groups in order for students to better process the question and get it answered from a “big picture perspective”. He is also thinking of

having students present in class with the goal of increasing their ability to “*present and communicate effectively*”. He also feels that having them present would “*take some of the lecture out of*” topics while still covering all of the material necessary.

Integration in Perceived Purpose within Roles. Tony does not demonstrate any integration of his perceived purpose as a learner and as a teacher.

Action possibilities as a Learner. Tony worked with his group to analyze their field study data during the second week of the PD. They then developed a poster to present to their peers and did the presentations. He also participated in an assessment session and a NOS session.

Action possibilities as a Teacher. Tony shared that his commitments were “*instruction and assessment*”, however he did not go into detail about those commitments. He would like to do a “*brain trust concept*”, which he explained as, “*basically a think-pair-share group concept that you do think, and then you pair up and do small groups, and bigger small group of 4-6 and then those 4-6 can come up with results*” (Post: 411-413). He was also thinking of having his students do presentations. He gave the following example:

“we spend a week on quantum theory and scientists, we could spend that same week, instead of 3 days of lecture, only one day of lecture, one day of research, and one day of presentations and you’d still cover all of it” (Post: 200-202).

He was also thinking of perhaps bringing in “*other people’s best practices*”, which might include another teachers’ “*rockin’ lesson for something*”. However, he did not give any concrete examples of this.

Tony shared that he and his partner teacher already do many of the assessment techniques discussed during the PD. Although they do not do it “*formally*”, they go

through a sort of “*checklist*”. He said, “*we do it in a much faster and we essentially mark up a test to see what’s missing, what processing levels need to be better, and what questions are missing*” (Post: 69-70).

Integration in Action Possibilities within Roles. Tony demonstrated a limited amount of integration of his learner and teacher roles through his plans for having students do presentations. The presentations, however, seemed to be about factual information rather than design and implementation of work.

Post-Alignment. Tony’s positive perceptions of working with his group and generally being around other teachers who he considers to be like-minded align with his belief that teachers need to feel safe in order to have bigger conversations. This further aligns with his purpose of “*talking*” philosophy with the teachers at the PD and his purpose of questioning his philosophy and classroom practices. This also aligns with his plan to implement a brain trust activity with his students, which he believes will allow them to discuss larger issues in the safe space he creates for them.

Tony’s post-interview perception that the field study allowed the teachers to “*reconnect*” with the hard science they majored in aligns with his belief that field work is the “*basis for all science*” as well his belief that teachers become removed from field work. Although he had negative perceptions of the assessment portion, and wished that they had not just “*talk[ed] around it*”, it did result in him discussing some of his assessment development practices with his co-teacher, which he considers to be in line with the information discussed at the PD.

Tony continues to demonstrate some misalignment as well. He still seems to perceive the PD as college-level work rather than something that could be appropriate for

high school students. He also believes that the PD has to do with AP Environmental Science more than anything, which further limits him from seeing the applicability of the PD to his teaching. This has led to a lack of integration between his roles as a learner and teacher, and continues to limit his purpose and action possibilities.

Post-Summary. Tony leaves the PD perceiving that he had a positive experience that included many opportunities for social interaction with other teachers as well as opportunities to “reconnect” to the hard sciences each teacher majored in during college. He felt that the PD allowed him to talk philosophy and reconsider his practices. However, he still considered the field study to be at a college level and believed that it was an AP environmental science study. He leaves the PD with plans to encourage more social interaction for his students, including implement a brain trust activity with the goal of his students dealing with “bigger picture” questions. He is also planning to have students do presentations with the goal of taking “some of the lecture” out of certain topics.

Overall Change. Tony seemed to experience very little change during his time at the PD. He gave several examples of his perceptions and beliefs being reinforced by his experiences at the PD, but no examples of altering his perceptions, beliefs, or goals. For example, he perceived that the PD experience reinforced his philosophy of collaborating with others, both as learners and as teachers. He also perceived that the data collection and analysis experience reminded him of why he loves the lab as well as why he left that career option. Although he said that the PD experience “forced me to go back and begin to question, I guess, my whole reasons that through philosophy and classroom practice” (Post: 317-318), he did not express any changed beliefs as a result. Tony did come away with the idea of having students design labs, but not actually do the labs. Although he

explained that this would remove constraints and force students out of their comfort zone, his true beliefs and purpose surrounding that plan were not entirely clear.

Overall Alignment. Tony's perceptions and beliefs surrounding risk taking and social interaction demonstrated alignment across the interviews. He perceived that he was able to take risks at the PD due to his group's comfort level and that the social interaction he was experiencing both as a learner and as a teacher was valuable. The field study aligned with his perceptions the experience being "*right in normal life*" from a "*chemistry perspective*" and served to remind him why he is no longer in that field and why he became a teacher. His goals and practices involving social interaction continued to align with his belief in the value of collaborating as well as his perception of the PD experience.

Tony left the PD with misalignment present. He perceived the PD as college-level work rather than something that could be appropriate for high school students. He also believes that the PD has to do with AP Environmental Science more than anything, which further limits him from seeing the applicability of the PD to his teaching. This has led to a lack of integration between his roles as a learner and teacher, which seems to be causing him to make very few plans or goals associated with his PD experience.

Overall Summary. Tony entered the PD with a love of teaching and a perception of himself as different from other teachers based on his pathway to becoming a teacher. He was seeking social interactions with other teachers and felt that he provided those types of interactions for his students. He said that he teaches for students' college future, and was looking for his students to feel comfortable enough to take risks in his class. His perception of the PD field study as a college-level experience seemed to limit his ability

to make connections across his roles as a learner and teacher. The PD served to reinforce many of his pre-interview perceptions, beliefs, goals, and practices, including his “*philosophy*” of collaborating with other teachers and desire for continued social interactions. He leaves the PD with very few plans for implementing practices associated with the experience. The plans he discussed at the mid- and post-interview were small steps that included limited explanation behind them, making it difficult to gain an understanding of his true motives.

VITA

Stephanie J. Hathcock
 Department of Curriculum & Instruction
 Darden College of Education
Shath005@odu.edu

EDUCATION

- 2014 Old Dominion University, Norfolk, VA.
 Doctor of Philosophy in Curriculum & Instruction, Science
 Education
- 2006 University of Arkansas, Fayetteville, AR.
 Master of Science in Special Education: Emphasis in Gifted
 Education
- 2002 John Brown University, Siloam Springs, AR.
 Bachelor of Science in Education: Emphasis in Middle School
 Math & Science

POST-SECONDARY TEACHING EXPERIENCE

STEM 434: Developing Instructional Strategies PK-6: Science
 STEM 454: Secondary Methods for Science Teachers
 TLED 592: Integrating Math & Science for PK-3
 TLED 360: Secondary Classroom Management

PUBLISHED PAPERS, BOOKS, MONOGRAPHS, AND BOOK REVIEWS

Journal Articles:

- Hathcock, S. J.**, Dickerson, D., Eckhoff, A., & Katsioloudis, P. (Accepted). Scaffolding for creative product possibilities in a design-based STEM activity. *Research in Science Education*.
- Dickerson, D., Eckhoff, A., Stewart, C.O., Chappell, S., & **Hathcock, S.J.** (2014). The examination of a pullout STEM program for urban upper elementary students. *Research in Science Education*, 44(3), 483-506.
- Dickerson, D., **Hathcock, S.J.**, Stonier, F., & Levin, D. (2012). The great build-a-buoy challenge. *Science and Children*, 49(9), 62-66.

SELECT PRESENTATIONS

- Hathcock, S. J.** (May, 2013). "STEM in Action: Collaborative Antarctic Explorations". Invited Research Talk at Oklahoma State University, College of Education in Stillwater, OK.

- Hathcock, S. J.,** Garner, J. K., & Kaplan, A. (January, 2014). *Using professional identity to examine impacts of professional development*. Session presented at the annual meeting of the Association for Science Teacher Education. San Antonio, TX.
- Hathcock, S. J.,** Dickerson, D., & McConnell, W. (November, 2013). *Using inquiry questioning to scaffold creativity in a STEM activity*. Session presented at the annual meeting of the Virginia Association of Science Teachers. Norfolk, VA.
- Hathcock, S. J.,** & Dickerson, D. (April, 2013). *Student navigation of design-based STEM activities*. Session presented at the annual meeting of the National Association for Research in Science Teaching. Rio Grande, Puerto Rico.
- Hathcock, S. J.,** & Dickerson, D. (April, 2013). *Lights, camera, action: Promoting environmental stewardship through documentary film creation*. Session presented at the annual meeting of the National Association for Research in Science Teaching. Rio Grande, Puerto Rico.
- Hathcock, S. J.,** Garner, J.K., Kaplan, A., Davidson, Y. (March, 2013). *Investigating the impacts of teachers' professional development through change in professional identity*. Session presented at the annual meeting of the Eastern Educational Research Association. New York, NY.
- Hathcock, S. J.,** & Dickerson, D. (January, 2013). *Real-World STEM: Explorations in field-based oceanography*. Session presented at the annual meeting of the Association of Science Teacher Educators. Charleston, SC.