# LEARNING AND TRANSFER IN A COMPLEX PROFESSIONAL DEVELOPMENT SETTING: A CROSS-CASE ANALYSIS OF THE PERCEPTIONS AND PRACTICES OF SCIENCE TEACHERS

A Dissertation

by

LISA ANN BROOKS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2009

Major Subject: Curriculum and Instruction

LEARNING AND TRANSFER IN A COMPLEX PROFESSIONAL DEVELOPMENT SETTING: A CROSS-CASE ANALYSIS OF THE PERCEPTIONS AND PRACTICES OF SCIENCE TEACHERS

A Dissertation

by

LISA ANN BROOKS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Approved by:

| | |
|---|---|
| Chair of Committee, | Carol L. Stuessy |
| Committee Members, | Janie Schielack |
| | Cathleen C. Loving |
| | Anthony Petrosino |
| Head of Department, | Dennie L. Smith |

May 2009

Major Subject: Curriculum and Instruction

# ABSTRACT

Learning and Transfer in a Complex Professional Development Setting: A Cross-Case Analysis of the Perceptions and Practices of Science Teachers. (May 2009)

Lisa Ann Brooks, B.S., Rutgers University;

M.Ag., Texas A&M University

Chair of Advisory Committee: Dr. Carol L. Stuessy

In this dissertation the relationships among teachers' classroom contexts, teaching practices, personal practice theories and their learning from reform-based professional development were examined. This study is based on the cases of three high school science teachers whose participation in the Information Technology in Science (ITS) Center's professional development experience (PDE) resulted in different perceptions and interpretations. Qualitative and quantitative data, including classroom observations, in-depth interviews, teacher-generated written work from the PDE, and student classroom perceptions were analyzed and compared. The within-case analyses revealed that each teacher's thoughts, actions and perceptions were highly congruent. The cross-case analysis illuminated variations among the cases. Bandura's (1999) model of triadic reciprocal causation was applied as an interpretive frame. This frame was used to connect five indicators used in the study to coherently compare and evaluate the alignment of each teacher's thoughts, actions, and perceptions with the vision of reform-based teaching promoted by the ITS Center's PDE. Results of this interpretation show that the differences among the cases stemmed from the different problems the teachers believed reform-based teaching methods addressed. Recommendations for the design of PDEs include the importance of (a) focusing on flexible learning goals that can be meaningful and appropriate for all teachers, (b) understanding and engaging teachers' prior knowledge, (c) making changes in teachers' thinking visible and (d) keeping in mind the challenges involved in changing practice to reflect the recommendations of reform. Recommendations for future research include the development of learning trajectories for teachers with different orientations toward reform and deepening our current understandings of teacher educator expertise.

# DEDICATION

To my parents

Bonnie and Joseph Brooks

ACKNOWLEDGEMENTS

When I arrived at Texas A&M in 2001 I could scarcely have dreamed of the multitude of individuals I would meet and the opportunities I would have. It is an impossible task to attempt to acknowledge all those who have helped me along the way so to those I do not mention in this brief statement, thank you.

First and foremost I owe a special thanks to Dr. Carol Stuessy. From the day I wandered into her office I have been constantly amazed and overwhelmed by the depth of her friendship, support, patience, loyalty, and expertise. There were many times I came close to walking away from the overwhelming task of completing this study. She always knew exactly what I did (or often did not) need to keep going. I could not have come close to finishing this and would not be half the person I am today without her, and owe her my lifelong gratitude for taking the time and exerting the effort to see me through.

Thanks need to be given to the three research projects that supported me during my graduate work. The first project I was involved in was with Dr. Marvin Harris and the members of the Pecan Insect Lab. They provided me with the means to begin my graduate work along with the friendship, guidance, and patience that was all the more necessary. The second project I was involved with was with Dr. Janie Schielack and the other members of the ITS Center. The extraordinary generosity and support that was extended to me through this project was more than I ever thought possible. The final project I dove into while at Texas A&M was with Dr. Christine Ehlig-Ecconomides, Dr. Bugrahan Yalvac, and the other members of the ENGR 101 teaching team. From day one they accepted and valued my input and provided me with a multitude of experiences that challenged and extended my understanding and taught me valuable lessons about the world of educational design and research.

To all of the professors that taught me along the way, thank you. The passion you showed for your work as well as the insight I gained fostered my own passion. Specifically, thanks needs to be extended to Dr. Anthony Petrosino for the valuable insight into his work and experience and for keeping me sane by providing occasional doses of New Jersey-ism, to Dr. Carolyn Clark for introducing me to the art of qualitative research and for putting up with my struggles to understand, and to Dr. Cathleen Loving for introducing me to the world of science philosophers and providing invaluable feedback and support on my dissertation.

This dissertation would certainly not have been possibly without the generosity of the teachers interviewed for this study. Their willingness to share their ideas and lives allowed me to understand teaching in new ways and to complete this project.

Were it not for the foundation provided by my parents I would not be who I am today. Their unending love, support, and understanding saw me through.

Finally, the multitudes of friends I've made along the way made spending eight years in a small Texas town not only bearable for a New Jersey girl, but enjoyable. To everyone of you, thank you for being a part of my journey and I look forward to many more years of friendship.

# TABLE OF CONTENTS

CHAPTER Page

# LIST OF FIGURES

FIGURE Page

FIGURE Page

FIGURE Page

# LIST OF TABLES

TABLE Page

# CHAPTER I

# INTRODUCTION

## Rationale

> The terms and circumstances of human existence can be expected to change radically during the next human life span. Science, mathematics, and technology will be at the center of that change—causing it, shaping it, responding to it. Therefore, they will be essential to the education of today's children for tomorrow's world. (1993, p. xi)

Problems facing our society and our education system today are complex. More and more technological advances create an environment in which information is constantly at our fingertips, decreasing the value of retaining large amounts of information in our minds. Reformers place value instead on an individual's ability to understand, synthesize, evaluate, and use information in creative and innovative ways. These habits of the mind have traditionally been valued in the field of science, a field in which American students perform significantly below their international peers (National Center for Education Statistics, 2000). For this reason science literacy, which intertwines an understanding of science, mathematics, and technology, has been a central focus of current educational reforms.

Teachers learning to teach in ways that reflect these changing values when they have not experienced them as learners is difficult, if not impossible (Darling-Hammond, 1997; Darling-Hammond & Bransford, 2005; Darling-Hammond & McLaughlin, 1995; Fullan, 1993). Unfortunately, this is precisely what many science teachers are being asked to do in light of current visions of reform (American Association for the Advancement of Science, 1990, 1993; National Research Council, 1996). Reform documents call for teachers to adopt inquiry-based teaching practices founded on constructivist teaching principles. In order to accomplish these practices, teachers must make drastic changes in the fundamental structures of their curricula and their classrooms. They must confront attitudes and beliefs that have been developed from a

---

This dissertation follows the style of *The Journal of the Learning Sciences.*

lifetime of observation and years of practice. The *National Science Education Standards* (NSES) (National Research Council, 1996) recommend "Changing Emphases" outlining specific changes in multiple aspects of the education system that are necessary for successful reform. Changing emphases call for a departure from the traditional lecture, recitation, and examination methods focused on student acquisition of knowledge, which have been the norm in our education system for decades. The goal is to move towards constructivist classroom practices where teachers and students share the responsibility for understanding and using scientific knowledge, ideas, and inquiry processes in a classroom community.

Reformers argue for inquiry-based investigations that are as close to "real science" as possible. Investigations of this sort encourage students to develop the scientific habits of mind that are central to the NSES vision (Chinn & Malhotra, 2002). Information technologies (IT), which allow users to visualize, communicate, manipulate or otherwise work with complex data sets, require students to use scientific reasoning skills (Edelson, 1997; Edelson, Gordin, & Pea, 1999).

How does a professional development instructor provide teachers with what they need to incorporate inquiry-based pedagogies and IT into their classroom practice? Reformers insist that high-quality professional development experiences (PDEs) must be developed, executed, and studied to determine the effects on classroom practice and student achievement (Anderson & Helms, 2001; Borko, 2004). *Designing Professional Development for Teachers of Science and Mathematics* (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003) describes seven principles that should be present in high-quality PDEs: (1) driven by a well-defined image of effective teaching and learning; (2) provide opportunities for teachers to build their content and pedagogical knowledge; (3) base their structure in research; (4) engage teachers as adults in a process of active learning; (5) provide collaborative experience, allowing teachers to work with colleagues and other professionals; (6) integrate with other parts of the educational system; and (7) evaluated continuously for positive impacts. These principles are well supported by other research (e.g., Jeanpierre, Oberhauser, & Freeman, 2005; Porter, Garet, Desimone, & Birman, 2003).

Even with the best of designs, research published over the last two decades has revealed that some teachers are willing and able to successfully adopt reform-based curricula, but many more have not been able to change their teaching (Crawford, 2000). Barriers to implementation abound. Some teachers lack the subject matter expertise and pedagogical skill necessary to understand the types of changes being called for, let alone effectively incorporate them in their classrooms (Smith & Southerland, 2007). Many teachers have spent extended periods of time as learners in traditional educational settings and have developed deeply rooted beliefs or "personal practice theories" (Cornett, Yeotis, & Terwilliger, 1990; Smith & Southerland, 2007) that are at odds with constructivist principles (Battista, 1994; L. K. Smith, 2005) and resistant to change (Gregoire, 2003; Henderson, 2005). In addition to the barriers that pertain to individual teachers, barriers are also embedded in the school contexts in which they teach (Vesilind & Jones, 1998). Contextual barriers encompass a wide range of conditions, including the pressure to maximize student scores on mandated standardized tests; inadequate resources such as space, equipment, and time; and lack of administrative support.

Teachers' personal practice theories have received particular attention in the research literature. A great deal of evidence suggests that understanding teachers' personal practice theories and how they drive teachers' classroom decisions is central to the success of reform (Battista, 1994; Gregoire, 2003; Smith & Southerland, 2007). Research findings indicate strong connections between the beliefs of teachers and their classroom practices (Brickhouse, 1990; S. L. Brown & Melear, 2006; Cronin-Jones, 1991; Gess-Newsome, 1999; Hasweh, 1996; Jones & Carter, 2007; Kang & Wallace, 2005; LaPlante, 1997), their acceptance and understanding of reforms and constructivist-based teaching practices (Gess-Newsome, Southerland, Johnston, & Woodbury, 2003; Lotter, Harwood, & Bonner, 2007; Lumpe, Haney, & Czerniak, 1998; Manconi, Aulls, & Shore, 2008; Yerrick, Parke, & Nugent, 1997), and their ability or willingness to change their practices to reflect the recommendations of reform (Cooney & Shealy, 1997; Gregoire, 2003).

## Context

The context that provided the foundation for this study was an intensive, high-quality, two-year PDE offered by the Information Technology in Science (ITS) Center for Teaching and Learning. A cadre of education specialists, researchers, scientists, and graduate students created this experience based on current research and experience gained from two prior iterations of the program. The goal of the PDE was to encourage and facilitate teachers' assimilation of authentic inquiry teaching practices involving IT in their own classrooms. This goal was accomplished through a complex learning environment in which teacher-participants spent mornings working with scientists in their laboratories and afternoons working with education specialists discussing current educational research and crafting inquiry cycles similar to their laboratory experiences with the scientists.

## Purpose

The purpose of this dissertation was two-fold. The first purpose was to inform the designers of the ITS Center's PDE about the impact of their work on the teachers who participated in the experience. The second purpose was to add to the growing body of research on teacher learning and discuss the theories on which the design of the ITS Center's PDE was based. These dual purposes were addressed through an in-depth multiple case study that focused on three high school science teachers who participated in the PDE. This study was immersed in the complex ecology between teacher and experience and attempted to capture and connect this complexity through descriptions, analyses, and interpretations. Throughout this process, I observed the teachers' school contexts and classroom practices and associated them with results of interviews exploring their perceptions and interpretations of various elements of the ITS Center's PDE. Exploring these relationships led to a better understanding of the complexities that existed between and among the various influences on the teachers' classroom practices and their learning from the ITS Center's PDE.

## Research Questions

The research questions that guided this study were:

1. What were the relationships among individual teachers' personal practice theories, school context, classroom practice, and perceptions and interpretations of the ITS Center's PDE? Specifically:
    a. What did the school context and classroom practice of each teacher look like?
    b. What personal practice theories emerged from discussions with each teacher?
    c. How did each teacher value, perceive, and interpret the various aspect of the ITS Center's PDE?
    d. What relationships could be seen between each teacher's teaching situation, practice, personal practice theories, and the value, perception, and interpretation of various aspects of the ITS Center's PDE?
2. How were the three teachers similar and different in their various attributes and their perceptions and interpretations of the ITS Center's PDE? Specifically:
    a. What were the similarities and/or differences in school context and classroom practice among the three teachers?
    b. How were the personal practice theories that emerged from discussions with the three teachers similar and/or differ?
    c. How were the three teachers' values, perceptions, and interpretations of the ITS Center's PDE similar and/or different?

The goal of this study was to address the complexities of teacher learning and connections to personal theories, classroom practice, and school context. Therefore, I employed a predominantly qualitative mixed-methods multiple case study design (Creswell, 2003; Stake, 2006; Tashakkori & Teddlie, 2002). I selected three teachers on the basis of their understanding of inquiry and other constructivist-oriented teaching principles. This understanding was revealed from (a) my analysis of lesson plans and research designs created during the ITS Center's PDE and (b) the results of short exit interviews conducted for all 32 teacher-participants. After selection, I made two visits to each of three teachers' school campuses to observe their classroom practice. Teachers participated in two lengthy semi-structured interviews after each of my visits to their classroom. I coded and graphed classroom observations using the *Mathematics and Science Classroom Observation Profile System* (M-SCOPS) (Stuessy, 2002). The *Classroom Learning Environment Survey* (CLES) (McRobbie & Tobin, 1997) was administered to all of the students in each of the teachers' classes. Once accumulated, data from each teacher was analyzed individually to form the basis of the within-case analyses. Once the within-case analyses were complete, I analyzed the data comparatively across the three teacher cases for the cross-case analysis. I used quantitative measures from the M-SCOPS and CLES to illuminate and triangulate findings.

## The Researcher

My role as researcher played a significant part this study. My experiences participating in the ITS Center's PDE in a variety of capacities (i.e. participant, mentor, designer, and instructor) offered me a unique understanding of the context and data. These perspectives allowed me to relate to the challenges faced by the participants, designers, and leaders of the PDE (more detail in Chapter III). While these experiences offered me valuable insight, my in-depth involvement also served, at times, to cloud my judgment. In order to address the validity of the claims I made, I employed a variety of methods discussed extensively in the qualitative research literature (Lincoln & Guba, 1985). These methods included: (a) critical and ongoing self-reflection as I journaled on an almost daily basis, (b) peer debriefing as I shared my ideas with colleagues and friends as often as possible, (c) triangulating data from multiple sources to substantiate claims, and (d) conducting member check interviews with participants. As an additional step, I described data sources in as much detail as possible, following Geertz's discussion of "thick description" (1973).

## Key Terms

Many of the key terms used in this dissertation have multiple connotations in literature. Therefore, I found defining them to be an essential precursor to the analyses and interpretations included in this dissertation.

*Belief Systems:* I use this term to encapsulate all a teacher knows and believes about teaching, as defined by Jones & Carter (2007). The term includes a teacher's knowledge, skills, attitudes, and beliefs related to content, pedagogy, science, students, and curriculum.

*Personal Practice Theories:* I use this term to discuss the particular beliefs about teaching, learning, and science that drive a teacher's classroom practice (e.g., Smith & Southerland, 2007).

*Information Technology (IT):* This term provides the basis for the name of the Information Technology in Science Center. This term is used to designate those types of technologies that are integral to scientists' work and to capture the core components of scientific reasoning as they are used to visualize, communicate, manipulate, or otherwise work with complex data sets in ways that scientists would be unable to without them (Edelson, 1997; Edelson, et al., 1999).

*Instructional Technology:* This term is used in contrast to *information technology*. *Instructional technology* describes technologies that are used to organize or present information. Instructional technologies, like PowerPoint or tablet PCs, are often used as more efficient substitutes to other forms of presentation, such as blackboards, whiteboards, and overheads.

*Inquiry:* This study adopts the enhanced version of the definition of inquiry central to the *National Science Education Standards* (National Research Council, 1996) and presented by Chinn and Malhotra (2002). This definition emphasizes the importance of maintaining the focus of inquiry on the core components of "authentic" scientific reasoning while making them accessible to students by taking into account the limitations of space, time, money, and expertise that exist in schools.

*Inquiry Cycle:* The ITS Center's PDE asks teachers to create an *inquiry cycle* as part of their work during the first summer experience. The design of this inquiry cycle is based on the work of Etheredge and Rudnitsky (2003) and contains four parts: (1) immersion, (2) researchable question, (3) research, and (4) consequential task. This cycle is explained in more detail in the course syllabus for the first summer's PDE (Appendix A) and in the descriptive portions of the within- and cross-case analyses.

## Nomenclature

Multiple abbreviations are used throughout this dissertation. To facilitate the reader in following them they are listed here:

| | |
|---|---|
| PDE | Professional Development Experience |
| ITS | Information Technology in Science |
| NSES | *National Science Education Standards* |
| IT | Information Technology |
| IF | Instructional Framework |
| ARP | Action Research Plan |
| M-SCOPS | Mathematics and Science Classroom Observation Profile System |
| RS | Representational Scaffolding |
| IS | Instructional Scaffolding |

## Organization of Remaining Chapters

I organized the following chapters to facilitate clarity and understanding. Following the traditional format, Chapters II and III review the literature and methods, respectively. I focused Chapter II, the literature review, on research and theory pertaining to the current vision of reform in science education, teacher expertise, the design of PDEs for teachers, and teacher learning. Within this review, I tied these bodies of literature to the design of the ITS Center's PDE. In Chapter III, I present and justify the methodology chosen to guide this study. I include descriptions of the characteristics of mixed methodology, case study, and multiple case study research, the instruments and data collection and analysis procedures used, and my integral role as researcher. I designed chapters IV, V, and VI to focus on the description and analysis of the data from each teacher-case as a whole. As such, I present each of these chapters as a single-case study. To increase clarity, I wrote each chapter using Research Question 1 and its four sub-questions as an outline. I wrote Chapter VII to bring the three cases together and to discuss the similarities and differences among them. Much like the within-case analysis chapters, I organized this chapter using Research Question 2 and its four sub-questions as an outline. I wrote Chapter VIII as an interpretation of the three cases. Bandura's model of triadic reciprocal causation (Bandura, 1999) is the interpretive frame; indicators stemming from those I used in collecting data from each case and the literature discussed in Chapter II illuminate patterns within and across the cases. These interpretations provide the basis for the conclusions, implications, and directions for future research discussed in Chapter IX.

# CHAPTER II

# REVIEW OF THE LITERATURE

The relationships among teacher learning, conceptual change, current visions of reform, and professional development in science education are complex. This complexity is mirrored at multiple levels of this study. Theory and research from the learning sciences as well as research on teacher learning informed the designs, actions, and judgments involved in executing the ITS Center's PDE as well as this study at every level.

This chapter is organized into five main sections. The first of these sections provides a brief overview of the ITS Center's PDE. This overview is included because the design of the ITS Center's PDE was informed, as was this study, by the literature discussed in this chapter. Including it here allows me to introduce how the design and execution of the ITS Center's PDE incorporated ideas from current research and discuss these ideas in more depth throughout this review. The second section of this chapter describes the current vision of science education reform. The third section discusses the knowledge and skills necessary for teachers to be willing and able to teach in this manner. The fourth section focuses on the design of PDEs and teacher learning, drawing heavily from literature focused more broadly on learning environment design and learning in general. The fifth and final section focuses on the difficulties of teacher change and how teachers' knowledge, skills, and dispositions influence their interpretation of reform messages and learning.

As might be expected, there is significant overlap among these sections. The vision of effective science teaching portrayed by reform stems from a clear vision of science teacher expertise. Both of these visions ground and inform the design of effective learning environments for teachers and the design of the ITS Center's PDE. Understanding teacher change requires an understanding of the changes we expect teachers to make and the learning experiences we employ to help accomplish the goals of reform. My purpose was not to separate these bodies of literature. Instead, it was to connect and discuss the relationships among them, they ways they informed the design of the ITS Center's PDE, and the manner in which they informed the design and analysis of the three teacher cases in this study.

ITS Professional Development Experience

The ITS Center was Center for Learning and Teaching funded by the National Science Foundation. Through its five years of funding much of the ITS Center's focus was on the design and dissemination of high-quality professional development experiences (PDE) for teachers of science and mathematics. This PDE formed the basis of a dialogue about teaching and learning among scientists, mathematicians, education researchers, education practitioners, and a diverse population of graduate students. The PDE went through three iterations or cohorts, as we refer to them. This study focuses on three of the teacher-participants from the third and final cohort.

The ITS Center's PDE was designed to reify the principles of teaching and learning it attempts to convey to participants. I hope that an understanding of the PDE that was the context of this study will help you, the reader, better understand my analysis and interpretation of the three teacher cases and the differences and similarities among them. Figure 2.1 provides the visual representation of the ITS Center's PDE design that was included in the course syllabus (Appendix A). It may be helpful to refer back to this diagram as the ITS Center's PDE is discussed further throughout this study.

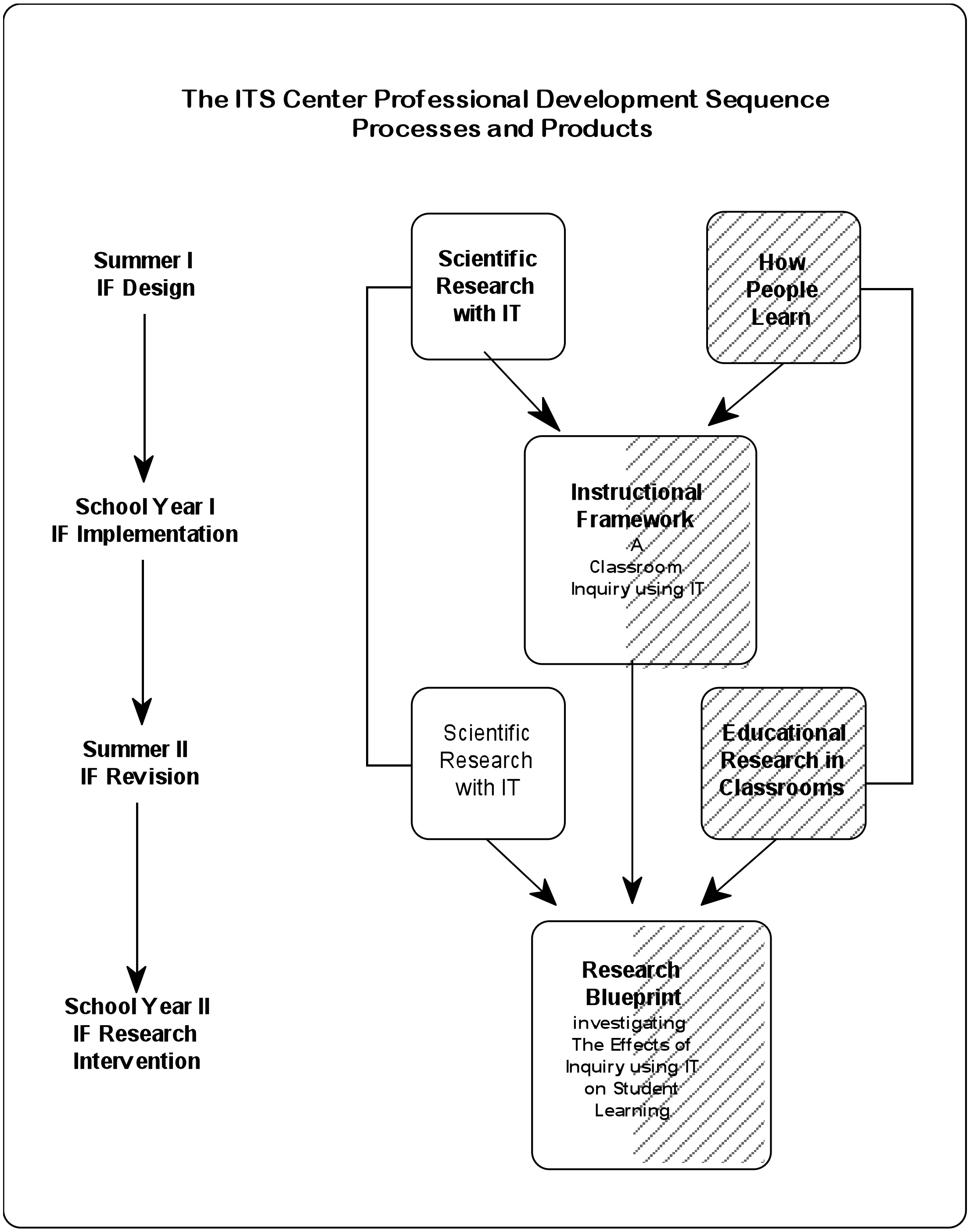


FIGURE 2.1 The ITS professional development sequence, processes, and products (Stuessy, 2005).

The ITS Center's PDE was an intensive two-year experience for graduate students and teachers of science and mathematics. Teams of scientists, with the help of education researchers and graduate students, designed and led teams of 8-15 participants. Each of these teams focused on a specific topic related to the scientists' areas of expertise. The teams for the third cohort were: (1) landscape ecology, (2) molecular view of the environment, (3) water environment, (4) forces at the nanoscale, and (5) plant genomics. The main portion of this experience took place during two subsequent summers when 60 participants met for three weeks on the campus of a large Research I University.

During each summer's three-week session, participants spent their mornings as a member of a project team immersed in learning about scientists' research. They learned more about the science content behind the scientists' work, visited the scientists' labs and/or field sites, and discussed ideas about science, research, and teaching. During the afternoons, participants stayed in their project teams and worked with one another, education researchers, and graduate students to discuss current theories about teaching and learning and to translate their morning experiences into an Instructional Framework (summer I) and an Action Research Plan (summer II).

Participants from the first summer were expected to translate the experience they had working with the scientists into an Instructional Framework (IF) or "school inquiry task" (Chinn & Malhotra, 2002), incorporating elements of technology essential to scientists' work (Edelson, 1997; Edelson, et al., 1999). Teachers were expected to follow a backwards design approach (Wiggins & McTighe, 1998) to design their IFs as well as to align them with Etheredge and Rudnitsky's inquiry framework (2003) and current research about how students learn (Donovan & Bransford, 2005). During the school year following the first summer, participants who wished to return for a second summer were required to implement their IFs in their classrooms. Before returning for the second summer, teachers submitted samples of students work, wrote a reflection paper, and completed a series of surveys that asked them about details of their implementation.

The Action Research Plans (ARPs), which teachers developed the second summer, were intended to be an opportunity to explore questions about students' learning that emerged from reflections on their implementation of the IF. Participants were expected to utilize their IFs as interventions in the second round of implementation. They reviewed literature, formulated research questions, and developed research plans based on their areas of interest. During the school year following this second summer, teachers were encouraged to implement their ARPs in their classrooms and submit a report detailing their research.

Through the completion of this two-summer experience, teachers and graduate students received 12 graduate credit hours that could be applied to a master's or doctoral degree; they also received a certificate of completion. Over the course of their two years of participation, graduate students and teachers were compensated for their time and expenses and all tuition costs were paid. As an additional incentive for completing the each school year implementation, participants were compensated an additional amount.

As you can tell from the brief description above, the ITS Center's PDE was a complex endeavor. Many people, including scientists, educational researchers, graduate students, and teacher practitioners, worked for multiple years on the design and delivery of the ITS Center's PDE. This design was informed by our understandings of current research on teaching, learning and reform-based science instruction that were guided, shaped and reshaped by our experiences integrating these theories in practice.

## Science Education Reform

Recommendations about the knowledge and skills needed for individuals to lead informed, successful, productive, and personally fulfilling lives has changed greatly over the last three decades. Technology has been a major factor in much of this change. Advances in technology have made many manual jobs obsolete and have increased the demand for creative, innovative, adaptive, critical thinkers. These are patterns of mind common to the field of science. Traditional methods of science instruction that focus on memorization and application of established facts, principles, theories, and formulas do not effectively foster these types of thinking patterns. Science literacy has become the focus of a great deal of research and reform (e.g.American Association for the Advancement of Science, 1993; American Association for the Advancement of Science, 2008; Bell, Blair, Crawford, & Lederman, 2003).

The goal of this section is to describe the current vision of science education reform in the United States, as well as the vision of expertise in reform-based science teaching. I begin with a discussion of the vision of current reform regarding teachers as informed professionals, individuals having both the responsibility and freedom to creatively adapt their classrooms and their instruction to the needs of their students and learning goals. This discussion is followed by a discussion of the "changing emphases" for science teaching outlined in the *National Science Education Standards* (National Research Council, 1996) and the epistemological and pedagogical shifts called for in these changes. The final portion of this section discusses research on expertise and how it pertains to current ideas of what expert science teachers should understand and be able to do.

*A Vision of Informed Professional Judgment*

Science education reform is nothing new to the United States as it has received a great deal of attention for the better part of the last half-century. Although the idea of reforming education in science is not new, many aspects of the current reform effort differ significantly from past efforts. One of the main ways this reform differs is the emphasis placed on teachers as the agents of change. In order for current visions of reform to become reality, teachers need to be viewed as professionals and offered the freedom to make decisions in their classrooms. To fulfill this role, teachers need to be experts in pedagogical content knowledge (PCK) (Shulman, 1986). PCK is a complex term, encapsulating the intersection of a teachers' knowledge and understanding of content and pedagogy and their ability to situate and adapt their knowledge and understanding to their students and teaching practices.

In his book *Change Forces with a Vengeance* (2003), Michael Fullan provides a diagram (Figure 2.2) that relates the different ways that the role of teachers in reform have been viewed.

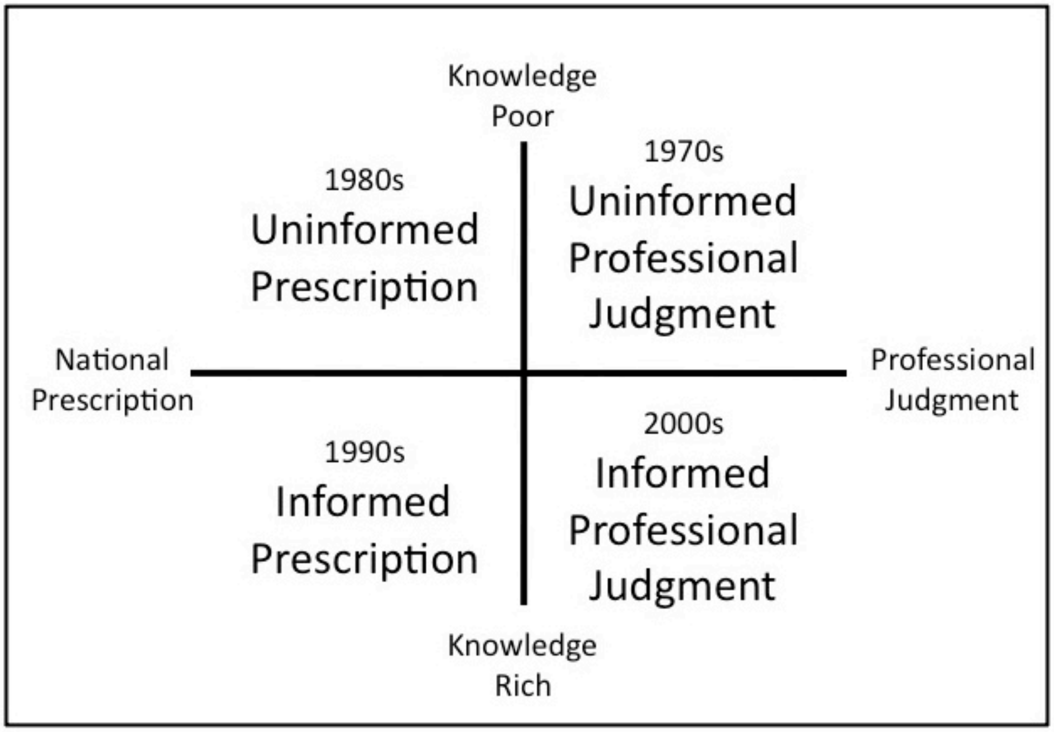


FIGURE 2.2 Knowledge poor-rich, prescription-judgment matrix (Barber (2002, April) as cited in Fullan (2003, p. 4)).

The two axes in the figure represent two continua. The vertical axis represents the range of knowledge about curriculum and pedagogy teachers were thought to need. The horizontal axis represents the range of control levels teachers were offered over their classrooms. The pairing of these two continua forms four quadrants. The four quadrants relate to four different ways a teacher's role had been conceptualized by reform.

The quadrant related to the prominent reform vision of the 1970s was one of what Fullan (2003) terms "uninformed professional judgment." During this time teachers were told neither how nor why to teach. The majority had little or no grounding in pedagogical theory; instead their instructional methods were driven by their experiences as learners and the belief systems and personal practice theories formed from them. The 1980s were characterized by uninformed prescription where teachers were told what to do but not why. Scripted, "teacher-proof" curricula that dictated teachers' actions were thought to be the solution to increasing student achievement. The use of these scripted curricula continued through the 1990s. Over time it became evident that teachers' knowledge, skills and beliefs greatly impacted the ways in which the curricula were used and its impact on student achievement. This understanding led to a period of informed prescription. During this period PDEs that helped teachers understand how and why these curricula should be used became a focus of reform. The final quadrant represents the current vision of reform where teachers need to be informed professionals with a firm understanding of what they are doing in their classrooms and why. They need to be able to make informed judgments that shape their practice to the needs of their students and student learning goals.

Ideas about a teacher's role and judgment in reform have steadily changed over time. The way in which these ideas are enacted in schools is not black and white. Viewpoints and practices falling into each of Fullan's quadrants can be found in different schools; teachers' abilities to act as informed professionals are often in question. Sawyer (2004) focused on this issue as he discussed how underprivileged, low-performing school districts faced with high pressures to improve students' scores on standardized tests often turned to the use of a pre-scripted curriculum. This act drives current practice away from the vision of reform, as these curricula tend to focus instruction on the lower-order skills, skills that are easily measured by national tests. Understanding that current reform is calling for teachers to act as professionals with the freedom to use their knowledge and understanding to make informed judgments is essential to making sense of current reform. This understanding was a central tenet of the ITS Center's PDE.

This section continues with a discussion of how good science teaching is conceptualized by current reform and concludes with a discussion of what an expert science teacher, with the ability to exercise informed professional judgment, understands and is able to do with respect to this vision.

*A Vision of Reformed Science Teaching*

The *National Science Education Standards* (NSES) (National Research Council, 1996) set the tone for the last two decades of science education research and reform and their influence remains strong today. The vision of science teaching they portray is best summarized in the following table of "changing emphases":

TABLE 2.1
Changing Emphases for Teaching (National Research Council, 1996, p. 52)

| CHANGING EMPHASES | |
|---|---|
| The *National Science Education Standards* envision change throughout the system.<br>The teaching standards encompass the following changes in emphases: | |
| **Less Emphasis On** | **More Emphasis On** |
| Treating all students alike and responding to the group as a whole | Understanding and responding to individual students' interests, strengths, experiences, and needs |
| Rigidly following curricula | Selecting and adapting curricula |
| Focusing on student acquisition of information | Focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes |
| Presenting scientific knowledge through lecture, text, and demonstration | Guiding students in active and extended scientific inquiry |
| Asking for recitation of acquired knowledge | Providing opportunities for scientific discussion and debate among students |
| Testing students for factual information at the end of a unit or chapter | Continuously assessing student understanding |
| Maintaining responsibility and authority | Sharing responsibility for learning with students |
| Supporting competition | Supporting a classroom community with cooperation, shared responsibility, and respect |
| Working alone | Working with other teachers to enhance the science program. |

As is evidenced by the title "changing emphases," the NSES do not prescribe a set curriculum. Instead, they outline more general recommendations for changes throughout the education system intended to increase the focus on the development and fostering of the higher-order habits of mind society demands. This open-ended approach to describing the standards is the basis for the need of teachers to act as informed professionals, to embrace these recommendations, and to use their understanding of them to drive the decisions they make in their classrooms.

The changes recommended by the NSES are substantive. They call for teachers to change their teaching practice and to change many of their assumptions about their practices, including those about science, learning, and teaching. This shift stems from the epistemology of constructivism on which the NSES are based (Yore, 2001). Constructivism, in short, stems from a belief that knowledge and understanding are not simply transmitted to students, but that students play an active role in the transmittal process. Constructivists assume that existing mental schemas shape the ways in which new information is received, perceived, assimilated, and accommodated. Recently, constructivists also assume that learning is a largely social process. These ideas contribute to the lack of emphasis in the NSES on how teachers should teach and focus instead on how students learn. The recommendations from the NSES focus on helping teachers create powerful learning environments that guide and foster student learning.

**Inquiry and the NSES**

Inquiry-based teaching practices that mirror the investigations scientists conduct as part of their work are central to the recommendations of the NSES (National Research Council, 2000). A central position of the NSES is that an understanding of the scientific enterprise and how scientists do their work is vital to scientific literacy. The NSES state:

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (p. 23)

As this passage demonstrates, inquiry is a complex activity requiring a focus on higher-order skills. Engagement in inquiry offers students the chance to develop not only deep conceptual understanding of course concepts, but also core problem solving skills including metacognition, as well as a broader understandings about the nature of the scientific enterprise.

The development of deep conceptual understanding fostered by an inquiry approach to teaching stems from extended investigations into topics. Ideally, inquiry provides students with opportunities, based on learning goals appropriate to age and subject, to become immersed in and deeply investigate a broad range of topics (Etheredge & Rudnitsky, 2003). Much like scientists, students involved in authentic inquiry are not focused on finding a single correct answer. Instead, students focus on understanding, discussing, debating, and supporting their ideas with evidence from both reading and experimentation. As with authentic inquiry, students' investigations should provide opportunities for practice, feedback, revision, and reflection. These types of experiences help students connect ideas and concepts to prior knowledge and understanding. Results include the development of meaningful conceptual frameworks organized around big ideas, rather than a surface-level understanding often accompanied by isolated facts and procedures (Goldman, Petrosino, & Cognition and Technology Group at Vanderbilt, 1999).

Helping students develop deep conceptual understandings organized in meaningful conceptual frameworks can also help them develop metacognitive and adaptive habits of mind. Metacognition is simply defined as the process of thinking about thinking or learning how to learn. Offering students opportunities for practice, feedback, revision, and reflection encourages them to take initiative for their own learning and develop self-knowledge, self-regulatory skills, and self-improvement expertise (White & Frederiksen, 2000). These skills lead students to be better equipped to flexibly and adaptively apply their understanding to new topics or problems.

Inquiry-based teaching also helps students develop an understanding of the scientific enterprise. Traditional science instruction presents science concepts as indisputable facts that are closed to discussion or debate, which is the opposite of the actual practice of scientists. Involvement in extended opportunities for inquiry-based investigation helps students understand and engage in social discourse and critical analysis. Explicit involvement creates creating students who are more likely to consider evidence and alternatives as they engage in their own approaches to supporting claims both within and outside the field of science.

Chinn & Malhotra (2002) argue that inquiry, as often conceptualized and practiced in schools, differs greatly from the authentic practice of scientists. They contend that students need to be engaged in activities that capture the patterns of reasoning used by scientists in order to realize the current vision of reform. To illustrate their point, they discuss a variety of the cognitive processes involved in the "authentic inquiry" of scientists that are either different or excluded from the "simple inquiry tasks" often detailed in resources like textbooks. They assert that an important part of reform-based science education is the development of "school inquiry tasks" that capture the core components of scientific reasoning within the limitations of space, time, money, and expertise present in a classroom environment.

Authentic inquiry processes in which scientists engage often rely on technology (Chinn & Malhotra, 2002). Technologies integral to scientists' work allow them to visualize, communicate, manipulate, or otherwise work with complex data sets in ways that they would be unable to do without them. These types of technologies were referred to as Information Technologies (IT) during the ITS Center's PDE. The Center argued that students who have opportunities to manipulate data in authentic ways allows involvement in many of the core components of authentic scientific reasoning (Edelson, 1997; Edelson, et al., 1999).

The terms "inquiry" and "IT" are not focused on procedures, but rather on the thought processes that guide procedures. Much like the vision of effective science teaching portrayed by the NSES, this distinction is complex and anything but straightforward. While the incorporating hands-on activities into science instruction is part of the definition of inquiry a much larger part rests beneath the surface of *what* students are doing, and focuses on *how* and *why* they are doing it.

Much like inquiry, the distinction between technology and IT also lies in the "how's" and "why's." Many types of technology can be included in classroom activities.

However, IT provides opportunities for students to ask and answer questions and think critically about data in ways that reflect the thought processes and patterns of reasoning used by scientists.

I discuss these ideas to explain that that the vision of effective science instruction portrayed by the NSES is not a straightforward, absolute, or prescribed vision. Instead, the vision is laced with subtlety and complexity. The demands of being an agent of informed professional judgment in light of the complexity of these recommendations are immense. Teachers who effectively embrace and enact the vision of the NSES are also experts in content, pedagogy, and pedagogical content knowledge. They are also experts in innovative, reflective, and adaptive thinking. What follows is a discussion of literature on expertise, focused specifically on characteristics of expertise in science teaching.

## Science Teacher Expertise

The expertise of teachers is a crucial contributor to student achievement. Wright, Horn, and Sanders (1997) examined the effects of multiple classroom factors, including teacher effects, intraclassroom heterogeneity, student achievement level, and class size on student achievement. They found that teacher effects had the highest level of influence on student achievement. They summarize the major conclusion of their study with the phrase, “teachers make a difference.” Similarly, Monk (1994) analyzed data from the Longitudinal Study of American Youth to find that, in general, teachers’ levels of both content and pedagogical preparation were positively related to gains in student learning.

In the vision of the NSES, the role of the teacher is more complex and more important than ever. In order to successfully implement inquiry-based science practices, teachers need high levels of pedagogical content knowledge (Shulman, 1987). They also need to be able to creatively and efficiently adapt that knowledge as they confront complex decisions demanded by reform-based teaching (Darling-Hammond & Bransford, 2005; Sawyer, 2004).

A clear understanding of learning goals is central to the design of an effective learning environment (Wiggins & McTighe, 1998). Similarly, a clear image of science teaching and learning is central to the design of an effective PDE (Loucks-Horsley, et al., 2003). Such a vision of science teacher expertise was central to the design of the ITS Center's PDE. Recently, the concept of expertise has received a great deal of attention. Research and theory related to expertise have revealed several key principles:

1. Experts notice features and meaningful patterns of information that are not noticed by novices.
2. Experts have acquired a great deal of content knowledge that is organized in ways that reflect a deep understanding of their subject matter.
3. Experts' knowledge cannot be reduced to sets of isolated facts or propositions but, instead, reflect contexts of applicability: that is, the knowledge is "conditionalized" on a set of circumstances.
4. Experts are able to flexibly retrieve important aspects of their knowledge with little attentional effort.
5. Though experts know their disciplines thoroughly, this does not guarantee that they are able to teach others.
6. Experts have varying levels of flexibility in their approach to new situations.(Bransford, Brown, & Cocking, 2000)

A focus on "varying levels of flexibility" mentioned in the final principle led to Hatano and Inagaki's (1986) description of two courses of expertise: routine and adaptive. Routine experts, such as many doctors, are able to recall and follow fixed sets of procedures rapidly and accurately. Adaptive experts, on the other hand, are not only able to efficiently draw from a large knowledge base but are also prepared to adapt procedures in creative ways. From this distinction, more recent literature from the learning sciences focuses on two dimensions of learning and transfer: innovation and efficiency (Schwartz, Bransford, & Sears, 2005). The relationship between these two dimensions and the two courses of expertise are represented in Figure 2.3.

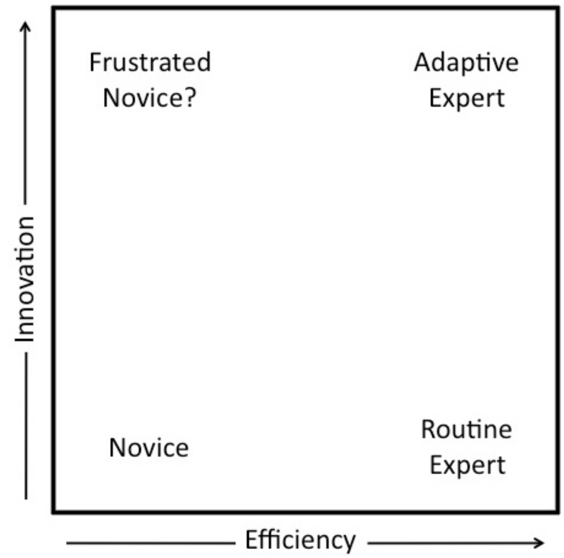


FIGURE 2.3 Innovations vs. efficiency framework (Schwartz, et al., 2005, p. 28).

Efficiency is defined as the ability to "rapidly retrieve and accurately apply appropriate knowledge to solve a problem or understand an explanation" (Schwartz, et al., 2005, p. 28). Innovation, on the other hand, is much more difficult to define. Innovation includes aspects of creativity, adaptability, and the use prior knowledge and understanding to interpret and rearrange new environments, experiences, and ideas. Innovative individuals often resist accepting the first thought that comes to mind. Instead, they reflect on their ideas and, in a way, play with them as they interpret them in light of their knowledge and experiences. Routine experts are characterized as having high levels of efficiency and low levels of innovation; adaptive experts are characterized as having high levels of both innovation and efficiency. Stemming from this framework, Crawford et al. (2005)

I used these pieces of literature to organize my ideas about science teacher expertise. To successfully enact the ideas of reform, science teachers need to be adaptive experts. The complex decisions involved in the day-to-day and moment-to-moment demands of teaching require both efficient and innovative thinking. Teachers need a high degree of content knowledge and also need to be able to use this knowledge creatively, innovatively, and reflectively. Both are needed to make informed professional judgments that shape and adapt classrooms and curricula to the needs of students and student learning goals.

*Content Knowledge*

Teachers who can teach science as portrayed by the NSES "have theoretical and practical knowledge about science, learning, and science teaching" (National Research Council, 1996, p. 4). This knowledge includes knowledge of content, pedagogy, curriculum, perceptions of science as an enterprise, expertise, learning and teaching.

Shulman (1986) described three categories of teacher knowledge: subject matter knowledge, pedagogical content knowledge, and curricular knowledge. According to Shulman, a teacher's subject matter knowledge needs to go beyond mere facts or concepts to a deeper understanding of the structure of the discipline. He states: "a teacher must not only know *that* something is so; the teacher must understand *why* it is so, on what grounds its warrants can be asserted, and under what circumstances our belief in its justification can be weakened and even denied" (Shulman, 1986, p. 9, emphasis in original). Pedagogical content knowledge represents a teachers' pedagogical knowledge as it relates to both subject matter and students. It includes "for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations" (Shulman, 1986, p. 9) as well as an understanding of what makes topics easy or difficult, the preconceptions and misconceptions of students, and strategies for addressing and overcoming these challenges. The final category Shulman describes is that of curricular knowledge. Curricular knowledge includes a teacher's knowledge of the various tools, materials, and activities available for teaching a certain topic and in what situations they are best applied.

Shulman's discussion of teacher knowledge is mirrored and enhanced by the work of many others. As far back as Dewey (1933) the important role of teacher knowledge has been discussed. Dewey wrote:

> The problem of the pupils is found in the *subject matter;* the problem of teachers is *what the minds of pupils are doing with the subject matter.*

> Unless the teacher's mind has mastered the subject matter in advance, unless it is thoroughly at home in it, using it unconsciously without need of express thought, he will not be free to give full time and attention to observation and interpretations of the pupils' intellectual reactions. (p. 275, emphasis in original)

More recently, Sawyer (2004) situated ideas about teacher knowledge as he described a notion of teaching as improvisation. He stated:

> To create an improvisational classroom, the teacher must have a high degree of pedagogical content knowledge—to respond creatively to unexpected student queries, a teacher must have a more profound understanding of the material than if the teacher is simply reciting a preplanned lecture or script(Feiman-Nemser & Buchmann, 1986; Shulman, 1987). An unexpected student query often requires the teacher to think quickly and creatively, accessing material that may not have been studied the night before in preparation for this class; and it requires the teacher to quickly and improvisationally be able to translate his or her own knowledge of the subject into a form that will communicate with that student's level of knowledge. Both of the students quickly discovered the correct answer but because they used different methods, they each at first think the other is wrong. (p. 15)

Teachers who can respond to the individual interests, strengths, experiences, and needs of students, guide students in extended scientific inquiry, and provide opportunities for scientific discussion and debate among students, must also be able to create and maintain an improvisational classroom. Teachers who can orchestrate an inquiry-based learning environment must understand what reasoning in science entails (Ball & Cohen, 1999). Lederman (1999) outlines six aspects of the nature of science generally agreed upon as important for both teachers and students to understand:(1) scientific knowledge is tentative (subject to change), (2) empirically based (based on and/or derived from observations of the natural world), (3) subjective (theory laden), (4) necessarily involves human inference, imagination, and creativity (involves the invention of explanations), (5) necessarily involves a combination of observations and inferences, and (6) is socially and culturally embedded (p.917). Although an understanding of these characteristics of science is essential to teaching science as inquiry, understanding alone does not always translate into classroom practice. Teachers must also have explicit opportunities to connect their understanding of the nature of science to their teaching practice and to reflect on these connections (Brickhouse, 1990; Lederman, 1992, 1999).

An understanding of how students learn science is the last form of teacher knowledge outlined in the NSES. *How Students Learn* (Donovan & Bransford, 2005) outline three fundamental and well-established principles of learning that are of particular importance to the practice of teaching:

1. Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.
2. To develop competence in an area of inquiry, students must (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application.
3. A "metacognitive" approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them. (pp. 1-2)

Inquiry-based teaching requires that teachers are able to reveal, understand, and engage the various preconceptions students may bring with them to the classroom. Also necessary is a teacher's knowledge and understanding of content and techniques for developing and assessing student learning. Situating these understandings and skills in an environment that fosters the development of metacognitive skills and allows students take control of their learning is also paramount.

Increasing science teachers' expertise with science, learning, and science teaching was central to the design of the ITS Center's PDE. Teachers worked with scientists in the mornings during their weeks on campus to explore and expand their understanding of science content and processes. Afternoon experiences were focused on current research and theory about how students learn, inquiry-based science teaching, and helping teachers to develop an IF that could transfer their ideas to their classroom setting. An overview of the explicit way that these ideas were presented to teachers is contained in the EDCI 666 course syllabus (Appendix A).

Teachers were required to implement their IF and reflect on the experience.

These activities offered explicit opportunities for teachers to connect their learning from the ITS Center's PDE to their classroom practice. These opportunities were expected to help teachers to develop deeper understandings of the ideas presented during the ITS Center's PDE and become better equipped to implement inquiry in their classrooms.

*Adaptive Expertise*

Recent research discusses the need for science teachers to be adaptive experts in order to use and promote the types of knowledge, understanding, and skill discussed above (Darling-Hammond & Bransford, 2005). Crawford, Schlager, Toyama, Riel, and Vahey (2005) characterized several processes and dispositions involved in science teacher adaptive expertise (Table 2.2). These characteristics of adaptive expertise are essential to the ability to teach in the constructivist, inquiry-based methods portrayed in the NSES. For example, the characteristics of "maintaining an epistemic distance" would allow a teacher to notice differences between their understanding, new information they receive and/or the understanding of their students. Constructivist learning environments are often complex and unpredictable. Teachers' understanding of the world as complex and their willingness to work at the limits of their knowledge and skills allows them to embrace this complexity and unpredictability. An inclination towards learning is also essential as teachers work at their limits, often learning from their students as much as teaching them.

TABLE 2.2
Aspects of Adaptive Expertise (Crawford, et al., 2005, p. 7)

| *Epistemic and Disproportional Aspects of Adaptiveness* | *Adaptive Cognitive and Metacognitive Processes* |
|---|---|
| • Maintain an epistemic distance between prior knowledge and model of a case or problem at hand<br>• An epistemic stance that views the world as complex, messy, irregular, dynamic, etc.<br>• Comfort or willingness to reveal and work at the limits of one's knowledge and skill<br>• An inclination toward learning rather than merely applying knowledge | • Data-oriented forward reasoning (hypothesis-based reasoning)<br>• Causal reasoning<br>• Seeking and analyzing feedback about problem-solving processes and outcomes<br>• Monitoring results and performance<br>• Monitoring own learning<br>• Assessing own knowledge states<br>• Assessing adequacy of current knowledge for solving case at hand |

A teachers' use of the characteristics of "adaptive cognitive and metacognitive processes," outlined in the above table, in their everyday teaching practice is also essential. Through teachers' constant probing and assessing of their students' learning, teachers are "seeking and analyzing feedback about problem solving processes and outcomes" as they "monitor the results" of the instructional decisions they have made and the "performance" of their students. At the same time, they "monitor their own knowledge states" as they pertain to both the content of the lesson and student learning of it. Teachers are also able to "monitor their own learning" and "assess the adequacy of their knowledge" as they decide to probe student understanding further or modify their method of instruction.

## Professional Development for Teachers of Science

The demands of creating and maintaining constructivist, inquiry-based learning environments portrayed by the NSES are substantial. Without a firm and thorough understanding of content, science, and learning as well as the ability to adaptively use that understanding, teachers cannot be expected to fully realize the vision of reform. Many teachers do not have these types of understanding or skills and find it difficult to understand the recommendations of reform, let alone create and maintain reform-based teaching environments in their classrooms (Smith & Southerland, 2007).

In addition to issues stemming from lack of expertise, many teachers also lack exposure to the types of learning environments portrayed by the NSES. It is difficult if not impossible for teachers to teach in ways they have not learned (Darling-Hammond, 1997; Darling-Hammond & Bransford, 2005; Darling-Hammond & McLaughlin, 1995; Fullan, 1993). If teachers are to succeed at reform, they need opportunities to experience the unique challenges and benefits of learning in inquiry-based teaching environments. The NSES state:

> If reform is to be accomplished, professional development must include experiences that engage prospective and practicing teachers in active learning that builds their knowledge, understanding, and ability. The vision of science and how it is learned as described in the *Standards* will be nearly impossible to convey to students in schools if the teachers themselves have never experienced it. Simply put, pre-service programs and professional development activities for practicing teachers must model good science teaching, as described in the teaching standards in Chapter 3.(National Research Council, 1996, p. 56)

The purpose of this section is to review research and theory on the general design of effective learning environments and discuss how this literature pertains to literature on teacher learning, the design of effective professional development, and the design of the ITS Center's PDE. Elements of all three discussions are intertwined throughout.

*Design of Learning Environments*

A useful approach to thinking about the design of learning environments was presented in the book *How People Learn* (HPL) (Bransford, et al., 2000). This book synthesizes results from decades of educational research on learning and learning environments into a simple framework. This framework presents four perspectives, or lenses, that characterize learning environments. Figure 2.4 represents the connections among the four perspectives of the HPL framework. Three of these perspectives, learner, knowledge, and assessment, are embedded within the larger perspective of community. An optimal learning environment would consider each of these elements and strike a balance that supports learners and the goals of instruction.

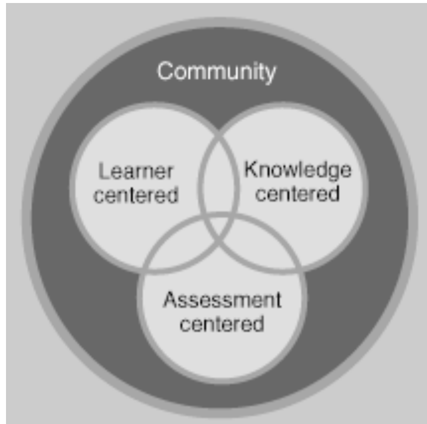


FIGURE 2.4 The How People Learn framework (Bransford, et al., 2000).

Note that these four perspectives – learner-centeredness, knowledge-centeredness, assessment-centeredness, and community-centeredness – are represented in the diagram to indicate that it is undesirable to consider them as four separate compartments. For instance, when we look at a new idea for a classroom from the perspective of learners, we cannot separate that perspective from the communities our learners come from and learn in. The diagram also shows the overlap of learner-centered perspectives with knowledge- and assessment-centered perspectives. In terms of teachers' use of the model to think about learners, the model tells us that we would think about learners and all others together. Thinking about learning and knowledge together, for example, might make the teacher consider the appropriateness of the content, the standards that the state has adopted to guide curriculum choices, or the context in which the content should be made available for learners. In similar ways, teachers would use the model to focus on the design of the learning environment from assessment-centered perspectives, knowledge-centered perspectives, and community-centered perspectives. I use this framework to guide my review of the literature on the design of learning environments.

**Learner-Centered Perspective**

Learner-centered perspectives put the focus on learners and the knowledge, skills, attitudes, and beliefs learners bring with them. An effective learning environment should address and incorporate students' prior knowledge, utilize and build upon their skills, and address and accommodate their beliefs and attitudes. An effective teacher understands that learners bring with them an understanding of how the world works based on knowledge, experience, and intuition (Vosniadou & Brewer, 1992). These unique understandings need to be taken into account and steps to help learners understand information in their own context should be taken (Au & Jodan, 1981). Teachers also understand that learners construct their own meanings using their knowledge and skills (Bell, 1982a, 1982b) and that their beliefs and attitudes may influence the ways in which new knowledge is constructed (Ajzen, 1985).

Teachers are adult learners. When creating learning experiences for adult learners, professional developers must keep in mind that adults are internally motivated and need to see reasons for learning new material. Adults are also responsible for their own learning and they bring an ample amount of knowledge and skills with them (Mundry, 2002).

Time needs to be spent situating learning for teachers (Putnam & Borko, 2000). Many researchers have argued that learning for all students is not devoid of context (Anderson, Reder, & Simon, 1996; Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). How information and skills are learned, or how they are situated, plays a vital role in the way they become integrated in the learner's cognitive framework. Teachers need learning to be situated so that connections to their personal teaching situations can be seen (Darling-Hammond, 1997; Darling-Hammond & McLaughlin, 1995; Garet, Porter, Desimone, Birman, & Yoon, 2001; Mundry, 2002). The overall design of the ITS Center's PDE accommodated learner-centered perspectives by focusing on teachers as individual learners. Through small group activities and discussions, teachers were placed in an environment where active learning was fostered and encouraged, prior knowledge was engaged, and misconceptions were discovered and challenged. Graduate student mentors engaged their small groups of teacher-participants in active discussions centering on the design of HPL-like learning environments for classroom learners. They modeled the discourse, group work, and created a challenging environment of active engagement personalized to the needs of each learner.

The design of the ITS Center's PDE also situated learning for teachers by providing opportunities for them to connect and apply their learning to their personal teaching situations. Products of teacher learning, Instructional Frameworks and Action Research Plans, were devised personalize teachers' learning. Teachers spent time during the first summer experience discussing, troubleshooting, and writing their Instructional Frameworks. These frameworks connected their understanding of science content, the scientific enterprise, and learning theory to their classroom. School-year requirements offered the teachers an opportunity to implement and reflect on their Instructional Frameworks and Action Research Plans.

**Knowledge-Centered Perspective**

Knowledge-centered perspectives focus on information and skills. This includes the new knowledge we want students to learn and the prior knowledge students bring with them to the classroom. Many documents help define appropriate and worthwhile learning goals (American Association for the Advancement of Science, 1990, 1993; National Research Council, 1996; state standards). Creating metacognitive learning environments that help students take to control of and monitor their own learning also plays a large part in the knowledge-centered lens (Donovan & Bransford, 2005). These types of learning environments offer students opportunities to decide whether information makes sense for them, learn to seek help when it does not, and helps them develop reflective habits of mind so they can improve future performances (Palinscar & Brown, 1984; White & Frederiksen, 2000).

As demonstrated by the previous section on teacher expertise, teacher knowledge plays a large role in effectively facilitating student learning. The NSES emphasize that PDEs should provide opportunities for teachers to build on and bring together their knowledge of science, learning, and science teaching. These experiences should engage teachers in learning through inquiry as well as in practical experiences using their new knowledge in classrooms.

These suggestions mirror those of other researchers who argue that learning for all students is not devoid of context (Anderson, et al., 1996; Brown, et al., 1989; Lave & Wenger, 1991). Like learning for all learners, learning for teachers needs to be situated so that connections to their personal teaching environments can be seen (Darling-Hammond, 1997; Darling-Hammond & McLaughlin, 1995; Garet, et al., 2001; Mundry, 2002).

The NSES also discuss the need for teachers to develop the skills for lifelong learning. Their description of lifelong learning skills includes the metacognitive skills of self-knowledge, self-regulation, and self-improvement expertise. The NSES contend that science teachers need opportunities for practice, feedback, revision, and reflection, mirroring recommendations from literature on learning environments that encourage the development of expertise (Goldman, et al., 1999).

The design of the ITS Center's PDE accommodated knowledge-centered perspectives by focusing on new science content and current research and theory in education. During the morning sessions teachers worked with scientists in their laboratories to learn about cutting-edge techniques, associated with using information technology, to do authentic scientific research. These opportunities also provided the teachers with the chance to interact with scientists and learn about their work and lives. In the afternoons, small-group discussions focused on current educational theory and research. Pairs of graduate student mentors worked with their small groups every afternoon and were supported by the education faculty in a cognitive apprenticeship model (Collins, 2006; Collins, Brown, & Newman, 1989).These two experiences, working with scientists and working with educational researchers, were fused in the crafting of each teacher's personalized Instructional Framework.

Metacognitive skills were fostered as teachers discussed, wrote, revised, implemented, and reflected on their Instructional Frameworks and Action Research Plans. They shared their ideas and received feedback from other teachers, graduate students, scientists, and education researchers. Skills for lifelong learning were specifically targeted as teachers developed assessments for their Instructional Frameworks during the first summer and research questions and methods for their Action Research Plans during the second summer. These activities gave teachers tools for answering questions about student learning in their own classroom. The activities also provided teachers with insight into how their expertise as science teachers could contribute to research and theory on teaching and learning.

**Assessment-Centered Perspective**

Assessment-centered perspectives focus on the ways in which student knowledge, understanding, and skills will be measured. This aspect of the learning environment is not for the sole benefit of the instructor. Feedback and a chance to revise performance are central to student learning (Goldman, et al., 1999; Wiggins, 1998; Wiggins & McTighe, 1998). Metacognition is an important area of focus in assessment-centered, as well knowledge-centered, perspectives. Feedback and chance for revision allow students to come to understand their own strengths and weaknesses as learners and to assess their own learning.

Opportunities for learners to reflect on and revise their performance plays an important part in the development of expertise (Goldman, et al., 1999). Through a process of feedback, revision, and reflection teachers can learn the content of the PDE they are participating in, while learning to self-monitor their performance. The incorporation of metacognitive practice into assessment overlaps with many of the learner perspectives. Allowing opportunities for teachers to actively learn through reflective assessment promotes the incorporation of teachers' prior knowledge and beliefs, situates learning in their own context, and gives opportunities for them to understand the reasons for learning.

Assessment-centered perspectives were accommodated in the design of the ITS Center's PDE. During the first summer, participants crafted their Instructional Frameworks, which went through multiple revisions before the end of the summer experience. Teachers then implemented their Instructional Frameworks in their own classrooms. They reflected on the implementation experience by writing a final reflective paper and completing four surveys during the school year at various stages of implementation. Participants returned ready to discuss and revise their implementations during the second summer experience. They also crafted Action Research Plans where the Instructional Framework became the intervention or the "treatment" of the research plan, which they proceeded to implement and reflect on during the second school year. This iterative process of "plan, do, reflect, and revise" helped teachers to engage in reflective practice and develop metacognitive skills, as well as directly connect their new knowledge to their personal teaching situation. Through this process, teachers gained new scientific and pedagogical knowledge, tested it out in their classrooms with an Instructional Framework that they had designed in the first year and tested and reflected on the impact of the Instructional Framework on student learning during the second year. Guidance, support, and scaffolding were provided through the design of the ITS Center's PDE, as well as discussions with other teachers, graduate students, scientists, and educational specialists.

**Community-Centered Perspective**

The final perspective the HPL framework gives us is that of community. The model shows the community-centered perspective as surrounding, or perhaps embedding, the other three. That the other three perspectives and all of the overlaps between and among them are embedded within the community-centered perspective demonstrates the importance of community in designing an effective learning environment.

The community perspective is multi-leveled. For instance, in a given classroom there may be small group communities: the class itself, the school, the wider community outside the school, and the world. While all of these communities play a role in learning, most emphasis is placed on the within-classroom community. The classroom is the place where communities of learners are formed, where students and their teachers come together to introduce, formulate, share, reflect, and revise new ideas about themselves as learners, as teachers, and about the world in which they live (Brown & Campione, 1996).

Learning for teachers needs to take place in a social, community environment (Garet, et al., 2001; Putnam & Borko, 2000). Teachers need opportunities to learn from and with one another (Wenger, 1998). They need to discuss new information, weigh the pros and cons, and hear different points of views, all of which strengthen their ultimate decision about how information can best be used. Capitalizing on the rich experiences of teachers can greatly enhance PDEs by allowing teachers to connect new information with information they already know (Mundry, 2002).

Putnam and Borko (2000) also argue that, although not commonplace in our schools today, allowing teachers to both work and learn in a community of distributed expertise is highly beneficial to their learning. Distributed expertise is a term describing a community of learners whose members have rich and varied experiences that are valued and leveraged (Lave, 1988). Within communities of distributed expertise, individuals develop expertise of their own and they learn the strengths and weaknesses of others. This allows each member of the community to draw from the collective expertise of the community rather than relying solely on their own knowledge.

Community-centered perspectives, as the HPL framework indicates, encompass everything that occurred within the ITS Center's PDE. Faculty members and graduate student mentors formed a tight-knit community as they participated in mentoring courses offered before participants arrived. Participants worked in small intimate groups with graduate student mentors and faculty members as they attempted to solve their individualized puzzles of how best to transform their scientific research experiences into viable inquiry-based classroom experiences. Participants learned to rely on each other's strengths as well as on the strengths of the graduate students and faculty mentors. These two very important layers of community enhanced the learning experiences of all participants who engaged in the learner-centered, knowledge-centered, and assessment-centered environment designed by the ITS Center.

*Design of Professional Development for Teachers of Science*

Theory and research on the design of PDEs, specifically the design of PDEs for teachers of science and mathematics, embodied the above discussion about effective learning environments and informed the design of the ITS Center's PDE. In particular, the book *Designing Professional Development for Teachers of Science and Mathematics* (Loucks-Horsley, et al., 2003) describes seven principles present in quality PDE. These principles state that effective PDEs are: driven by a well defined image of effective teaching and learning, provide opportunities for teachers to build their content and pedagogical knowledge, are research based and engage teacher as adults in a process of active learning, are collaborative, allow teachers to work with colleagues and other professionals, are integrated with other parts of the educational system, and are designed and continuously evaluated for positive impacts.

A recent study of the teacher feedback from the Eisenhower program revealed six similar features of quality PDEs: (1) form, (2) duration, (3) collective participation, (4) content, (5) active learning, and (6) coherence (Birman, Desimone, Porter, & Garet, 2000; Garet, et al., 2001; Porter, et al., 2003). A second similar study that surveyed 430 science and mathematics teachers from 30 schools derived more specific but similar features of quality: reform-based vs. traditional form, number of contact hours, time span, collective participation, active learning, coherence, content focus, use of technology, higher order instructional methods, and alternative assessment practices (Desimone, Porter, Garet, Yoon, & Birman, 2002). These findings substantiate the characteristics outlined in Loucks-Horsley et al. (2003).

The ITS Center's PDE was driven by the vision of science teachers and science teaching portrayed in the NSES, as well as more current research on inquiry (Chinn & Malhotra, 2002; Edelson, 1997; Etheredge & Rudnitsky, 2003) and how students learn (Donovan & Bransford, 2005). The summer experiences provided opportunities for teachers to build content and pedagogical knowledge through intensive involvement with scientists and education researchers as well as opportunities to test, reflect, and revise ideas. The ITS Center's PDE was research-based, in that it was grounded in research and provided opportunities for teachers to conduct research on their own teaching practice. Through small group activities and discussions, teachers were placed in collaborative environments where active learning was fostered and encouraged as they worked with colleagues, scientists, and education. The constraints of the ITS Center's PDE and its integration with other parts of the education system was probably its weakest feature, although teachers were provided with opportunities to troubleshoot and were counseled on the ways to handle informing administrators, other teachers, and parents about the unique activities they would be implementing in their classrooms. The two iterations leading up to Cohort III, as well as the day-to-day and semester-to-semester progression of the ITS Center's PDE, were continuously evaluated for positive impacts and modified as necessary.

The NSES call for substantive changes to the education system as well as teachers' practice. Southerland, Smith, Sowell & Kittleson (2007) discuss the "resistance to unlearning" present at multiple levels of our educational system. Their discussion demonstrates that, although the education of teachers plays a large role in reform, barriers to substantial change can be found throughout the system. Contextual barriers abound, including increased pressure to maximize student scores on standardized tests from federal mandates such as the *No Child Left Behind Act* (2001) and inadequate resources such as space, equipment, time, and support. Even under the best of circumstances a well-designed PDE cannot address all of these issues and does not assure that teachers are willing and/or able to learn the intended message or change their classroom practices to reflect their learning.

Even though issues above and beyond the control of PDE designers are many, we know that many challenges to reform are "internal to the teacher, including beliefs and values related to students, teaching, and the purposes of education" (Anderson, 2002, p. 7). Research shows that while some teachers are both willing and able to successfully adopt reform-based curricula (Crawford, 2000; Smith et al., 2007), many more are not (Davis, 2003; LaPlante, 1997; Lotter et al., 2007; Yerrick et al., 1997). Many of these teachers wind up writing off or misinterpreting the messages of PDEs and other reform related materials (Cohen, 1990; Smith & Southerland, 2007). As evidenced through my discussion of the learner-centered lens, teachers bring their knowledge, skills, and dispositions with them to a PDE. In order to foster the substantive changes to science teaching portrayed in the NSES, teachers need to see a need for change and view the goals of reform as valuable in order to commit themselves to the challenges reform presents. Because of this, I turned to literature on conceptual change, including literature specific to teacher change, to further inform my thinking about this study.

## Teacher Learning and Transfer

Previous research studies indicate that the dimensions of the HPL Framework, reflected in research specific to quality PDEs, mimic conditions necessary for effective transfer, deep conceptual understanding and change. The purpose of this section is to discuss these bodies of research and apply them to what is known about teacher learning, conceptual change and the context of this particular study of the ITS Center's PDE.

### *Transfer*

The concept of transfer is central to the field of education and is not new to educational research. Transfer is defined as the ability to flexibly apply new knowledge and skills outside of the context in which they were learned (Bransford & Schwartz, 1999; Bruer, 1993). This ability is at the core of our education system. We ask students to apply the knowledge and skills they are taught in the classroom to new problems at the end of the chapter, to written and practical exams, and eventually to a career. Although this section of the literature review focuses on transfer, many connections to the HPL Framework can be made.

Early researchers had ideas about transfer that were very different from the more modern notions of this difficult concept. For example, transfer was perceived to be a static process. Researchers looked for a process or a skill to be transferred to a novel situation shortly after it was learned. These static tests often failed to notice the more subtle aspects of transfer (Bransford & Schwartz, 1999; Bruer, 1993). More recently, researchers have come to understand that transfer is a dynamic process in which learners actively engage in the process of learning and transforming that which was learned into new knowledge.

Research has revealed that there are many different mechanisms and combinations of mechanisms through which transfer occurs. Evidence has been provided for many actions that can play a large role in determining the extent to which information may be transferred.

An instructional focus on understanding rather than on memorizing unconnected bits of information helps learners see the connections to situations outside the initial learning environment (Barron et al., 1998; Bransford & Stein, 1993; Bransford et al., 1982). This includes making sure enough time is available for learners to process new information (Pezdek & Miceli, 1982) and allowing time for learners to uncover underlying concepts so connections between new and prior knowledge can be made (Klausmeier, 1985). Providing time for learners to practice using new skills and knowledge is also an important part of transfer (Chase & Simon, 1973; Simon & Chase, 1973; Singley & Anderson, 1989). Opportunities to develop an internal feedback mechanisms through performance, reflection, and revision (Goldman et al., 1999) can contribute to a learner's ability to transfer information. Motivation affects the time and effort learners are willing to put into learning new material. Motivation can be affected by providing appropriate challenges (Vygotsky, 1978), perceived usefulness of new material (McCombs, 1996), or providing opportunities to contribute to a collaborative group (Cognition and Technology Group at Vanderbilt, 1998). Finally, the context in which information is learned and used can affect what and how new knowledge is transferred (Carraher, Carraher, & Schiemann, 1985; Lave, 1988).

This deepened understanding of the dynamic nature of transfer has led researchers to attempt to categorize different types of transfer. Saloman and Perkins (1989) described two types of transfer, *low-road transfer* and *high-road transfer*. Low-road transfer refers to the automatic trigger of a well-learned behavior in a new context. In order for low-road transfer to occur, this behavior must have been practiced in sufficiently varied contexts for it to become automatic. The situation the behavior is being transferred to must resemble those it was practiced in for the flexible element of the learning to be triggered (e.g., car driving skills used to drive a truck). High-road transfer, on the other hand, involves the learner (a) purposefully abstracting elements of a new situation for use in future situations or (b) deliberately recalling past situations to help solve the one at hand. Unlike low-road transfer, high-road transfer is active. The learner does not automatically use a well learned behavior, but actively uses their metacognitive abilities to abstract aspects of a situation for use in transfer.

Other authors who focus on strategies that promote transfer support this taxonomy. They claim that learners take a deliberate and active process in learning and transferring knowledge as they choose and evaluate strategies, process information, receive feedback, and consider resources (Ericsson, Krampe, & Tesch-Romer, 1993). Often, transfer is not direct. Rather, bits and pieces of what was learned are transferred (Bransford & Schwartz, 1999); and transfer can be enhanced by providing feedback, prompting the learner (Campione & Brown, 1987; Newman, Griffin, & Cole, 1989), or discussing potential transfer implications (Anderson et al., 1996; Klahr & Carver, 1988).

Barnett and Ceci (2002) take a different path in categorizing far transfer as the transfer of knowledge and skills to a context dissimilar to that in which it was learned. These authors focused their taxonomy on the knowledge and skills that transfer rather than how learning environments can promote transfer and the contexts in which transfer occurs. Three main content features of transfer were identified: learned skills, performance changes, and memory demands. Within each feature, different ways in which transfer may present were identified. For example, a performance change may present itself in the change of a learners' speed, accuracy, or approach to a problem. The second portion of their taxonomy identifies six salient features of context which affect transfer; knowledge domain, physical context, temporal context, functional context, social context, and modality. Each of these features is presented on a near-far transfer gradient (Table 2.3). As an example of the gradient for functional context, near transfer may occur in two contexts that are clearly academic, where far transfer would occur between an academic context and a play context.

Both sets of authors (Barnett & Ceci, 2002; Salomon & Perkins, 1989) use their taxonomy to provide evidence that transfer is a dynamic process and occurs more often than other authors claim (Detterman, 1993). The different aspects of and ways in which knowledge can be transferred demonstrate the difficulty many researchers have encountered in attempting to uncover it in past studies. The theory is supported by the observation that transfer is not rare, but highly specific to individual and context. An open mind is needed to uncover it.

*The Influence of Prior Knowledge*

Individuals develop an intuitive understanding of how the world works through their everyday experiences. This understanding is often deep-rooted, resistant to change, and not well aligned with currently accepted scientific explanations (Vosniadou & Brewer, 1992). Through extensive "apprenticeships of observation" (Lortie, 1975) teachers have developed their own intuitive understandings, or as I choose to call them personal practice theories, of science, learning, and science teaching. There is extensive evidence that teachers' personal practice theories drive their classroom practice and affect their ability and willingness to understand, accept, and change their practice to reflect the vision portrayed by current reform (For examples see Kang & Wallace, 2005; Smith & Southerland, 2007; Yerrick et al., 1997).

TABLE 2.3
Taxonomy for Far Transfer (Barnett & Ceci, 2002)

| | Near ←→ Far | | | | |
|---|---|---|---|---|---|
| Knowledge domain | Mouse vs. rat | Biology vs. botany | Biology vs. economics | Science vs. history | Science vs. art |
| Physical context | Same room at school | Different room at school | School vs. research lab | School vs. home | School vs. the beach |
| Temporal context | Same session | Next day | Weeks later | Months later | Years later |
| Functional context | Both clearly academic | Both academic but one non-evaluative | Academic vs. filling in tax forms | Academic vs. informal questionnaire | Academic vs. at play |
| Social context | Both individual | Individual vs. pair | Individual vs. small group | Individual vs. large group | Individual vs. society |
| Modality | Both written, same format | Both written, multiple choice vs. essay | Book learning vs. oral exam | Lecture vs. wine tasting | Lecture vs. wood carving |

Multiple terms have been used to capture and describe the personal practice theories of teachers including: attitudes, values, judgments, opinions, perceptions, conceptions, conceptual systems, preconceptions, dispositions, personal theories, rules of practice, and practical principles (Pajares, 1992). In addition to the difficulty of naming what it is that is being researched about teachers, many of these terms do a poor job at differentiating among knowledge, skills, attitudes, and beliefs (Jones & Carter, 2007; Pajares, 1992). This difficulty is, in part, due to the complexity of human thought that underlies decisions and judgments. Jones and Carter (2007) demonstrated this complexity well in their description of “belief systems”:

> In this chapter, we situate attitudes as a component of an individual's belief system. As Fishbein (1967) noted, attitudes have an affective dimension. Beliefs, however, are integral to larger belief systems that include self-efficacy, epistemologies, attitudes, and expectations. These are all intertwined and embedded in the socio-cultural context. For example, a teacher's beliefs about using cooperative learning in the science classroom cannot be separated from her beliefs about science, science teaching, science learning, her motivation, her self- efficacy, her knowledge of constraints, her knowledge of cooperative learning, her skills using cooperative learning, prior experiences, the class and school context, as well as the larger cultural contexts. Thus beliefs are part of belief systems and attitudes are components of this larger system (Jones & Carter, 2007, p. 1070).

A teacher's knowledge, acceptance, and use of an instructional method depend, as Jones and Carter demonstrate, on a myriad of ideas. Most of these ideas have been extensively observed and practiced throughout a teacher's academic life. These ideas are reinforced and habituated to the point of subconscious automaticity. Teachers' academic experiences, including those in grade school, college, teacher preparation, and professional work, more often than not reinforce ideas more aligned with traditional, teacher-centered methods, rather than the constructivist, student-centered methods advocated by reform (Luft & Roehrig, 2007). The process of helping teachers to adopt the ideas of reform is not one of simply telling or showing them what to do; it involves an extensive process of counter-socialization (Ball & Cohen, 1999).

I found the children's story *Fish is Fish* (Lionni, 1970), as used in the book *How Students Learn* (Donovan & Bransford, 2005), to be a helpful illustration of how life experience and prior understanding affect the interpretation of new knowledge. In the story, a tadpole spends his early life in a pond full of fish, but unlike the other fish he matures into a frog and leaves the pond to explore the rest of the world. He returns to visit his friend, a little fish, and tells him about the things he has seen in his travels. As he describes what he has seen to the little fish, who has never been able to leave the pond and see the land creatures that the frog describes, the little fish uses his own understanding of the world to interpret the frog's stories. Figure 2.5 contains an excerpt from the story.

*"I have been about the world—hopping here and there," said the frog, "and I have seen extraordinary things."*

*"Like what?" asked the fish.*

*"Birds," said the frog mysteriously. "Birds!" And he told the fish about the birds, who had wings, and two legs, and many, many colors. As the frog talked, his friend saw the birds fly through his mind like large feathered fish.*

FIGURE 2.5 Excerpt from *Fish is Fish* (Lionni, 1970).

Much like the frog relating his travels to the fish, education researchers are coming from far outside the "ponds" of teachers and trying to help them understand ideas about current reform. Much like the little fish, teachers interpret this new information within their own ideas about teaching and learning, ideas that have been reinforced and validated by culture, experience, and practice. These understandings influence the ways in which teachers process the ideas to which they are introduced and, much like in the story, their interpretations of our stories of reform become "fish with wings."

This way of thinking about teacher interpretation of and learning about reform is reflected in much of the research on teacher change in response to reform and participation in reform-based PDEs. Cohen's (1990) classic case study of Mrs. Oublier, a California mathematics teacher confronted with reform messages in mathematics education, found that even though she highly valued the message of reform, made significant changes to her classroom, and felt as though she was meeting the recommendations, her perceptions and actions departed significantly from the intention of reform.

More recently, Yerrick, Parke and Nugent (1997) described the "filtering effect" of teachers' beliefs on their interpretation and acceptance of ideas about scientific knowledge and assessment methods. Pre- and post-interviews revealed that, although teachers changed the way they talked about teaching, content, and assessment toward the end of their summer experience, their core beliefs had not only remained relatively unchanged but they had actually inhibited the teachers from understanding the merit of many of the ideas.

A second and even more recent example can be found in Smith and Southerland's (2007) comparison of two elementary science teachers' practices, beliefs, and interpretation of reform messages. They found that both teachers had different interpretations of reform methods, based on the beliefs about learning and teaching science that influenced their practice. Furthermore, they found that reform had not significantly changed the teachers' ideas about teaching and learning but rather the teachers' ideas had significantly impacted the way they had interpreted reform.

## Summary

This review of the literature represents only a small portion of the research that exists on the topics of science education reform, teacher expertise, professional development and teacher learning and transfer. The studies cited here provide support for the assertion that realizing the changes called for by reform is no simple task. The measurement of the transfer of complex skills, such as those involved in an inquiry-based approach to science teaching, is difficult. Changes may be observed in the way a teacher represents a concept to students, the way a lesson is planned or reflected on, the type of assessment used, or the connections made between content and everyday life. No simple test can measure any of these things. The perceptions and practices of teachers need to be deeply studied and analyzed in order for small impacts to be understood. In-depth study of individuals and their perceptions and practices is necessary in order to understand the complexity of learning and teacher input into analysis is invaluable. This study and its design not only lend itself to confronting the complex and dynamic nature of learning and transfer, but also to research on how to best assist teachers in helping their students learn.

# CHAPTER III
# METHODOLOGY

This chapter begins with a literature review that details and justifies the methods included in the design of this study. Included in this review are discussions of some of the underpinning assumptions involved in mixed methodology and case study research. Vital to qualitative research, I also include an in-depth description of my experience both as learner and leader within the ITS Center's PDE. Finally, I include a description of the data sources, procedures and instruments used in the study.

## Characteristics of Mixed-Methods Research

This study employed a two-phase mixed methods design within the context of a multiple case study. The overall design of this study was sequential, with data collection and interpretation from Phase I occurring before data collection and interpretation for Phase II. A visual representation of the overall study design can be found in Figure 3.1.

Mixed methodology is the mixing of quantitative and qualitative methods within the same research design. Mixed methodology is based on a paradigm of pragmatism (Tashakkori & Teddlie, 2002). In this paradigm, research questions drive research methods and methods that assist in acquiring the best answers to the questions. Worldviews are taken into consideration but do not drive the choice of method, unlike qualitative and quantitative designs. Through this mode of operation, mixed-methods lends itself to a systems approach. The employment of mixed-methods benefits this study in my attempt to understand the complexity of the interplay among the school settings, classroom practices, personal practice theories, and teachers' values, perceptions, and interpretations of various aspects of the ITS Center's PDE. While readers will notice that this study is predominantly qualitative, quantitative methods were used to select participants and to triangulate findings. These methods combine to paint a richer picture of three teachers, their classroom practice, and their perceptions regarding their learning in relation to the ITS Center's PDE and how that learning may have been incorporated into their classrooms.

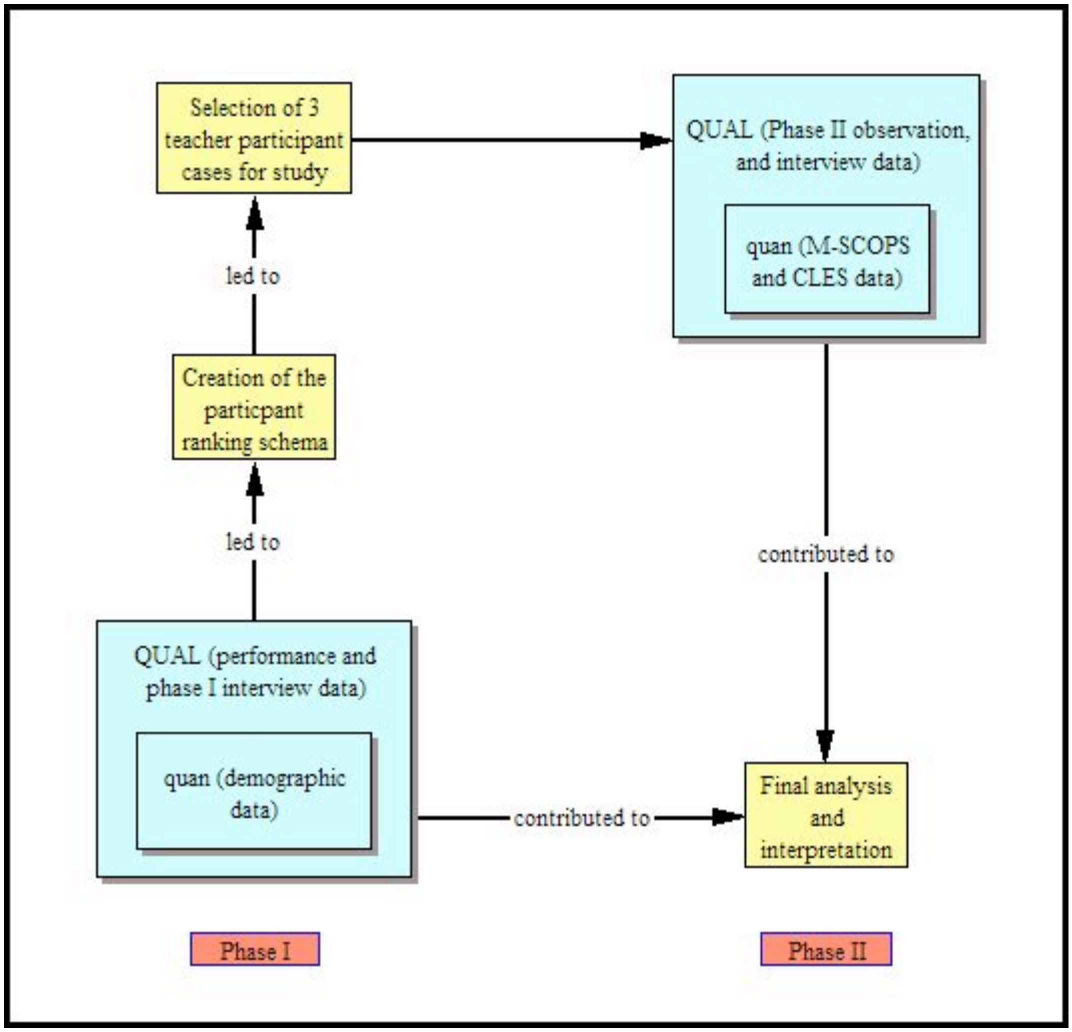


FIGURE 3.1 Overall study design

Recent research demonstrates that earlier conceptions of mixed methodology designs (Creswell, 2003; Tashakkori & Teddlie, 2002) fall short of describing the complexity of reasoning behind the decisions made by researchers (Collins, Onwuegbuzie, & Sutton, 2006). Current conceptions avoid the use of an overall pattern of method mixing, choosing instead to mix methods in different ways with varying degrees at each level of analysis. Much like the methods employed in this study, a researcher may choose to mix methods in different ways at different stages of research. A focus on quantitative methods may be prevalent at beginning stages of research, such as during this study's participant selection phase. The focus may shift to more qualitative methods as the focus of the research shifts either through a change in research phase from one of selection to understanding or as the process of analysis informs design. The focus is not on consistency, as would be desired in a quantitative study, but rather on the utility of the methods in providing the richest answer to the research questions at hand, hence the paradigm of pragmatism.

In this particular study, methods are mixed (a) for participant selection; (b) in the collection of both quantitative and qualitative data from students, teachers, and classroom observations; and (c) in the combination of data from all sources (both quantitative and qualitative) to answer the research questions. This data also serves to inform theory regarding the connections among the school settings, classroom practices, personal practice theories, and values, perceptions, and interpretations of various aspects of the ITS Center's PDE.

## Characteristics of Case Study Research

Case study research stems from a philosophy similar to mixed-methods, in which the research questions are one of the main determinants of the research strategy that is to be used (Yin, 1994). Case study does not imply methodology; rather it implies that a single or small set of cases form the basis of the research strategy and the methods used stem from this focus. Studies involving several cases related to one another in some way can take the form of a multiple case study, which narrows the study of the cases to a particular objective, phenomenon, or condition.

Yin (1994) outlined five main characteristics applying to most case studies: (1) importance of context, (2) detailed analysis, (3) importance of relationships and interactions, (4) small sample size, and (5) multiple data sources. Each of these characteristics is well supported by other authors (Merriam, 1998; Orum, Feagin, & Sjoberg, 1991) and evident in this study.

Context is an integral part of any case study. The cases in this study were drawn from the full-time teachers who participated in the ITS Center's PDE, which is an example of "a specific temporal and spatially bound context which was an obvious example of a program, event, or situation" (Merriam, 1998, pp. 9-10). The context of the ITS Center's PDE played a vital role in this study, because it formed the basis from which everything in this research was accomplished. Context belied the development of research questions, methodology, analysis, and interpretation at every step of the way.

This study also incorporated a detailed analysis in which "the observer renders the social action in a manner that comes closest to the action as it is understood by the actors themselves" (Orum et al., 1991, p. 8). This notion of detailed analysis is reinforced through the ageless and poetic work of Geertz (1973). He discussed the necessity of understanding an individual's actions in relation to the culture from which they come, which can only come from deep discernment and detailed or "thick" description. He states:

> As interworked systems of construable signs (what, ignoring provincial usages, I would call symbols), culture is not a power, something to which social events, behaviors, institutions, or processes can be causally attributed; it is a context, something within which they can be intelligibly—that is thickly—described. (p.14)

Wolcott (1994) further reinforces this idea with his discussion of "detailed analysis," which he breaks down into three separate components: description, analysis, and interpretation. I made an effort to describe my experiences observing and conversing with the participants in detail before moving toward an analysis of their actions and thoughts and finally toward an interpretation of what I had experienced.

The final two characteristics of case studies, small sample size and multiple data sources, are also evident in this study's design. Three participants were ultimately chosen for participation in this study; I collected many forms of data from each of them. Wolcott (1992) described three modes of qualitative data collection: participant observation (experiencing), interviewing (enquiring), and studying materials prepared by others (examining). I used all three of these qualitative modes in this study. I also included more the more quantitative measures of the *Classroom Learning Environment Survey* (CLES) (McRobbie & Tobin, 1997) and the *Mathematics and Science Classroom*

*Observation Profile System* (M-SCOPS) (Stuessy, 2002), to provide a means for data triangulation and to enhance my interpretation of events and experiences.

Characteristics of Multiple Case Study Research

When a multiple case study approach focuses on a particular target, the term *quintain* can be used to delimit the focus of the study: "A quintain is an object or phenomenon or condition to be studied – a target, but not a bull's eye. This quintain is the arena or holding company or umbrella for the cases we will study" (Stake, 2006, p. 6). The focus of this study, or quintain, was the relationships among the school settings, classroom practices, personal practice theories, and teachers' values, perceptions and interpretations of various aspects of the ITS Center's PDE.

The focus of this research was this specific phenomenon – relationships among teachers' values, perceptions and interpretations of the ITS Center's PDE and how their school settings, classroom practices and personal practice theories impacted their perceptions. The focus was not on the ITS Center, nor was it a focus on a single participant as a whole. The shift of focus from case to quintain changed the ways in which I viewed the data. Data were examined, analyzed, and evaluated in relation to the quintain. This focus allowed for a more thorough understanding of the teachers in the study as individuals through the filtered lens of the quintain.

The focus of my research on this specific phenomena emerged as I taught and reflected on the teachers' and graduate students' learning from the ITS Center's PDE. What each individual noticed and took away from the experience differed greatly. Some participants seemed to understand and interpret ideas from the ITS Center's PDE. Others seemed to misunderstand and misinterpret those same ideas. I wondered about the underlying characteristics that caused or influenced individuals to perceive and interpret the ITS Center's PDE in such different ways. I decided that the best way to answer this question was through an in-depth study and analysis of a few individuals.

Two levels of analysis are performed in a multiple case study: within-case and cross-case. The format of this dissertation reflects these two levels. Each case is first presented by itself in a separate chapter. Chapters IV, V, and VI present an in-depth and intertwined “thick” description and detailed analysis of all data collected from the individual teachers. Chapter VII presents the cross-case analysis, which brings the three cases together and discusses the similarities and differences among them.

## Role of the Researcher

The predominantly qualitative nature of this study makes my role as researcher central to the analysis and interpretation of the data (Creswell, 1998, 2003). As the main “instrument” used in analysis, I acted as an interpreter and distilled my experiences and data through the lens of my unique perspective. My experiences participating in the ITS Center’s PDE in a variety of capacities (i.e. participant, mentor, designer, and instructor) offered me a unique understanding of the context and data. These perspectives allowed me to relate to the challenges faced by the participants, designers, and leaders of the PDE. What follows is a description of my own experiences, which detail my experiences and the different perspectives I gained through my involvement in the ITS Center’s PDE as participants, mentor, designer, and instructor. Through these roles I gained a unique understanding of the difficulties learners faced during the experience, the reasoning behind the design of the PDE, and the difficulties of executing our design. I developed a personal interest in conducting this study as the research questions stemmed from the many questions about participant learning that arose from my experiences. In writing this, I am assuming that the reader is familiar with the ITS Center’s PDE or has read my description and discussion of it in Chapter II.

I began my involvement in the ITS Center’s PDE as participant during the summer of 2003 just after completing my master’s degree in entomology. The summer I entered the program was the first summer of Cohort II, the PDE’s second iteration. I had little experience with educational research as I had only taken two education courses during my master’s degree. I was learning many of the ideas that were presented during this first summer for the first time along with most of the other participants.

I spent every morning for three weeks working with about ten teachers and four scientists in a research team focused on biodiversity. Together we learned how scientists in the wildlife and fisheries sciences, entomology, and geography worked together, separately, and with the community in their research. We also worked together as a team to incorporate some of these ideas into workable classroom projects.

We spent each afternoon being shuffled around to different education specialists to work on online course modules centered around *How People Learn* (Bransford et al., 2000). We listened to lectures and engaged in activities focused on a variety of topics (e.g., assessment, inquiry, and the nature of science). My fellow participants and I struggled to incorporate these new topics into workable and acceptable Instructional Frameworks (IFs), which were to be the products of both the work with the team of scientists, who provided the content for the IF, and work with the team of education specialists, who provided the pedagogical framework for the IF.

After that first summer as a participant in the ITS Center's PDE, I began working on a Ph.D. in Curriculum and Instruction. I was funded as a Graduate Assistant for the ITS Center. I attended weekly Graduate Assistant meetings focused on the Centers' research agenda and worked with faculty and other graduate students designing the PDE for the participants returning for the second summer session. With a few other participants from Cohort II who had also become graduate assistants and a few more from Cohort I, I took on the new role of Campus Resource Person (CRP).

The CRPs were meant to be mentors to help the participants returning in July write their Action Research Plans (ARPs). ARPs used the IFs from the previous summer's work as "transformed" research interventions for studies designed by ITS participants). We began discussing and planning how we might prepare ourselves to fulfill our CRP duties. We decided that the best plan of action would be to focus our efforts during a three-week summer course before the July PDE. In the summer course we designed resources for the returning participants, learned about current research on mentoring and action research, and developed small-group mentoring strategies to assist participants in their struggle to design their plans for classroom research.

July came and I was reunited with the other participants in the biodiversity group. I began my role as CRP and helped the other participants develop and edit their Action Research Plans. The participants spent most mornings and afternoons busily writing either in the Wildlife and Fisheries Sciences computer labs or spread out in the education building on borrowed laptops. As a CRP I learned more about the difficulties other participants experienced as I helped them flesh out ideas about their projects, find supporting literature, develop research questions, and craft workable methodologies. I was neither exclusively teacher nor learner, but somewhere in between helping as best I could.

One of the main roles of the CRPs was that of liaison between the instructors and the participants. Since we were not instructors and had been participants the summer before, we were seen as friends and the current participants felt comfortable confiding their problems, frustrations, and fears to us. Our evenings as CRPs were spent looking over daily feedback forms and discussing what we could do to improve the quality of work and help with the problems the participants were facing. We spent time determining what kinds of help would be of greatest benefit to the participants during the coming days.

The second summer came to a close and the teacher-participants returned to their homes. Our weekly GA meetings resumed with the fall semester and we began discussing the design of the first summer of Cohort III. Again, an intensive three-week summer course occurred in which the CRPs, along with the PDE's instructor, Dr. Carol Stuessy, worked together to design the course and develop resources for the participants.

The ITS Center determined, from the successes of our experiences mentoring participants the prior summer, that a sense of community was paramount to the success of the Cohort, much like the *How People Learn* framework indicates (see Figure 2.4). A focus on small-group discussions led by pairs of CRPs was decided to be the best approach. We spent the majority of the three week course planning the first week of the summer experience, creating a "blueprint" for the IF, and selecting the readings that would form the basis of the afternoon discussions. Our role as CRPs in the coming summer was to be more intense than it had been the previous summer. We were to act more as instructors than participants and we were to help foster a community of learners in which ideas were shared and IFs were written and discussed.

The next summer session with participants went smoothly. Most participants seemed content with our PDE design and were able to complete their IFs with relative ease. As CRPs, we were seen as mentors and friends; participants still confided in us much like they had in the previous cohort. Our evenings were spent relating the problems and desires of the participants to the instructor-of-record for the course, Carol Stuessy (who had also been our instructor in the CRP course) and revising papers.

Once more the summer came to a close and as the fall began our weekly GA meetings commenced. Dr. Stephanie Knight, the instructor for the second summer, scheduled our CRP course to meet for 90 minutes once a week during the Spring Semester. We spent our time in these meetings designing the blueprint for the ARPs, discussing how to best introduce the blueprint to the participants, and developing a database of educational articles and instruments that would aid the participants in completing their projects.

Participants were largely independent the second summer. They gratefully accepted the afternoons as free time during which they worked on their Action Research Plans and dutifully turned them in periodically for revision. My role reverted to an "as needed" mentor for the largely independent participants and, along with my CRP partner, I offered short help sessions during the first hour of each afternoon on participants' requests.

I spent four summers working on the ITS Center's PDE, first as a participant and then as a CRP. My immersion in the PDE allowed me to have a firm grasp on the goals of the ITS Center and an in-depth knowledge of what was taught and how the experience was received by its participants. This wealth of experience offered me a great deal of insight into the project at hand and allowed observations to be made that might be missed by someone who had not had these experiences. This variety of experiences afforded me a unique lens as a researcher. I was able to understand how the participants felt as they learned about and tested new ideas about knowing, learning, and the nature of science in their classrooms. I was also able to understand the journeys of the researchers and graduate students who designed the Center's PDE and to share in the hard work and high hopes that went into its orchestration. It was from this perspective that I approached this study and peered into the lives of a select few participants.

## Data Collection and Analysis Procedures

Figure 3.2 represents the overall progression of the procedures for data collection and analysis.

*Performance Artifacts*

The ITS Center's PDE was not solely a PDE; it was also a series of four graduate level courses. Participants were enrolled as non-degree seeking students at the university and received 6 graduate credit hours for completing each summer experience. Much like a typical graduate course, participants were required to submit a final paper at the end of each summer. Participants spent the majority of time constructing these two papers during the afternoon sessions of each summer of the ITS Center's PDE. During the first summer, participants were asked to translate what they had learned into an Instructional Framework (IF) (summer I). The following school year, participants returned to their classrooms to implement their IF. Upon completion of this implementation, participants were required to submit a reflection paper detailing how the implementation went (SYI Summary Paper). The following summer, they returned to campus for the second summer armed with observations, student work, and questions to craft an Action Research Plan (summer II) that utilized their IFs as interventions. A visual representation of the fit of the performance artifacts fit in the overall design of the ITS Center's PDE can be found in Figure 2.1. After the ITS Center's PDE was completed, I collected electronic copies of each of the teacher-participants' performance artifacts. These artifacts contributed to my analysis during both phases of this study.

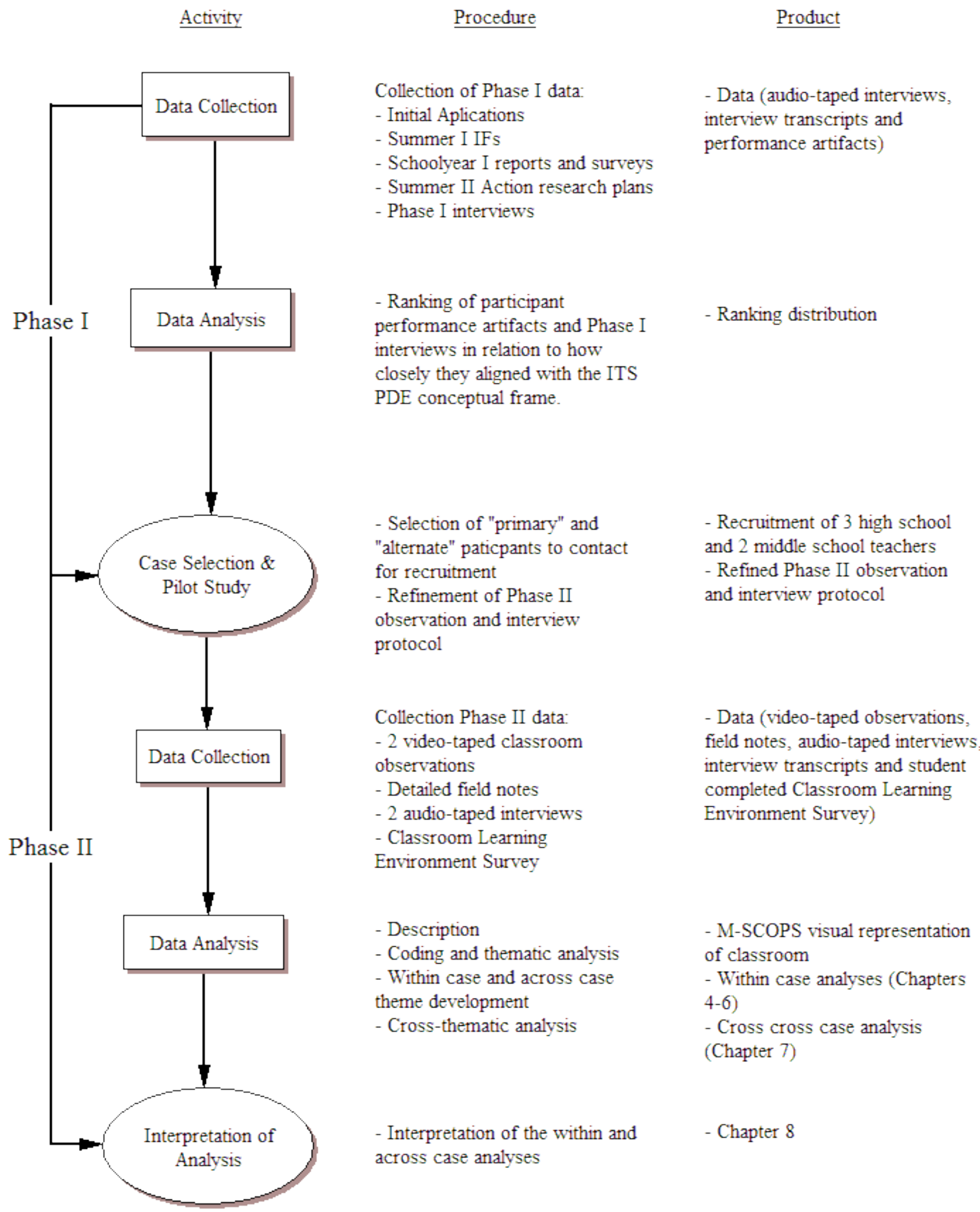


FIGURE 3.2 Data collection and analysis procedures

*Exit Interviews*

During the final three days of the second summer of the ITS Center's PDE, all 32 of the teacher-participants were asked to sign up for a 20-minute block of time in which to be interviewed. I conducted each interview in a structured format so that each teacher-participant was asked the same series of eleven questions (Appendix B). These questions focused on participants' perceptions of the ITS Center's PDE and its effects on their teaching and their thinking about their teaching. Interviews were recorded and transcribed verbatim.

*Classroom Observations*

Five teachers were chosen for participation in Phase II of this study and agreed to participate. They were contacted and asked for dates and times when the observation of their classrooms could be completed. Each observation was followed by a post-observation interview. I traveled to each teacher's school on two separate occasions and observed them teach two different classes of students. Each of these classes was videotaped with the camera focused solely on the teacher when possible, or on the ceiling or wall when it was difficult to avoid filming students, as per IRB requirements. During these observations I observed as unobtrusively as possible and concentrated on taking detailed field notes as I completed an M-SCOPS Scripting Sheet (Stuessy, 2002) in order to construct an accurate description and M-SCOPS Profile once the observation was complete.

*M-SCOPS Use and Interpretation*

The M-SCOPS used in this study provides a visual representation of what occurred in the classes observed. These Profiles allow multiple facets of teachers' classrooms to be more easily compared and they also facilitate a discussion of the differences. Before I begin to analyze what I observed in each teacher's classroom and compare the teachers to each other, a discussion of the M-SCOPS Profiles and how they are interpreted is necessary. The in-depth understanding of the classroom observations and how the Profiles relate to the actions of the teachers and students within them will greatly aid in forming a better understanding how the teachers' lessons compare to one another.

The M-SCOPS Profile depicts four dimensions of what occurs in a classroom: instructional scaffolding, representational scaffolding, segmentation, and flow. When these four elements are combined in the pictorial representation of a science or mathematics lesson, the researcher can go beyond description to a more holistic analysis of the lessons in which overall patterns within and between the lessons of different teachers can be seen and interpreted.

The primary focus of an M-SCOPS Profile is on the students' actions during a given lesson. The Profile is divided into two "halves." The left half of each Profile represents information students are receiving and/or actions they are being directed to perform (R&D). The right half of each Profile represents what the students are doing themselves through actions they are performing and the initiative they are taking to enhance their own learning (P&I). Both sides of the Profile have other features coded through segments and colors that are interpreted to represent the four dimensions of a classroom as listed above.

The first of those four dimensions is that of instructional scaffolding (IS), depicted by the central red band. The IS band remains the same width throughout the M-SCOPS Profile and its placement, more to the left or right of the median line, represents one of 6 levels of student centeredness (see Table 3.1). If students are doing the majority of acting, or performing, and taking more initiative for their learning the red band would be more on the right, or the P&I side of the graph. If you refer to the M-SCOPS Profile of Mrs. Patton's first observation (Figure 6.2) you can see that the red band is mostly on the right in segment 5 while the students are working in groups to design an inclined plane lab. If students receive a lot of information, in a lecture, for example, the majority of the red band would be on the left side, or the R&D side of the graph. A good example of this can be found in Figure 4.1, segment 2 when Mrs. Lewis is giving her students a power point presentation and they are in their seats taking notes and listening.

TABLE 3.1
M-SCOPS Levels of Instructional Scaffolding Strategies (Stuessy, 2002)

| *R&D/P&I* | *Instructional Strategy* | *Examples* |
|---|---|---|
| 5/1 | Individual students are directed to listen as the teacher or another student talks to the entire group; students are directed to read or do seat work; assimilation and/or accommodation occur passively with little or no interaction with others | Direct instruction models, including those where the teacher asks rhetorical, yes-no or one-word answers; lecture, silent reading, independent practice, seat work |
| 4/2 | Individual students respond orally or in writing to questions asked by the teacher, in whole group | Teacher-led recitation; question and answer; discussion led and directed by the teacher |
| 3/3 | Students in pairs or small groups work together under the teacher's supervision – with discussion; all groups do basically the same task | Student discussion in groups; may include task completion, verification laboratories, cooperative learning models |
| 2/4 | Groups and/or individual students work on different tasks with some choice; loosely supervised by the teacher | Student- or group-initiated work on options or suggestions provided by the teacher; while options provide choice in "centers" or learning situations, the teacher has structured the choice |
| 1/5 | Students in pairs or small groups discuss, and/or formulate their own plans for working in class on a specified task; minimal supervision | Open-ended laboratory or project work, invited by the teacher, but definitely where students are less restricted |
| 0/6 | Individuals or groups carry out their own work independently; minimal supervision | Individualized laboratory or project work |

The second dimension of an M-SCOPS Profile is representational scaffolding (RS), represented by the yellow, green and blue bands. RS depicts the representation of the content students are receiving and/or acting upon. There are three different types of RS represented by the three different colors of the RS band. The color yellow depicts the use of words and symbols, the color green depicts the use of 2-D images such as pictures, graphs and charts, and the color blue depicts the use of 3-D objects or manipulatives. The width of the RS band demonstrates which of six levels of thinking complexity students are using while working with the materials they are given (see Table 3.2). For example, in the M-SCOPS Profile of Mrs. Patton's first observation the segments numbered 2 and 3 have both yellow and green RS bands. These segments represent the portion of Mrs. Patton's class where she is working out the internet homework problems and the problems containing new material on her computer with the students following along in their seats. During this portion of the lesson, Mrs. Patton is using RS in the forms of symbols (represented by the color yellow) as she writes out words of the problems and 2D images (represented by the color green) as she draws pictures and graphs depicting what is going on in the problems. The colors are 4 units wide because students are acting on the information they are receiving in many of the ways described in the "transform" level of complexity (see Table 3.2) as they are working the problem along with Mrs. Patton and asking questions.

If we look at segment 5 of the same lesson, we see a different configuration of colors. This segment of the M-SCOPS Profile represents the portion of the class in which students are designing the incline plane labs in groups. During this activity students are using all three types of RS. They are using words and symbols as they talk with one another and write formulas and directions on paper, they are using pictures and graphs as they draw the objects on paper, and they are using 3D manipulatives and technology as they place the block of wood on the incline plane and use the force probes to measure the forces acting upon it. The colored bands are six units wide since the students are generating new ideas and performing many of the types of thinking that can be found in the 6th level of RS complexity, aptly called "generate."

Looking at the profiles reveals the third and fourth dimensions of the M-SCOPS Profile: segmentation and flow. Segmentation refers to the breaks in activity that students are given. Each segment is noted by a different number and often a shift in the levels of IS and/or RS.

TABLE 3.2
Complexity Levels of Representational Scaffolding (adapted from Stuessy, 2002, p. 6)

| *Action* | *Level (Code)* | *Receiving* | *Acting* |
|---|---|---|---|
| Attend | 1 | External or superficial features, attributes, directions to perform a level 1 action | Listen to, attend to, observe, watch, read, view |
| Replicate | 2 | Pictures, models, examples, identifications, descriptions, explanations, clarifications, calculations, duplications, measurements, reproductions, demonstrations, algorithms, level 2 directions | Recall, remember, list, tell, label, collect, examine, manipulate, name, tabulate, identify, give examples, describe, explain, clarify, calculate, document |
| Rearrange | 3 | Comparisons, groupings, sequences, patterns, rearrangements, balancing, classifications, disassembled parts of a whole together, level 3 directions | Compare, group, put in order, rearrange, identify a pattern, paraphrase, balance, classify, identify parts of a while, assemble parts to make a whole, disassemble parts of a whole |
| Transform | 4 | Different representations of the same system; arrangements of complex parts into a whole system transformation, changes, level 4 directions | Represent symbolically or pictorially, experiment, interpret, contrast, apply, modify, make choices, distinguish, differentiate, transform, change, arrange complex parts into a system |
| Connect | 5 | Alternative points of view, connections, relationships, justifications, inferences, plans, hypotheses, analogies, systems, models, solutions to complex problems, level 5 directions | Connect, associate, extend, illustrate, explain relationships in a system, use and/or connect representations to develop explanations, explain different points of view, infer, predict, plan, analyze, generate solutions to complex problems already conceived |
| Generate | 6 | Analyses, evaluations, summaries, conclusions, abstract models and representations, problem scenarios, level 6 directions | Justify, defend, support one's own point of view, develop or test one's own hypotheses or conceptual models, define relationships in new systems, generalize, recommend, evaluate, assess, conclude, design, generate a problem, solve a problem of one's own generation |

Looking at the ways in which the segments change, one can see a lesson's flow. If we combine what we know about what occurred in Mrs. Patton's class the first time I observed her with the concept of flow, when thinking about the M-SCOPS Profile of that lesson, we can get a good idea of how her interaction with her students changed over the course of the lesson. Mrs. Patton's lesson began with some short announcements, represented by segment 1, moved to her solving various problems in segments 2 and 3, continued with her giving instructions for the lab students are about to work on in segment 4, shifted to students actually working on the lab in segment 5, and concluded with her bringing the students back to their seats, going over what they did and giving final instructions about lab write ups and homework for the next class.

When viewed together and pictorially in an M-SCOPS Profile, these four dimensions of a teacher's class can give us an easy way to compare what is going on in each. As the rest of the teachers' lessons are described and the Profiles representing them are seen, stark differences in the ways they teach and the flow of their lessons are revealed.

As we progress through the rest of the observations, distinct differences between the teachers' lessons become readily apparent when one views the M-SCOPS Profiles than they are in the descriptions alone. These differences include the number of segments in a lesson, the level of IS, the type and level of RS, the overall complexity of the lesson, and the amount of time wasted during lessons. The Profiles give us a starting point, an easy method of comparison to other lessons, and add to the overall analysis and interpretation of the cases in this study.

*Post-observation Interviews*

In all cases but one, post-observation interviews occurred immediately after the completion of the observed class. The one exception occurred during my second visit to Mrs. Major's class. Because of an after school meeting I had to wait an hour before she had time to complete the interview.

Each post-observation interview had three main parts to it. (Appendix C) The first of these parts was unique to each set of interviews, while the second and third parts remained the same for both. The first part of the first interview focused on collecting what I would call a "teaching history." During this portion of the interview I asked questions about the teachers' general background, their certification process, their likes and dislikes about teaching, and the collaborative and professional development activities they participated in. The first part of the second interview focused on the participants' motives for applying to and subsequently attending the ITS Center's PDE. I wanted to know where they had found out about it, what they knew about it, and what they thought they might learn from it before they dedicated themselves to it for two years. I also wanted to know if and how they saw it as being different from other PDEs they had attended in the past.

The second portion of both interviews focused on the thought process behind the lesson I had observed that day. This portion included questions about how typical of their teaching the lesson was, how they had planned for the lesson, if there was anything they would change about how the lesson went, and the evolution of their thought process about teaching this topic over the years. Many of these questions moved away from the specific lesson I observed and were answered in a more general manner as they talked about trends in their teaching.

The third and final portion of both interviews focused on the impact, if any, the ITS Center's PDE had had on their teaching or thinking about the lesson I observed and on their thinking or teaching in general. These questions provided me with a lot of insight into each teacher's personal practice theories and how they may have affected their incorporation of ideas from the ITS Center.

*Classroom Learning Environment Survey*

During my second and final visit to the classrooms, each teacher was given 100 copies of the Classroom Learning Environment Survey (CLES) (McRobbie & Tobin, 1997) (Appendix D) along with a postage paid envelope. I asked each teacher to have their students fill out the CLES before the end of the fall semester. Upon receipt of the completed surveys I used a combination of SPSS and Excel to create the frequency distributions and graphs that can be found in Chapter VII.

The CLES was chosen as an instrument because of its alignment with the HPL framework (Figure 2.4). This framework played a large part in the design of the ITS Center's PDE and the design of the participants' IFs. The survey asks students to answer 25 questions on two Likert scales: desired and actual. These scales ranged from very often to never and students were asked to circle the number corresponding to how often they would like to see a particular action occur in their classes (desired) and how often they actually experienced that action (actual). The 25 questions were evenly distributed to assess student perceptions of five constructs: participation, autonomy, relevance, commitment to learning, and disruptions to learning.

## Phase I Data Collection and Analysis

The first phase in the design of this study was dedicated to case selection. Within this phase I conducted an exit interview with each teacher-participant individually. I also accumulated their performance artifacts (IFs, School Year I Reflection Papers, and ARPs) and quantitative demographic data. From this data, five teacher-participants were ultimately recruited for participation in this study and three of those teachers were included in this dissertation. My goal in the selection of these participants was to diversify the cases in the best way possible in order to maximize what could be learned from them. What follows is a detailed account of all of the procedures and decisions that contributed to the four steps that took place during this phase.

### *Step 1 –Exclusion*

Interviews and other documents were analyzed to see which of the 30 teacher-participants were going to be full-time public school science teachers during the 2006-2007 academic year. Twelve teachers were excluded in this first step. Exclusions were based on the following:

- 2 teachers were excluded because they were part of the project team that the researcher taught
- 1 teacher was excluded because she worked at a private school

- 4 teachers were excluded because they were changing jobs and would become specialists or principals instead of classroom teachers in the next year
- 3 teachers were excluded because they were community college instructors
- 2 teachers were excluded because they taught mathematics, not science

*Step 2 – Categorization*

The intention of this study was to examine the school contexts, teaching practices, and personal practice theories of the three teachers and how these characteristics influenced their perceptions and interpretations of the ITS Center's PDE. Because of this, I decided to choose case study participants from the 19 full time public school teacher-participants based on how well the ideas expressed in their performance artifacts and exit interviews aligned with the conceptual frame of the ITS Center's PDE. An overview of this conceptual frame can be found in the course syllabus (Appendix A). In order to maximize what completing this study could reveal, it seemed important to me to choose participants with diversified contexts, views, and understandings. I hoped that by diversifying my choice of participants in this manner I could select teachers who differed in their school contexts, classroom practices, and personal practice theories as well as their perceptions and interpretations of the ITS Center's PDE. Additionally, selecting cases based on diversity across contexts is a practice advocated by Stake (2006).

After reviewing all of the performance artifacts, it was evident that three of the artifacts, the exit-interview transcripts, the School Year I (SYI) summary papers, and the Summer II Action Research Plans (ARPs), gave us an adequate understanding of how each participant's ideas aligned with the conceptual frame of the ITS Center's PDE. These three artifacts from the remaining 18 teachers were comparatively analyzed and ranked by myself and another graduate student in order of the understanding they demonstrated. Each document was read, discussed, and compared to the others of the same type. Discrepancies were discussed until both researchers agreed on the appropriate place in the ranked order for each performance artifact.

Two more participants were excluded during this step because they were found to have worked collaboratively on one project for which they both submitted the same paper. Their individual ideas and understandings could not be easily separated from this one paper.

After all of the documents had been ranked we decided where the breaks between levels occurred by clustering performance artifacts with similar qualities within the same level. After each performance artifact had been assigned to a level, a table containing the level of each participant's performance artifacts was constructed and all but one participant could be easily placed into an appropriate level.

The ranks of the performance artifacts of the one participant who could not be placed within a level were too different to easily place her in one level. Her interview transcript had been ranked close to the top and her SYI Reflection and Summer II ARP had been ranked close to the bottom. Because of this discrepancy she was labeled as an "interesting case" and it was decided that she would be contacted for participation in the study.

The remaining 15 participants were easily separated into five distinct categories. We used the designation low to high to name these groups since they were based on our comparative rating. A designation of "low" signified a low level of alignment with the expressed ideas in the conceptual frame of the ITS Center's PDE, while a designation of "high" signified a high level of alignment. Participant distribution was as follows:

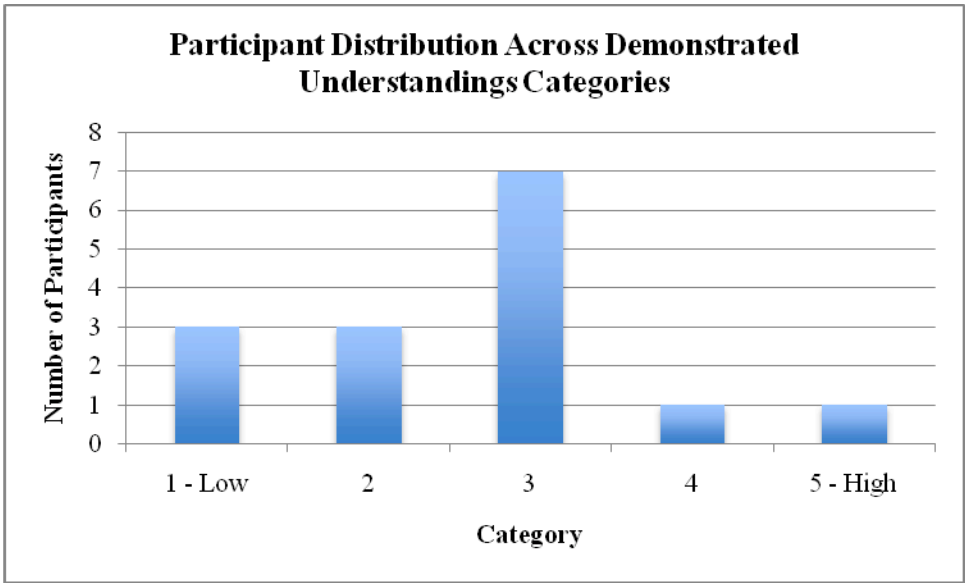


FIGURE 3.3 Distribution of ITS teacher-participant alignment (n=15).

*Step 3 – Case Selection*

It had already been decided to contact the teacher we had labeled as an "interesting case" for participation in Phase II of this study. Other cases were selected purposefully from the distribution shown in Figure 3.3 in order to maximize diversity in the sample.

During this step, four teachers were labeled as being undesirable for participation in the study. Two of these teachers were labeled as such because of the distance required to travel to observe them teach (over 1000 miles). One was eliminated because of his lack of focus during the exit interview (i.e. he gave run-on answers that did not come close to answering the questions asked) and another because all indications were that he was an uninspired and unresponsive participant from whom little could be learned.

I decided that I would make an attempt to recruit three middle school and three high school teachers for participation in the second phase of this study. One of the top two scoring teachers was a middle school teacher and the other was a high school teacher, so I chose them to be contacted. I explored the demographics of the remaining nine teachers. Four were listed as "primaries" and the rest labeled as "alternates" in case the primaries could not be contacted or declined to participate. The main variables used in choosing primary vs. alternate candidates were school size and the ITS project team in which they had participated, with a focus on maximizing diversity.

*Step 4 – Participant Contact*

Of course, everything is easier in theory than in practice and my beautiful plan fell through in places when participant recruitment began. E-mails were sent to the seven participants selected as primary cases on October 5, 2006 the same day that IRB approval was granted. The teacher labeled as "interesting" immediately declined for personal reasons, four of the other teachers immediately agreed to participate in the study, and the final two did not respond. Multiple attempts were made to contact the other two participants by both e-mail and phone with no luck. On October 23rd, 2006, the decision was made to contact three of the alternate participants who were closest in all factors to those who had not replied. One of these three immediately consented to participate. No heavy attempt was made to contact the remaining teachers because neither of them fit the unfilled place in the study.

Each of the six teachers who had consented to participate in the study were asked to submit a letter from the principal or school board stating their school's consent to participate as required by the IRB. Five of the 6 teachers complied immediately. The sixth teacher's school district had its own "Research Board" which had to approve all studies being implemented in their district. This board met a few times a semester and their scheduled meeting took place the week after Thanksgiving. At this meeting it was determined that their district was engaged in too many studies to allow any new ones to begin and my request for approval was denied.

The final sample that consented to participate in the second phase of this study consisted of two middle school teachers and three high school teachers. The general characteristics of the recruited teachers are as follows:

TABLE 3.3
Demographic Distribution of Teachers Recruited for Study Participation

| *Teacher* | *Rank* | *Grade* | *Subject(s) taught* | *School Size* |
|---|---|---|---|---|
| Mrs. Black | Low | 8th grade | Middle school science | 2500+ |
| Mrs. Spade | Medium | 6th grade | Regular and honors science | 2500+ |
| Mrs. Patton | High | 10-12th grade | Pre-AP and AP physics, | 2500+ |
| Mrs. Major | Medium-low | 9th grade | Biology and IPC | ~2000 |
| Mrs. Lewis | Low | 11th& 12th grade | General, pre-AP and AP physics and chemistry | ~400 |

## Phase II Data Collection and Analysis

During Phase II I collected two sets of classroom data for each of the five teachers recruited for the study. These sets of data included two video-taped classroom observations coded using the *Mathematics and Science Classroom Observation Profile System* (M-SCOPS) (Stuessy, 2002) and two semi-structured interviews for each teacher (Appendix B). Each teacher was asked to have their students complete the *Classroom Learning Environment Survey* (CLES) (McRobbie & Tobin, 1997; Appendix C) before they left for December break.

My early analysis of the Phase II data I had collected from each of these of these teachers revealed that a cross-case analysis of both middle and high school teachers would be difficult to accomplish. The two groups were drastically different in the content that they were expected to teach and the pressures placed upon them by their students and schools. In response to this, I eliminated the middle grade teachers from my research plan and decided to concentrate on the three remaining high school teachers, Mrs. Lewis, Mrs. Major, and Mrs. Patton. A comparison of the characteristics used for selection can be found in Table 3.3.

As recommended by other qualitative researchers (Bogden & Biklen, 2003), data collected in Phase I and Phase II was combined and analyzed holistically. Although it sounds straightforward to say: “data was combined and analyzed holistically,” I have come to understand that qualitative data analysis is a complex and personal endeavor. This characteristic was not readily apparent in my first attempts at analysis. I struggled through literature on qualitative research trying to find a method through which I could analyze my own data.

During this time I took a course on narrative analysis taught by Dr. Carolyn Clark. In this course Dr. Clark offered us the idea of qualitative methodologies being something akin to a “tool box.” She focused her course on supplying us with various “tools” to place in our relatively empty “boxes” and on helping us experiment, using the tools she offered, on a variety of qualitative data. These tools consisted of ideas and methods about analyzing qualitative research that had been used and published by others. One of the take home messages I got from her course was that in order to begin, and hopefully complete, an insightful analysis of qualitative data I need to open that tool box, take out a couple of tools and begin to apply them to my data. As I was at a bit of a dead end in my mind and required to do so for her course, I decided to begin to fiddle with the data I had, in the light of some of the new “tools” and understandings of qualitative research I had gained through Dr. Clark’s class, in order to attempt to answer my original research questions.

After a good deal of playing, I found myself emerging with what I thought was something that looked like an analysis. Although a little rough, the basic steps I took to reach this point were similar to the list below.

1. Read the data – I did this many times.
2. Speak to the data, carry on a conversation with it – I reread each interview and wrote exactly what I was thinking when reading it; including ideas, connections, and any additional questions that came to mind. I wrote down anything and everything I thought of.

3. Summarize comments – After a bit of "speaking" with the data I would take a step back and summarize all that I had read, thought, and asked during my conversation with the data.
4. Pull out informative segments – I went through each interview and pulled out all of the segments and ideas that the participant offered. I typed and inserted these segments as bubbles in an application called *Inspiration*©. The application was of little consequence. I could have achieved the same effect by writing them on index cards or printing them out and cutting them up. I just wanted to have a way to manipulate the data segments so I could begin to move them around and make connections between them.
5. Organize segments – Once the segments were pulled out and easily manipulated, I began to move them around, group them according to topic or theme, and draw connections among them. What I wound up with were large, pseudo concept maps containing all of the pertinent data segments and my thoughts and ideas about them.

I have since found that the steps I took in analyzing my data were not completely unique. I have come across several other well known authors on qualitative research who present a similar analysis schema. Bogden and Biklen (2003) present a series of ten steps of data collection and analysis. The five final steps they present mirror those I have listed above and lend support to my approach. Those steps are:

1. Write many "observer comments" about ideas you generate
2. Write memos to yourself about what you are learning
3. Try out ideas and themes on subjects
4. Play with metaphors analogies and concepts
5. Use visual devices

Much like my own approach to analysis, these five steps advocate beginning analysis with written comments, conversing with the data candidly, playing with ideas, labels and metaphors, and utilizing organizational methods with an emphasis on visual representations.

Harry Wolcott, in his book *Writing up Qualitative Research* (2001), provides a less straightforward but similar method of qualitative data analysis. He suggests that researchers type or write data on cards or sheets of paper or use some type of electronic medium that can be manipulated easily. In this manner data can be sorted into categories quickly and easily and the researcher can get away from the consuming task of data entering and on to the actual analysis. I used the concept bubbles I created in *Inspiration*© as the electronic medium and was able to manipulate the data and visualize categories, patterns, and themes with relative ease.

## Member Check

E-mails were sent to Mrs. Lewis, Mrs. Major, and Mrs. Patton in November 2008 requesting their participation in a member check interview. Mrs. Major responded that she did not wish to participate and no further action was taken. Mrs. Patton responded to my first email and agreed to participate. A copy of Chapter VI was sent to her shortly after. A second e-mail was sent to her at the beginning of January to try to set up a time for an interview. She responded that she was very busy at that time and would be in touch when she found time to review the chapter. I did not hear back from her before this dissertation was completed. Mrs. Lewis responded to the initial e-mail and was sent a copy of Chapter IV. She responded to the reminder e-mail sent at the beginning of January and a time for an interview was arranged. A description of our discussion during this interview is presented before the analysis in Chapter IV.

# CHAPTER IV

## MRS. LEWIS WITHIN-CASE ANALYSIS

This chapter is the first of the three case studies of the high school science teachers ultimately chosen for study. The goal of these three cases is to give the reader an in-depth understanding of each teacher's ideas, practice and perception of the ITS Center's PDE. This in-depth understanding of each case is necessary to address the relationships between research question 1 and its four sub-questions:

1. How did the personal practice theories, school context, classroom practice, and perceptions and interpretations of the ITS Center's PDE of each individual teacher relate? Specifically:

    a. What did the school context and classroom practice of each teacher look like?
    b. What personal practice theories emerged from conversations with each teacher?
    c. How did each teacher value, perceive and interpret the various aspect of the ITS Center's PDE? and
    d. What relationship could be seen between each teacher's teaching situation, practice, personal practice theories, and the ways they valued, perceived, and interpreted various aspects of the ITS Center's PDE?

The purpose of this case is to describe Mrs. Lewis, an individual who appeared, at least superficially, to be representative of a group of teachers who had difficulties in understanding the ideas presented in the conceptual frame of the ITS Center's PDE. Through my analysis, I came to understand that Mrs. Lewis' major teaching goal was to prepare her students to succeed in the college level science courses many of them would take. She held a very traditional view of teaching and focused on lower-order skills through didactic methods of lecture, practice, and recitation. My analysis revealed that Mrs. Lewis found that learning new ways to model or reinforce some of the concepts that were difficult for her students to understand was a highly valuable part of the ITS Center's PDE and she constructed an IF that mirrored this view. These perceptions appeared to have had a great deal of influence on the way she understood various concepts such as inquiry, conceptual understanding, and transfer as she interpreted them through the lens of her personal practice theories.

The presentation of this case study uses the research questions as an outline and includes: (1) a brief introduction to Mrs. Lewis and a discussion of the process that led to her selection as a participant in this study, (2) a description of the school context in which Mrs. Lewis taught, (3) a description of my classroom visits including the resulting M-SCOPS Profiles and brief interpretations of them, (4) a description of what I learned about Mrs. Lewis' methods of planning and teaching and personal practice theories from our discussions, (5) a description of the performance artifacts that resulted from Mrs. Lewis' participation in the ITS Center's PDE, (6) a description of Mrs. Lewis' perceptions and interpretations of constructs from the ITS Center's PDE, and finally, (7) my analysis of these experiences and artifacts, which relates the data sources to a unifying theme, allowing me to derive some insights regarding the relationships among her thoughts, perceptions, and actions.

## Introduction

At the time of this study, Mrs. Lewis was a chemistry and physics teacher in her 10th year of teaching. She had been teaching for two years at Triton High, a small high school in a rural town. Triton High was the second school at which she had taught; her first school was in a similar town and of a similar size.

Mrs. Lewis received her bachelor's degree in chemistry in the late 1980's and took some time off from work and school to raise three daughters. Her husband, a mining machine operator, was the primary wage earner in her family and her teaching salary was a supplement to his.

Once her daughters were old enough to be enrolled in a full day of school, Mrs. Lewis made the decision to begin teaching. The decision to teach was an easy one for her because the hours she would be working would match those her children would be in school and she wouldn't need to put them in childcare. Mrs. Lewis acquired an emergency teaching certificate and taught chemistry for a year before returning to college to complete her teaching certificate through an alternative certification program. She was able to complete the alternative certification process relatively easily. She was required to take only a few extra education courses, as she already had more content courses than the certification process required.

In the ITS Center's PDE, Mrs. Lewis was a member of the Molecular View of the Environment science team. The morning sessions, led by two geologists and two chemists, focused on exploring connections between the current research in their respective fields of study. Two graduate students led the afternoon discussion groups, one who was working on a Ph.D. in geology and the other who was close to finishing her Ph.D. in science education.

In order to answer the research questions, the three teachers were selected based on the alignment with the original philosophy of the readings included in the ITS Center's conceptual frame indicated by their performance artifacts and exit interviews. From this selection process, Mrs. Lewis was placed in the second lowest category of alignment. This placement was due to several factors, including the way in which her IF aligned with the Etheredge and Rudnitsky (2003) inquiry frame, her discussion of the ideas presented in the book *How Students Learn* (Donovan & Bransford, 2005), her use of the literature on transfer to support her ARP, and her views on what she found valuable from the ITS Center's PDE. All of these sources of data indicated that Mrs. Lewis' practice was largely traditional and focused on content mastery and lower-order application skills.

<u>School Context</u>

Triton High was a small school that served about 400 students. It was situated in a small rural community of about 3500 residents (2000 census data).The student population of Triton High at the time of this study was 87% White, 4% African American and 8% Hispanic. 33% of students were considered to be economically disadvantaged and 46% of students were considered "at risk."

Mrs. Lewis taught all sections of chemistry and physics, which included two general sections, one pre-AP section, and one AP section. Triton high adopted a reduced block schedule to accommodate their athletics program. On this schedule, there were five 75-minute block periods every day and courses spanned one semester. Because of the condensed manner in which courses were taught, Mrs. Lewis taught all of her chemistry sections in the fall and switched to physics in the spring.

The school district in which Triton high was situated had a curriculum director who was responsible for the curricula of all grades K-12. Because of this large scope, Mrs. Lewis was free to plan and choose her curriculum. The only constraint she had in the planning of her curriculum were the standards that list the concepts students should know and the procedures they should be able to carry out by the end of a course.

## Classroom Observations

I made two trips to Mrs. Lewis' classroom in which I observed her classroom practices. During each visit I observed a single class. During my first visit I observed a general chemistry class and during my second I observed an AP chemistry class.

*Observation 1*

Tuesday, October 31, 2006

I made my way down to the hotel lobby to grab something off the continental breakfast buffet before packing up my things and heading toward Mrs. Lewis' town. I didn't have to be at Triton High until 1:00 p.m., but I wanted to leave a bit early in case there were complications with the directions I had printed off the Internet before leaving home. I was soon packed, loaded, and driving steadily toward my destination.

As the highway speed limit dropped, I followed my wrinkled set of directions and turned at the first traffic light onto a very unkempt, gravel-like road a bit before the small town main street began. I wondered to myself: "Exactly what am I doing here?" I would have never considered myself a "city kid" growing up in the suburbs of New Jersey, but out here I guess I was rethinking my definition of city. I passed what looked like an official building on my right, but no sign let me know exactly what it was. I'd read about small town schools in books and the building fit my naive perceptions, so I wondered if that might have been it. My attention was then immediately drawn to a large, rickety set of bleachers on the left side of the street a bit further down the block with a sign advertising the high school football team. I remembered my amusement with the obsession Texans seemed to have with high school football and remembered that I'd seen the movie "Friday Night Lights" at some point in the not-so-distant past. I knew the high school had to be close to that field.

As I continued down the road a series of tan trailers, like trailer park trailers, came into view. Many of them had large block letter signs pasted on the outside, which made me think they were organized in some fashion. A brick building in the shape of a cross stood behind them. Although unsure, I was reasonably certain that I had found the school. I was early and decided to see if I could find a more inhabited parking lot than the makeshift one that consisted of three or four cars parked on the grass next to a huge air conditioning unit in between two of the trailers.

A bit further down the road the houses started to look like part of the school, too. They had windows decorated with art like many of the elementary schools I grew up in. I sighed and thanked myself for planning to be early, as it might just take a while to find the high school science wing, or trailer, or house.

When the road I was on ended and I still hadn't come across a bigger parking lot I headed back to the cars I had seen to try to find the office, where I assumed I had to register as a visitor. I made the decision to begin my search for the office in the brick building, which seemed the most school-like to me. I got out, adjusted my skirt, and set off.

I entered the brick building and was pleasantly surprised to find out I had made the right choice. It was a school and the classrooms that were along the corridor I entered were filled with students who looked like they were about high school age. I walked down the hall, glancing in the classrooms and catching bits and pieces of lectures from the doors that were open. It didn't sound like science. I thought it was probably English or history. I made it to the middle of the cross shaped building, made note of the trophy cabinet so I could find the hall that led back to my car, and turned left. I marched on down that hallway with no luck, turned around and made my way past the hallway I had come from to the part of the hall I had not yet visited.

About halfway down that hall was a series of windows that overlooked a small space with another series of windows on the other side. There were a bunch of students and no visible adult in the vicinity, but there was a sign that said “office.” I entered the windowed space and asked if I could sign in as a visitor and if someone could help me find Mrs. Lewis’ chemistry class. One of the students called for a secretary, who emerged from a room, and I repeated my question. I was told that I didn’t really have to sign in and Mrs. Lewis’ classroom was out in trailer F. I asked if someone could show me where the trailer was located. One of the students led me to the doors farthest from where I had parked and pointed across a wooden deck to a trailer with a large block letter F stuck to the side.

I thanked the student and quickly made my way back to my car for the tripod, video camera, and laptop. I dragged the equipment back through the school building and over the wooden deck and peeked into the window of the trailer. When I saw that there was no class inside, I gently knocked.

Mrs. Lewis got up from her desk and opened the door for me. Another teacher was talking with her in the room. Upon my arrival the second teacher promptly excused herself and Mrs. Lewis greeted me warmly and asked where I would like to set up. There was a lack of outlets in the far back corner I chose so Mrs. Lewisoffered me an extension cord,which I plugged into the lone outlet on the back wall of the classroom. I set up my camera, took out my notepad, and was ready to observe.

I was about 15 minutes early and as I waited for the class to begin I studied the inside of the trailer. The majority of the classroom was taken up by about 20 chair-desks facing a single lab station at the front with a modern looking overhead projector on its left. The projection screen was pulled down over a whiteboard and an LCD projector was set up on the lab station facing it. There was a bookcase filled with chemistry related material to my right and an open environmental chemistry book on the desk in front of where I was sitting. Next to the bookcase was a table with plastic paper organizers that looked like they held completed assignments and/or tests. The table was followed by a couple of filing cabinets and after them Mrs. Lewis’ desk faced the chair-desks. There was a bathroom behind Mrs. Lewis' desk with a shoe organizer on the outside of the door, which held about 20 graphing calculators and probes. Posters relating to chemistry covered the walls.

Mrs. Lewis appeared to be a young, bright, and energetic woman. She pleasantly asked about my drive and if I had had a chance to explore the main street area. She told me about the cute little antique and specialty shops, including a winery with an outstanding restaurant and one widely known bakery that made a wonderful sour cream pound cake. She also warned me that I had come to see general chemistry, this was the last period of the day on Halloween, and even though they were normally a bit unfocused they would probably be even more rowdy than usual.

A bell rang signifying the end of the last period. Students began to filter into the classroom so I turned the camera on, focused it on the filing cabinet in front of me (since I wasn't supposed to get students in the frame), and sat down. Mrs. Lewis greeted them sociably, seeming to know them all by name and sat down at her desk to take attendance at the computer.

One particularly large, loud male student entered the room and proceeded to challenge a few others to a water chugging contest (M-SCOPS Segment 1). A few other male students proceeded to take out water bottles, accepting the challenge. They filled them at the lab station at the front of the room as the bell signifying the beginning of class rang. Mrs. Lewis joked with them and let them chug their water as she turned on the projector and opened her PowerPoint presentation. The boisterous male who had initiated the contest, a little more wet and less thirty than he had come in, won. Mrs. Lewis did not appear to be bothered or even notice the students' antics and I wondered if this was "more rowdy than usual" or merely usual.

About five minutes after the first bell rang Mrs. Lewis asked students to sit down. She began class by telling them their tests from yesterday had not been graded and humorously fielded sarcastic comments from the students concerning their test grades. Even though she had warned me about their lack of focus, I couldn't help but be amused by their antics, especially those of the student who had initiated the contest before class. I was struck by how much time had passed before class actually began.

It seemed as though class today would begin with a lecture on Chapter VIII, the third leg of their "journey through chemistry land," as Mrs. Lewis called it (M-SCOPS Segment 2). She grabbed her book and her InterWrite SchoolPad™ and moved to the middle of the classroom. Mrs. Lewis sat at one of the student desks and began a lecture on converting word equations to formula equations. She progressed slowly through the PowerPoint slides, waiting after each change for the students to copy down what was written on the slide. A few male students consistently made off-topic comments about how hard chemistry was and how poorly they were doing in the class. While she was waiting for students to copy down the slides, they joked with her about their IPC class teacher, football, and Halloween. Little or nothing was said about the content of the slides by anyone but Mrs. Lewis. She would read each slide, ask a few questions of the students that could be answered in one or two words, and then socially talk with them as she waited for them to copy down the slide.

Little changed over the course of the 30-minute lecture as Mrs. Lewis proceeded through her ten-slide presentation. She continued to ask short answer questions and students continued to respond and converse in-between slides. She spent the majority of the lecture defining terms like equation, chemical equation, skeletal equation, catalyst, balanced equation, and coefficient. Once she was done with the definitions, she directed the students to a table of symbols, told them they should memorize them, and proceeded to work a few problems.

After the lecture was over, homework was assigned and the students were given the rest of the period to work on it in class (M-SCOPS Segment 3-6). A small group of students occupied Mrs. Lewis with questions for the remaining 40 minutes of class. Every now and again she would make an announcement directed toward the whole class concerning items in the book that needed to be memorized. While this went on, the majority of the class did what they pleased. Most of the students sat at their desks talking with one another about anything other than chemistry. Two students in particular spent their time harassing the students who were actually paying attention to Mrs. Lewis. Once the small group of students ran out of questions, Mrs. Lewis sat at her desk while the students continued to gossip and tease one another (M-SCOPS Segment 7). About five minutes before the bell, most students were packed up and stood by the door waiting. The second the bell rang and they all rushed from the room.

*M-SCOPS Profile Interpretation*

The M-SCOPS Profile representing my first observation of Mrs. Lewis' class can be found in Figure 4.1. An analysis of the flow in this 90-minute lesson revealed seven segments of instruction. The two segments at the beginning and end of class, which composed 20% of the total class time, were segments in which students were off task. These segments were intentionally left blank since neither the teacher nor the students were focused on class material. The remaining 80% of class time was broken into five teacher-directed segments. All five of these instructional segments were teacher directed at a "5/1" level of instructional scaffolding. Students listened to a lecture focused on a PowerPoint presentation for 39% of total class time and completed teacher assigned homework problems from the book for the remaining 41% of the time.

During the five instructional segments, students received verbal and symbolic information about writing and balancing equations. Complexity levels for receiving information remained low throughout the entire class and scientific information was represented by words and symbols; no manipulatives were used. There were no explicit opportunities for students to discuss their ideas about what they learned with other members of the class. The class ended with no closure or opportunity for reflection on what was learned during the class period.

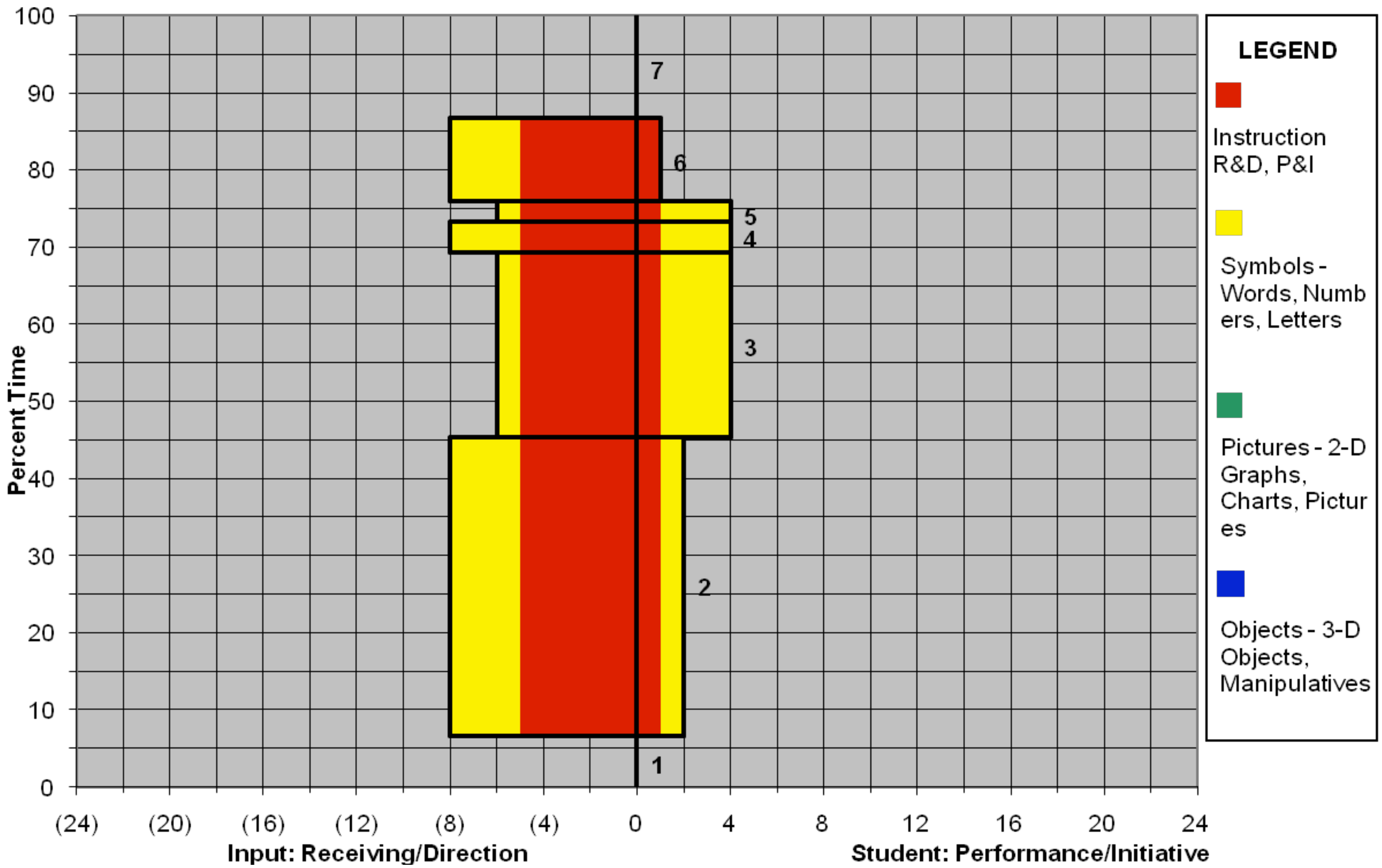


FIGURE 4.1 M-SCOPS Profile from the first observation of Mrs. Lewis' class

*Observation 2*

Friday November 17, 2006

I woke up in the small bed and breakfast room, packed up all of my things and ventured to the main house to pay my bill and procure the breakfast portion of our agreement. A small apricot poodle greeted me with an apprehensive bark and I was ushered into a gorgeous dining room filled with antiques. I was served coffee and a bagel on exquisite china and spread my cream cheese with a wonderfully detailed silver knife while making small talk with my host. I took my time polishing off a couple more cups of coffee from the carafe and thinking about how my day might play out and what I might learn about Mrs. Lewiswhile observing her teach AP Chemistry.

I thanked my host and took my leave of the incredible dining room atmosphere about 45 minutes before the class I was to observe began. I made my way down the town's main street and turned onto the dirt road I now knew led to the school. I easily found the "real" parking lot this time, made my way through the front doors I now knew led to the office, and felt obliged to at least try to sign in, even though I now knew they didn't require me to.

After checking in with the office, I made my way to Mrs. Lewis' trailer-classroom. I was there a few minutes before the first period bell, and so I had a bit of time to set up my equipment. Mrs. Lewis apologized that she had forgotten to tell me that classes were on an alternate schedule that day due to an after school pep rally for a championship football game, and her class would be 15 minutes shorter than normal. After a few minutes, students began to trickle in, talking and commenting about assignments, the pep rally, and the football game. Mrs. Lewis joined in with the student's banter, joking with them. The bell rang and no significant change came over the classroom as students kept on with their joking. It took about 3 minutes for them to eventually settle down and focus on the PowerPoint projected at the front of the room.

Mrs. Lewis began class with the following statement:

> Okay, electrochemistry. I kind of let you guys read over that first section and answer the questions, but I'm going to go over some of the stuff. I will tell you ahead of time, I can do electrochemistry, it does not float my

> boat and I'm going to have to try really, really hard to be excited about electrochemistry. Some of you guys might like electricity and electrochemistry better than I do, probably Graham, but it just doesn't do a whole lot for me, so, this is the chapter. (Observation 2)

A student immediately asked a question about how the cold might affect his cell phone battery, and Mrs. Lewisanswered his question by telling him that batteries often slow down in the winter and many car batteries die. By answering the student's question in this manner, I believed Mrs. Lewis lost an opportunity to connect the content being discussed to the real world.For the next 40 minutes Mrs. Lewis progressed through her PowerPoint presentation, pausing to remind students that they should know much of what she said from the text they read for homework. After each slide she would pause to allow students time to copy down the text from the slide. During this time, students talked about many things, including football, college, dirty clothes, and food, but not about the content they were being asked to learn.

Mrs. Lewis addressed me and asked if I was getting the idea that her AP students could "multi-task." I took this to mean that she was amused that they could be talking about unrelated topics while still taking notes about electrochemistry. It did not surprise me that her students could be relatively unengaged with the content and stillbe able to memorize the information she was presenting. AP students in general are smart and highly motivated by external reinforcement. I assumed they had quickly learned exactly what was expected of them in this class and focused on the essential features that would get them the best grade possible.

This pattern of presenting slides and giving students time to talk/copy down the information continued for the duration of the presentation, the better part of the 60-minute class. Afterward, students were given the last 20 minutes of class to do homework and test corrections from the test they had recently taken. During this time, many students worked while others talked and joked. After about 15 minutes the bell rang and students stormed out of the classroom.

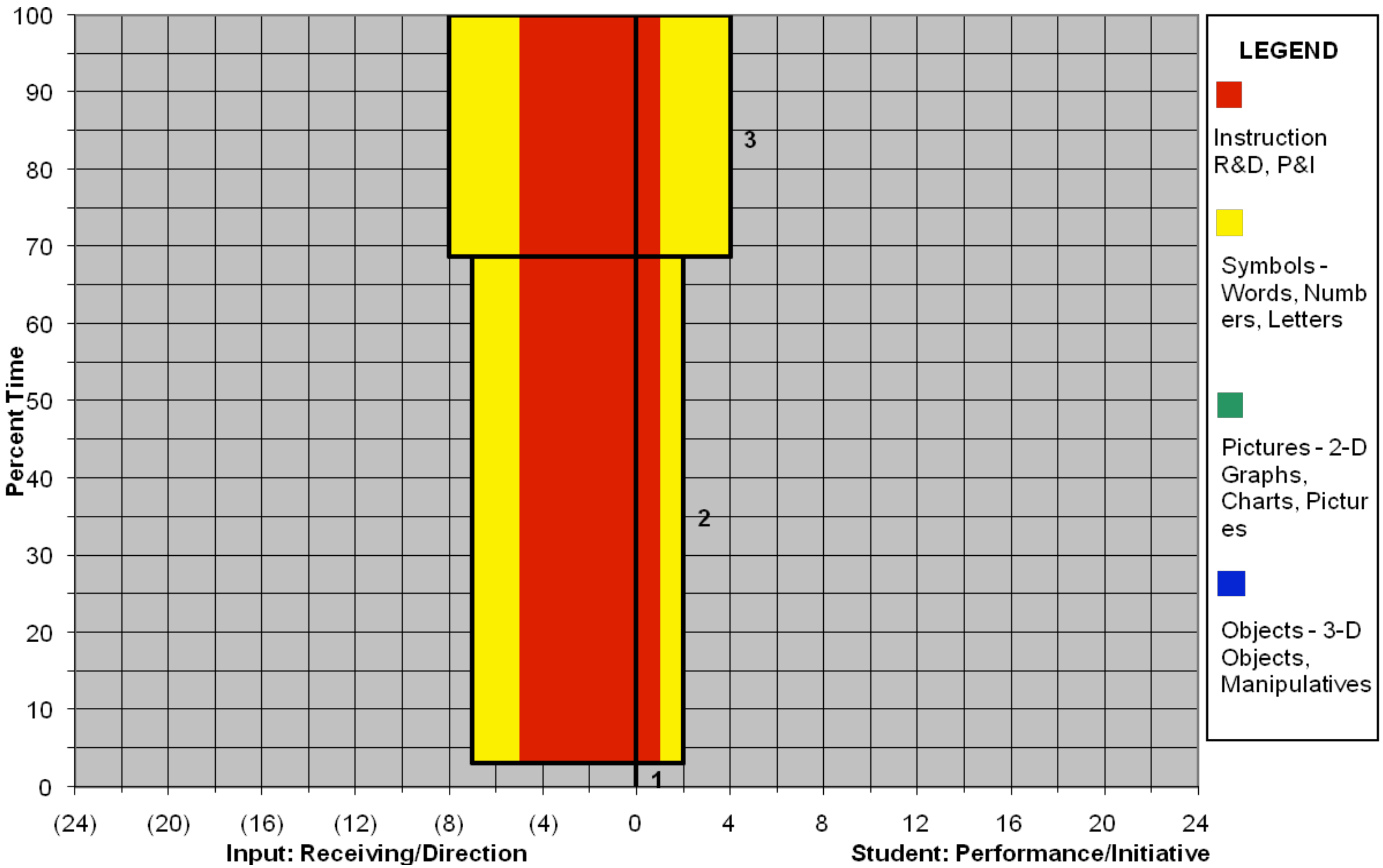


FIGURE 4.2 M-SCOPS Profile from the second observation of Mrs. Lewis' class

*M-SCOPS Profile Interpretation*

The M-SCOPS Profile representing my second observation of Mrs. Lewis' class can be found in Figure 4.2. This 60-minute lesson consisted of three segments. During the first segment, which composed 3% of the total class time, all students were off task. This segment was intentionally left blank since neither the teacher nor the students were focused on class material. The remaining 97% of class time was broken into two teacher-directed segments. Much like my first observation, both of these segments were teacher directed at a "5/1" level of instructional scaffolding. Students listened to a PowerPoint focused lecture on electrochemistry for 66% of total class time and completed either teacher assigned homework problems from the book or corrected their tests from the previous week for the remaining 31% of time.

During the two instructional segments, students received verbal and symbolic information pertaining to the topic of electrochemistry. The complexity level of the information students received was at the level of "2" (replicate) 66% of the time and a level of "1" (attend) 31% of the time. The complexity level of the information students acted on was at the level of "1" (attend) 66% of the time and a level of "3" (rearrange) 31% of the time. Student learning was focused solely on words and symbols; no manipulatives were used. There was no explicit opportunity for students to discuss their ideas about what they learned with other members of the class. The class ended with no attempt by Mrs. Lewis at closure or reflection on what was learned during the class period.

## Personal Practice Theories

After each observation I conducted a semi-structured interview with Mrs. Lewis. The list of questions I followed can be found in Appendix B. During these interviews, I learned a great deal about the personal theories that guided Mrs. Lewis' practice. Two major themes emerged from my analysis of these interviews: her view of chemistry as a series of concepts, and her goal of preparing her students for college.

*Planning and Teaching*

Mrs. Lewis organized her curriculum around the chapters in the book. She did not follow the book straight through, but jumped around and "hit about a chapter a week" (POI1, L375). She told me that her classes followed a rather consistent format. Class began with the answering of any questions students had about the previous day's assignment, new material was presented in a PowerPoint lecture format, andstudents were given time to work on a new assignment.

As I mentioned before, Mrs. Lewis' school utilized a very tight schedule. Classes met every day in 75-minute blocks for one semester. This schedule caused Mrs. Lewis to feel pressed for time. Although she had sole control over what she taught and when she taught it, she had to cover a lot of information during shortened periods over the course of a single 18-week semester. On this schedule, Mrs. Lewis said she felt as though she could not spend time making sure students understood topics or going back over concepts that they did not understand the first time. She felt she had a responsibility to cover what needed to be covered within the constraints of her schedule.

Prior to the semester of this study, Mrs. Lewis used overhead transparencies to deliver her lectures. She designed the presentations and filed them for future use. During the semester in which I observed Mrs. Lewis' class she was working on switching from the filed overheads to PowerPoint presentations. With three different lectures to prepare for four classes each day, this was a lot of work. She mentioned what a relief it would be once they were done, and she could concentrate on making the presentations more "attractive" and "self-explanatory" by adding movies and visualizations(POI2, L338) for future semesters.

*Chemistry as a Series of Concepts*

One of the main personal practice theories that emerged from my analysis of Mrs. Lewis'interviews was that she viewed chemistry as a series of concepts that build on one another as they ramp up in complexity. Each concept needed to be mastered in order for the next to be understood. This belief was apparent in Mrs. Lewis' discussion of the topic sequence in her general chemistry class. She stated:

> I call it epic adventure through chemistry, where if you didn't learn how to name compounds in chapter 6 or it escaped you, or you don't know the chemical quantities, then we start on this so they're starting on this, this is a struggle, and then we'll end up with stochiometry, which you remember that, so they'll not only be predicting the reaction, the reactants, they're going to be balancing the equations, and then they're going to be working calculations on balanced equations so they're building to a point. (POI1, L349)

The way Mrs. Lewis discussed the progression of topics in this quote demonstrated a viewpoint of chemistry as "concept transmittal and mastery." The structure of the class and her use of phrases such as "you didn't learn" and "it escaped you," for example, indicated that she placed the majority of responsibility for learning or mastering concepts on her students. She never mentioned how she might deliver her lectures differently or provide her students with different activities to help them learn. This quote also demonstrated her concept mastery view of chemistry. Her metaphor of chemistry as an "epic adventure" and her discussion of future topics being a "struggle" for students whodidn't learn them since they were "building to a point" demonstrated that each topic she taught needed to be mastered before the next could be understood.

This focus on chemistry as a series of concepts was further reinforced as she discussed planning of lectured-based classes around the chapters of the book. She stated:

> I have them for 18 weeks, and I taught 1 through 5 in my book and then I skipped to chapter 13, I'm sorry because it just went better in the order sequence, I thought it was better to go to electrons and atoms and all the SPDF and electron configuration after studying the atoms, so I go from 5 to 13 and teach 13, 14, 15, and 16 and then I drop back to 6 and pick that up, so, just made more sense, I don't know, in the order of things. (POI1, L367)

The focus on the use of the chapters of the book seen in the above quote showed me that Mrs. Lewis' manner of thinking about her subject was reinforced or guided by the book she used. As a result, the book provided the basis for the concepts she taught and was reinforced through her lecture-recitation patterned lesson cycle.

Mrs. Lewis' use of laboratory activities further reinforced her focus on concept transmittal and mastery. She stated:

> When we, you know what, and I hate to use the term the kids use. We may hit a chapter where 2 or 3 labs are good, they're good labs and they help promote understanding. Then we may hit a chapter where they are just like 'those labs are so gay and we're not doing them.' From what the kids say, I'm not getting, we're not going to do this so I don't tie myself to having to do that lab for that chapter if it's not going to be beneficial. (POI1, L974)

Mrs. Lewis'discussion of using the laboratories offered by the book and her use of the phrase "help promote understanding" in the above quote indicated that the laboratories she used were ways of reinforcing the concepts she was teaching in lecture, rather than tools to get her students to extend their understanding to a new situation or problem. Due to her tight schedule she did not often have multiple days to go over the same concept and therefore did not complete many labs with her students. When she did conduct labs, she tended to do so more in her pre-AP and AP classes since they were a bit more motivated and covered the content more quickly than the general chemistry classes, which left her with more time to reinforce difficult ideas.

*Chemistry is for College*

The second personal practice theory that emerged from my analysis of Mrs. Lewis'interviews was that she viewed high school chemistry as a method of preparation for chemistry in college. This belief caused Mrs. Lewis to have some fairly strong views about the types of students who should have to complete a high school chemistry course.

When asked what the biggest hurdle in her job as a teacher was, Mrs. Lewis focused her response on the students who were not college bound. She stated:

> Student apathy is probably one of the largest ones. I think this whole trend that we have now, with TEA and the state board of educators pushing toward everybody going to college, you know? That college

> bound thing, it changes the kind of student that I have or that I'm used to working with and I personally, my husband had one year of college. He drives a bulldozer and makes 2 and a half times the money that I make. So, if God made you a plumber, you should be a plumber, you know? I don't know, so I have some problems with the state and their slant on vocational training versus academia, because there's people who need to go to college and people who don't, who don't need to go. I don't know, there's more value in finding what you were meant to do. Whether it was going to college or work, do paint and bodywork, which is another field that makes probably a whole lot more money than you and I will ever make. So that's probably, and student apathy, probably. (POI1, L165)

This statement demonstrated that Mrs. Lewis did not believe that many of her general chemistry students would be going to college and that the chemistry content she taught was not highly useful outside of the college-preparation context.

To further reinforce this belief, when asked about the highlights of her job as a teacher Mrs. Lewis told me that her favorite part of her work was when her students returned to visit her after their first semester at a big university and they have done really well. When they came back successful she was proud, because she knew her students were able to get "just as good an education here as they might would at a bigger school" (POI1, L123).

## Performance Artifacts

Mrs. Lewis' performance artifacts provided a valuable lens into the ways her interpretations of the ideas and constructs we discussed during the ITS Center's PDE align with their original philosophy and her personal practice theories.

### *Instructional Framework*

All teachers in the ITS Center were asked to use the Etheredge and Rudnitsky (2003) Inquiry Cycle as the basis of their IF. This Inquiry Cycle consisted of four steps: immersion, hypothesis generation, investigation, and consequential task. As E&R describe, this cycle should be focused on a system of variables that engages students in investigating research questions they create based on the observations they make about the system. Mrs. Lewis' IF appeared to focus on reinforcing the concept of solubility and not a system of variables like the E&R described. Without being focused on a system of variables it is difficult to create an inquiry cycle that follows what E&R describe and Mrs. Lewis' IF appeared as more of a series of activities than a true cycle of inquiry.

The immersion experience that Mrs. Lewis described in her IF consisted of three steps. The first of these steps was a brief discussion based on pictures of thermal fish kills. Students looked at the pictures and brainstormed possible reasons for the death of the fish. After they formed some initial ideas, students completed two hands-on laboratory exercises that utilized both temperature and dissolved oxygen CBL2 probes. During the first of these labs, students dissolved salt into water as it was heated. The increasing temperature of water was monitored using the temperature CBL2 probe. The second of these labs utilized the dissolved oxygen probe in addition to the temperature probe. Students monitored the amount of dissolved oxygen in the water as the temperature increased. During these labs, students collected data and entered it into Excel. Once the lab was completed, time was allotted to produce graphs that demonstrate the relationship of the amount of salt or oxygen to the temperature of the water or, in other words, a solubility curve. All groups completed a formal lab write-up and presented their results in poster format to the class. The results and how they related to the students' preliminary ideas of the reasons behind the thermal fish kills were discussed.

The inquiry cycle steps of hypothesis generation, investigation, and consequential task were subsumed under the umbrella of a group research project. After the immersion experience was complete, students were asked to connect what they knew about solubility to real-world examples of how solubility affected the environment. Each group chose one example as the basis for their independent research project. The groups researched their topic and designed a PowerPoint that they presented to the class.

Mrs. Lewis also incorporated a discussion of parts of the three principles of learning Donovan and Bransford (2005) present in chapter 1 of their book. She discussed how she could explore student's prior knowledge (principle 1) and engage her students in reflection (part of principle 3). Mrs. Lewisdiscussed exploring students' prior knowledge by using a written pre-test. On this test students were asked to define solute and solvent and write down their ideas about what could have caused the deaths of the fish in the thermal fish kill pictures. This pre-test helped Mrs. Lewisto gauge her students' prior knowledge and understanding of the concept of solubility and evaluate how much they learned from her IF. While valuable, this pre-test mainly explored students' factual knowledge of solubility. It did not provide much insight into how students understood or used the concept and did not significantly engage their initial understandings or preconceptions in the manner discussed in *How Students Learn*.

Mrs. Lewis' ideas about engaging students in reflection on their learning also appear to be focused on factual understanding. She indicated that, after completing the two solubility labs, students reflected on their learning by taking a posttest and looking at the posters created by other groups of students that display the solubility curves they constructed from the lab. The solubility labs that provided the basis for this activity were confirmatory in nature. It appeared that Mrs. Lewis chose these two labs in the hopes that students would get very similar results from them and would be able to clearly see the inverse relationships between the solid/liquid vs. temperature curve and the gas/liquid vs. temperature curve as they viewed and discussed the resulting graph posters. Because the intent of the lab was to demonstrate a phenomenon and not problematize it, there was little room for mistakes or misinterpretation, which in turn offered little fodder for discussion and/or reflection.

*School Year I Summary Paper*

As can be predicted, Mrs. Lewis' School Year I summary paper, which described the implementation of her IF, demonstrated a similar departure from constructivist philosophy and alignment with her personal practice theories. She began her summary paper by stating that she was unable to implement her IF in her pre-AP class and so she had only completed it with her AP students. This was not surprising since she let me know in her interviews that she felt she had more time in her higher-level chemistry classes.

She indicated that her implementation began as she described in her IF. She gave her students a pre-test and had them discuss their ideas about pictures of thermal fish kills they viewed over the Internet. She then had her students complete the described series of two confirmatory labs. The complete immersion experience took one week, which translated to five 75-minute periods of Mrs. Lewis' class.

After the immersion, students chose an environmental impact of solubility to do some research on. They were given two weeks or ten 75-minute periods to complete their "independent research and preparation of power point presentations" (Reflection, Page 5). Students worked in five groups to complete these projects and the chosen topics were: acid-rain, the Exxon Valdese oil spill, a local chicken slaughter house's effluent water treatment, nitrates in water, and the New Orleans hurricane Katrina floods.

In addition to describing how the actual implementation of the IF went, Mrs. Lewis described how she incorporated the seven steps of designing an inquiry cycle outlined on pages 34-35 of the Etheredge and Rudnitsky (2003) book. These seven steps were:

1. Consider students' background.
2. Create/describe the system of variables.
3. Design an initial immersion experience.
4. Generate researchable questions.
5. Conduct the research.
6. Design a consequential task.
7. Assess understanding.

Her discussion of these steps continued to demonstrate her surface-level focus. The steps were discussed briefly, and she did not seem to have based her interpretations of them on an understanding of the philosophy on which they were based. For example, she stated of the first two steps:

> The first two guidelines contributed to the IF being implemented with my AP Chemistry class instead of my Pre-AP chemistry class. Aqueous systems, solution chemistry, reaction rates and gas laws were all groundwork that had been thoroughly laid prior the inquiry unit. Three traditional tests and four laboratory investigations determined that the students were well aware of the variables associated with the system regarding solubility. (SYI, Pg. 4)

This statement demonstrated that Mrs. Lewis only thought about her students' backgrounds in relation to the content knowledge they gained from the material that she covered in class. In their chapter, E&R (2003) detailed other questions the inquiry cycle designer should answer about students as their backgrounds are considered. These questions include their experience collaborating, their experience with inquiry, and any preconceptions or misconceptions they may have about the inquiry content (p. 35). The activities Mrs. Lewis designed for her students did not reflect the type of inquiry E&R discussed so some of these questions were not directly related to the students' prior knowledge and the skills her project engaged.

The above excerpt also demonstrated Mrs. Lewis' interpretation of step two; create/describe the system of variables. She wrote that the activities she planned made certain that "students were well aware of the variables associated with the system of solubility" (Reflection, Page 4). The purpose of an immersion experience, according to my interpretation of E&R, is not to make sure the students have learned or are aware of the variables, but rather to have students "collaborating in establishing knowledge claims—things they know and understand about the system" (p. 37). Again, Mrs. Lewis' IF was not based on a system of variables through which students could test or establish knowledge claims, and it followed suit that her interpretation of this step was misguided as well.

As I read Mrs. Lewis' description of the rest of the steps, they continued to demonstrate the same patterns of interpretation. Her description of her "design of an initial immersion experience" was straight-forward. Much like she had in her IF, she described the final four steps together as she subsumed them within the completion of the research papers and presentations portion. She stated:

> An extensive hands on lab experience allowed students to test first-hand some of the scientific concepts through a learner-centered lens (Donovan & Bransford, p. 13) that would help them create researchable topics and questions promoting ITS-Centers enhancement of enduring understanding through authentic scientific inquiry (Stuessy, 2005). (Summary Paper, Page 4)

While I had little doubt that this portion of her IF had been a valuable and meaningful learning experience for her students, I did not see this experience as being akin to the experiences described in E&R. Her replacement of the term "researchable questions" with her own term "researchable topics" was one indication of this. This seemingly small substitution changed the entire intent of the step. E&R had intended students to develop questions based on a system of variables they had explored. The labs included in Mrs. Lewis' IF were intended to demonstrate a concept rather than explore a system.

Also notable in the above statement was Mrs. Lewis' use of the terms "learner-centered," "enduring understanding," and "authentic scientific inquiry."In my mind, each of these terms is loaded with deep and subtle meaning. To truly understand them takes one far beneath the surface of the simplistic manner in which they are often defined. It appeared that Mrs. Lewishad interpreted these terms without thinking about these deeper meanings. She appeared to use her interpretation of the surface level definition in a manner that departed from the philosophy on which their deeper meanings were based.

In particular, I found Mrs. Lewis' use of the last term, "authentic scientific inquiry" interesting. Her use of it in relation to the IF she had designed demonstrated that she had not interpreted "authentic scientific inquiry" as engaging students in the same thought processes as the scientists she had spent time with during the three-week ITS Center's PDE demonstrated.

*Action Research Plan*

The Action Research Plans (ARPs) teachers were asked to write during the second summer of the ITS Center's PDE were based on the IFs they had written the prior summer and had tested out in their classrooms during the prior school year. Understanding that Mrs. Lewis' interpretations of many of the concepts that had been the focus of the first summer's experience had departed from the original philosophy, I expected her thinking about her research to demonstrate a similar misunderstanding of ideas.

The research question Mrs. Lewis posed as the focus of her ARP was: “Does coupling a science inquiry immersion using CBL-2s and Excel that explores factors affecting solubility with a real world based independent research project culminating in a Power-Point produce enduring or long term conceptual learning for the students?” (ARP, Page 3). The literature Mrs. Lewis cited in support of this question focused on the benefits of utilizing inquiry-based learning techniques to improve students’ long term conceptual learning and transfer of situated learning to novel real world situations. From this literature review and the methods she described, it appeared that the Mrs. Lewis was not focused on conceptual understanding and transfer in the way I understood them. She was focused on examining how thoroughly students learned the concept of solubility, how well they could apply their understanding to a real-world example, and whether this experience increased the amount of knowledge of solubility they retained in the next semester.

Once again, Mrs. Lewis’ interpretation of E&R’s inquiry cycle did not reflect the same philosophy as the text. Because of this, many of the ideas she utilized to support her ARP, which stemmed from a similar philosophy, appeared to be misplaced as well. For example, much of Mrs. Lewis’ literature review focused on the ways in which inquiry fostered “deeper understanding” of content. She used this term interchangeably with “mastery” and “long-term retention,” terms that demonstrated a focus on concept reinforcement. She also discussed how inquiry activities had been shown to increase students’ ability to transfer skills from classroom activities to novel settings. While she was asking students to apply their knowledge of the concept of solubility to real world examples, this activity did not appear to probe her students understanding of solubility in a manner that would make visible their conceptual or deep understanding of it.

When I interviewed Mrs. Lewis she discussed her ideas behind her ARP at length. The ideas she verbalized about her ARP also aligned with my thoughts of her interpretations. She stated:

> My research is how, the big thing is to try to create um, lasting knowledge. Not just memorize and regurgitate this and forget it the next day. So I’m trying to create something that’s going to stay there and so

> I'm trying to couple our inquiry experience in the lab and writing the lab report and pig tailing that onto this assignment outside of class which they're going to try to relate that to something that they're going to have to take and apply those to and then bring that back and see if they can't create an enduring understanding of a learning that's going to be something that'll last. Then I'm going to be giving them, most of them that I'll have in AP physics, and I'm going to give them another test probably about three or four months after not having had any of that for a while and see if they can't have some kind of lasting transfer of this knowledge, maybe that transfer and coupling it to this project. (POI1, L934)

This statement further demonstrated that Mrs. Lewis' focus was on retention of information. Her discussion of the goal of her IF as creating knowledge that would "stay there" and her discussion of the way in which she would determine if students retained the information by administering an exam months after completing the "inquiry experience" detailed in her IF and APR. She appeared to use the term transfer to describe her student's ability to recall information on this exam, not to be able to apply their understanding to a novel situation, demonstrating that it was not used in a manner consistent with the original philosophy.

## Perceived Impacts of the ITS Center's PDE

My analysis of my discussions with Mrs. Lewis revealed three impacts on her teaching she appeared to attribute to the ITS Center's PDE. These impacts were: integrating new technologies, new ways to model concepts, and broadening her ideas of how her content connected to other areas of science. In addition to these impacts, I also found it interesting to discuss the lack of impact she found in the educational research we had asked her to read and discuss during the ITS Center's PDE.

### *Technology Integration*

Mrs. Lewisdiscussed the ITS Center's PDE as having a huge impact on her everyday teaching by encouraging her to integrate new forms of instructional technology. As I had observed, she now taught all of her classes using PowerPoint presentations paired with an InterWrite SchoolPad™, which is a Bluetooth device that allowed her to write on the PowerPoint slides from anywhere in the classroom. She saw this as a big change since she previously used the overhead projector to present her lectures, and she saw the ITS Center's PDE as giving her the "push" to go back and begin the time-consuming and tedious process of re-creating these overheads in PowerPoint.

Aside from her new uses of instructional technology, Mrs. Lewis also began to help her students visualize chemistry concepts through the use of technology in a few hands-on laboratories. She had used the CBL2 temperature and dissolved oxygen probes in her IF to demonstrate solubility concepts to her students. She also utilized an Excel program her morning scientists had made to demonstrate the concept of rate constants to her pre-AP and AP students.

*Concept Modeling*

Mrs. Lewisalso discussed learning a lot of new ways to "model certain aspects in chemistry" (POI1, L691). She felt the morning scientists had put an emphasis on finding new ways to make concepts clearer to students and that this experience had gotten her excited about adapting her lesson plans with "technology and some of the modeling in science that we're looking at" (EI, L13), a process that she had "kind of gotten away from" (POI1, L691) in recent years.

Among the new things Mrs. Lewisdiscussed incorporating into her class were a few hands-on activities, such as using the "black box" experiment to demonstrate the scientific method, using the Excel template her morning scientists had designed to demonstrate rate constants to her preAP and AP students, and implementing her IF.

*Broadened Ideas*

Mrs. Lewis also indicated that the scientists from the morning team had really broadened her ideas and helped her see connections between chemistry and other areas of science, like geology and the environment. As a result of these experiences she stated that she was able to "furnish [her students] with a little more information, as far as some of the environmental chemistry aspects and hydrogen economy" (POI1, L800). She was also able to "talk about some of the research that [the scientists were] involved in and stuff like that and where this can take them [in their future careers]" (POI1, L769) with her pre-AP and AP students.

*Education Research*

Although Mrs. Lewis felt that she had learned a lot from the scientists she had worked with, she stated that she did not feel as though the education portion of the ITS Center's PDE had impacted her in any significant way. She actually never brought up the education portion of the ITS Center's PDE during our discussions except for when directly asked about it. When she was asked, she said that she felt the readings had contained "some good stuff "(EI, L109) but that "there was a lot of "rhetoric to wade through to get to the good stuff" (EI, L110). The surface level and procedural aspects that Mrs. Lewis had focused her IF and ARP designs on aligned with this statement, as did the departure from the philosophy she felt she had to "wade through"

This lack of appreciation for the philosophy on which the concepts presented in the education readings was further reinforced when Mrs. Lewis stated that she felt that the readings had "influenced a little bit or maybe gave validity to, to some of the things I was already doing" (EI, L107). Not understanding the philosophy on which many of the concepts and procedures were based could make it seem as though they supported the traditional methods that characterized Mrs. Lewis' practice. Coming to understand the philosophy would reveal that this was not the case.

Mrs. Lewis also indicated that she felt as though the ideas discussed in the educational research were too disconnected from her actual classroom practice to be of much use to her. She used the following analogy to express how she perceived this disconnect:

> You're like okay, you're telling me how to do this and yeah, it's like I don't know, it's like trying to you know, a mechanic trying to tell you how to change out your engine. Yeah, you're probably going to run into some things that don't go as planned.(POI1, L1007)

I found this analogy of education research to car repair to be very interesting. In my opinion, a car mechanic's job involved a series of set procedures that had to be carried out in a specific manner in order for them to be successful. I thought of teaching much differently, as a very reflective and subjective process. A teacher, unlike a car mechanic, has to be constantly reflecting on and adapting her practices as the understanding of her students evolved. The observations I had made of Mrs. Lewis' teaching had been much more like a series of set procedures than a process of reflective practice, making her analogy to a car mechanic understandable.

The most valuable contribution Mrs. Lewis perceived from the education portion of the ITS Center's PDE was the idea of action research. Mrs. Lewis was excited by the prospect of real teachers conducting education research in real classroom settings. She believed that, through this method, research would become more relevant to her practice and therefore more useable. She stated:

> I really like the whole concept that there's someone that's working in that field is coming up with the research questions because sometimes, some of the stuff that comes down from higher up is from people who haven't been in the classroom for a while, or who've never been in a classroom and you're like okay, you're telling me how to do this?(POI1, L999)

This statement reinforced my assertion that Mrs. Lewisfelt that the ideas of the education researchers were too disconnected from her actual classroom practice to be of much use to her. She was excited about the idea of action research because she believed that research that was done by real teachers, in real classrooms, who were facing the very real challenges she faced on a daily basis would be of more value than the ideas of the researchers who she believed were disconnected from real world classrooms. To me, this disconnect stemmed not from a lack of understanding, but from a drastically different philosophies.

## Analysis

From what I had learned about Mrs. Lewis, it appeared that she conceptualized teaching chemistry as transmitting a series of concepts. Our discussions indicated that she saw these concepts as building on one another and ramping up in complexity. Based on these views, she appeared to feel that students needed to practice and master each concept in order to succeed at the next. Through my analysis of observations, interviews and performance artifacts I came to see these personal theories as forming the basis of

Mrs. Lewis' practice. They drove her instructional goals, methods of planning, and choice of instructional methods, as well as they ways in which she interpreted and perceived various aspects of the ITS Center's PDE.

*Connections to Background*

Mrs. Lewis received her bachelor's degree in chemistry from a medium sized university. After being a devoted mother to three girls for a few years, she acquired an emergency teaching certificate and accepted a job teaching. After teaching for a year, Mrs. Lewis returned to college and completed her alternative certificate. She had considered her certification process relatively easy. She was only required to take a small number of education courses since she had more than enough content background.

Based on this progression it seemed as though Mrs. Lewis based the bulk of her knowledge about teaching on her own experiences as a learner. A statement she made concerning her chemistry teachers in junior college reinforced this thought. She told me that her junior college instructors had had the biggest impact her life "as far as what kind of people they were and what kind of teacher they were" (POI1, L132). With the majority of her experience stemming from college-type environments, environments that tend to focus on the transmission and mastery of concepts, it was understandable that Mrs. Lewis' views of chemistry would follow suit.

*Connections to Planning and Teaching*

Mrs. Lewis' habits of planning and teaching appeared to align well with this transmittal and mastery view of chemistry. I could see this personal theory embedded in multiple aspects of her practice. The most prominent themes that emerged from my analysis included her: goals of instruction, views on student motivation, curricular planning activities, instructional methods, and use of laboratories.

Mrs. Lewis' discussions indicated that her main instructional goal was to prepare her students for success in college level chemistry. This goal was well aligned with her strong background experiences in college level chemistry from which it appeared her transmittal and mastery view had come. As was discussed earlier, this goal could be see as she discussed the highlight of her job as being the return of her AP students after they had successfully completed their first semester at college and the hurdles of her job as the apathy of her general chemistry students who she did not see as college bound.

The basic structure of Mrs. Lewis' curriculum mirrored her focus on transmitting a series of concepts to her students. The chemistry book she used provided the framework on which she based her class. The way concepts were presented in the book mirrored and reinforced her concept transmittal view of teaching and they provided a logical framework for her curriculum. Mrs. Lewis explained that she "hit about a chapter a week." This statement reflected that she did not plan her instruction around the understanding of her students but rather planned it in order to maintain a steady pace at which she could complete coverage all of the necessary material. She discussed that, due to the time constraints in her schedule, she had time to present each topic only once. It appeared that she would give students time to practice and ask questions about each topic and then it would be up to them to spend the time needed to memorize and practice in order to be prepared to apply it to the next.

Motivation, as Mrs. Lewis discussed it, was essential to concept mastery and therefore success at chemistry. It appeared that she saw her students' levels of motivation as being the major differences between her classes. Because of her tight schedule, and her manner of teaching, Mrs. Lewis' students needed to be motivated to spend the time mastering concepts on their own. Her AP students, who were externally motivated by grades and class placement, put in the necessary time and effort and learned the material quickly and efficiently. Her general chemistry students, who were not as motivated by grades, did not seem to put in this time and so they "struggled" (POI1, L352) as the topics built in complexity. She also discussed motivation as the reason she allowed her upper division students correct their exams for extra credit, an opportunity she did not extend to the other classes, since her AP students would "learn from their mistakes" (POI2, L180).

The structure of the classes I observed mirrored the general format of the college level chemistry courses I experienced. The lecture-recitation structure of each 75-minute class was completely teacher-directed and focused on concept transmittal and mastery.

This format was well in line with her concept transmittal view of chemistry and her goal of preparing her students for college. Teaching students in the same format they would experience in college would prepare them by helping them develop the necessary self-reliance skills they would need once they got there.

Finally, Mrs. Lewis' use of laboratories also followed her concept transmittal and mastery view of chemistry. She viewed and used laboratory activities as a way to practice, reinforce, or "promote understanding" (POI1, L975) of certain chemistry topics. Using labs in this way would make the time spent completing them an extra days worth of time focused on a single topic, something she rarely had time for with her tight schedule. Since her AP students learned material more efficiently than her general chemistry students, it made sense that she felt she had more days to engage in such activities with them.

*Connections to Perception and Interpretation of the ITS Center's PDE*

Mrs. Lewis' view of her subject appeared to influence her views of her students, her instructional goals, and her habits of planning and teaching. It also appeared to influence her perception and interpretation of various aspects of the ITS Center's PDE. The aspects she had discussed as having the most value to her, along with the ways in which she interpreted various ideas from the educational research, demonstrated that her focus on concept transmittal and mastery carried over to her learning. She discussed having found the largest value in the motivation the ITS Center's PDE had given her to integrate instructional technologies, new methods of modeling concepts and connections to other areas of science into her teaching. She also stated that she felt the education research we had asked her to read had little connection to her classroom practice, and was of little value to her aside from reinforcing some of the things she already knew about teaching

The focus of Mrs. Lewis' performance artifacts also demonstrated a connection to her personal theories. Her IF was designed to reinforce and extend her students' knowledge of the concept of solubility and her ARP focused on evaluating student retention of their understanding of this concept. Finally, Mrs. Lewis' interpretation of the educational research she used in her IF and ARP further reinforced her personal theories and the connections they had to her instructional goals, planning and practice.

**Perceived Impacts**

Mrs. Lewis' personal theories remained evident in her discussions of what she perceived to be the highlights of the ITS Center's PDE. She stated that she felt that the most valuable impacts of the ITS Center's PDE were: the push to integrate technology into her class, the new ways to model concepts she had learned about, and the new connections she now understood between chemistry and other areas of science. Strong connections to her instructional goals, planning and practice emerged as I analyzed her thoughts about each of these impacts.

The ways in which Mrs. Lewis discussed the motivation the ITS Center's PDE had given her to integrate technology into her teaching practice did not demonstrate that she had changed her personal theories about teaching chemistry in any significant way. The main impact this motivation appeared to have was to encourage her to make the switch from using overhead transparencies to using PowerPoint slides paired with an InterWrite™ School Pad. Although this change had a big impact on the look and delivery of Mrs. Lewis' lectures, it did not change the teacher-directed nature or the low-level focus of her instruction.

Mrs. Lewis also talked about the new ways she had learned to model concepts for her students. She discussed learning about and incorporating several laboratories, two of which were based on technology, which she used to reinforce "certain aspects of chemistry" (POI1, L691). The incorporation of these activities, especially those that included technology, differed from Mrs. Lewis' normal teaching style but they did not change the reasons she had her students engage in labs, or the low-level focus of their learning.

The final aspect of the ITS Center's PDE that Mrs. Lewis discussed as having been of high value to her was the connections she now made between chemistry and other areas of science. She stated that understanding these connections would allow her to "furnish her students with a little more information" (POI1, L800) on certain chemistry topics and discuss where a career in chemistry “could take them” (POI1, L770). Much like Mrs. Lewis’ incorporation of technology and concept modeling activities, her discussion of how these connections would impact her actual practice did not deviate significantly from her normal teaching practice and continued to reinforce her focus on transmitting information.

I also saw strong connections between Mrs. Lewis’ concept transmittal and mastery view of chemistry and her lack of perceived impact of the educational research. The analogy she used to compare education research to “a mechanic trying to tell you how to change out your engine” (POI1, L1008) was telling. To me, the process of changing out an engine requires one to follow a relatively static set of procedures. If any changes to the procedures were made the engine would not work. In my mind, there was very little similarity between this process and that of a teacher using an inquiry-based instructional approach. In car repair, there is little room for interpretation or creativity, while these orientations are paramount in teaching through inquiry. Mrs. Lewis’ use of this metaphor made it appear as if she had been reading the educational research like it presented a well-designed activity that she should be able to incorporate into her curriculum. While the research was actually written to help teachers think about and design activities that could play to their strengths and be creatively adapted for incorporation. Approaching educational research looking for completed activities could make many of the discussion in the articles look like “rhetoric” (EI, L110) which one needed to “wade through” (EI, L110) in order to uncover the basic procedures through which the activity could be implemented. Mrs. Lewis’ focus appeared to be far removed from the focus required to understand much of the discussions included in the educational research. If she was looking for ideas that could be easily dropped into her curriculum, it would make sense that those she found often “did not go as planned” (POI1, 1009) since they were not intended in this way.

**Instructional Framework and School Year I Summary**

The steps described in Mrs. Lewis’ IF reflected an admirable attempt to assimilate many of the procedures and ideas expressed in the educational readings that she had been asked to discuss. Additionally, Mrs. Lewis had stepped well outside of the box of what I understood to be her normal classroom practices and had engaged her students in novel experiences that reinforced and extended their understanding of concept of solubility. These accomplishments are not small, but neither do they reflect an understanding of the constructivist philosophy on which the educational readings that formed the basis of the ITS Center's PDE were based. Understanding how Mrs. Lewis used laboratories to reinforce topics or concepts within her chemistry curriculum enlightened the way I looked at the design of her IF and her SYI Summary paper that explained her implementation of it.

Mrs. Lewis' IF focused on reinforcing and extending the concept of solubility. This was accomplished through a series of activities. The first of these activities was a discussion of thermal fish kill pictures. It appeared that this discussion was aimed at helping students to understand that that oxygen's concentration was inversely related to temperature, a negative solubility curve. This answer would be apparent through the data collected during the next activity. This activity involved a series of two verification laboratories. Temperature and dissolved oxygen data was collected with CBL2 probes and salinity concentrations were calculated by hand. All three of the data was graphed to show the positive solubility curve of salt and the negative solubility curve of oxygen. Students spent time discussing and compared their results, noting differences among the data they gathered and further reinforcing the concept of solubility. Finally, students chose an example of how solubility played a part in the real world and conducted an in-depth library research project on their chosen topic.

While the discussion of thermal fish kills both before and after the laboratories was a great anchor for the confirmatory labs, it did not reflect E&R's (2003) discussion of the construction of "a system of variables that creates a microworld in which students can explore relationships among variables" (p. 35). Neither did it reflect the beginning of an experience where students were sustained in "purposeful, systematic inquiry, where the class is collaborating in establishing knowledge claims—things they agree they know and understand about the system" (p. 39), since there was no true system of variables to explore. Mrs. Lewis provided two confirmatory labs that would demonstrate two opposite solubility curves and reinforce and extend their understanding of the concept of solubility.

The completion of the independent library research project provided students with a valuable connection of the chemistry content learned and reinforced through the immersion experience to the real world, but it did not follow E&R's ideas of having students use their understanding of a system of variables to investigate their own questions and eventually solve a novel task.

The series of activities that comprised Mrs. Lewis' IF led students through a series of exercises that reinforced the concept of solubility in a more student-directed and open-ended way than Mrs. Lewis normally taught. Her schedule did not provide a great deal of extra time and so she felt the need to cover concepts as quickly and efficiently as possible. Because of this, she did not often take the time to discuss topics before she taught them, reinforce topics through laboratories or assign large projects to her students.

This series of activities appeared to be a very positive addition to Mrs. Lewis' teaching. She did something out of the ordinary and found that both she and her students had been engaged and excited about it. However, the things Mrs. Lewis appeared to learn from completing this assignment did not confront or change her personal theories about chemistry and did not reflect an understanding of the philosophy that drove the ideas that had been a focus of the ITS Center's PDE.

**Action Research Plan**

Mrs. Lewis' ARP reflected a similar interpretation of educational research ideas as that of her IF. Her ARP appeared to be based on her interpretation of inquiry as hands-on activities used to reinforce concepts. Her interpretations of other constructs, such as "conceptual understanding" and "transfer," were well aligned with her interpretation of inquiry and, like this interpretation, demonstrated connections to her concept transmittal and mastery view of chemistry.

Since Mrs. Lewis had designed her IF to reinforce the concept of solubility, and interpreted inquiry in this way, it was logical that her ARP tested her student's retention of this concept. Her ARP demonstrated that she viewed her IF as providing an immersion experience that helped students develop conceptual understanding of the concept of solubility. Within her ARP she described the term conceptual understanding as a "deeper type of long term retention of science concepts" (ARP, Page 1) and a "mastery of conceptual knowledge that is enduring or long term" (ARP, Page 2). These definitions indicated to me that she had interpreted the construct through her concept transmittal and mastery view of chemistry

Her ARP went on to describe how students would be asked to apply, or transfer, this conceptual understanding to their independent research projects. She described the independent research projects as giving students the opportunity to "transfer skills and concepts from laboratory to novel settings" (ARP, Page 2). While her project did indeed ask students to apply their knowledge of solubility to a novel real-world setting, the goal of asking them to do this remained focused on long-term retention of the concept of solubility.

The research question and methods which formed the basis of Mrs. Lewis' ARP continued to reflect the same interpretations of inquiry and conceptual learning seen in her literature review. The method she used to answer her original question, including the pre-test, post-test and removed post-test, which would be given to students about 4 months after the completion of her IF, focused on retention. She discussed her tests in the following way:

> The pre-test and post-tests which will cover factors effecting solubility administered during the first semester of the AP Chemistry class contain seven open-ended questions that will be used for validating or evaluating acquisition of science conceptual knowledge. A subsequent re-administration of the post-test will be given in the spring to determine long-term understanding. (ARP, Page 5)

This statement demonstrated to me that Mrs. Lewis would be utilizing the same test three times in order to gauge how her students' performance on it improved. The open-ended questions which composed her test included: Define solute, Define solvent, what is the “general rule” for determining what type of solvent and solute are soluble in each other?, and name two variables that increase the “rate” at which a solute dissolves other than temperature. These questions demonstrated a focus on the acquisition of rote knowledge, which further reinforced her concept transmittal and mastery view of chemistry and the influence it had on her interpretation of the ideas presented during the ITS Center’s PDE.

Member Check Interview

Once this chapter was completed Mrs. Lewis was invited to review and comment on my descriptions and analyses. Aside from the myriad of mistakes I made in describing the details of her background, Mrs. Lewis felt the analysis accurately depicted her teaching style and her learning from the ITS Center’s PDE. Mrs. Lewis and I discussed three other aspects of my analysis in-depth.

The first of these discussions was focused on my assertion that her teaching focused on lower-order skills. While we discussed this idea in some detail, I felt that Mrs. Lewis’ ideas about the differences between lower and higher-order thinking were different from my own. Her comments demonstrated that she felt complex subject matter was “higher order” and she was teaching complex material. I explained that in my mind, higher order did not refer to the complexity of the material being taught, but rather what the students were doing with that material and how they were thinking about it. After this discussion she felt she better understood the differences in our ways of thinking and was more at ease with my use of the term.

The second of our discussions focused on my statement that she was “free” to plan her own curriculum. Mrs. Lewis wanted to make sure that readers would understand that there were many constraints to her practice, including her limited schedule, the standards set forth by the state, and the end of course tests her students had to pass. I agreed, and reworded the portion of my analysis section to include these views.

Our third and final discussion revolved around my interpretation of Mrs. Lewis’ statement that education research was “like a mechanic trying to tell you how to change out your engine.” She clarified this statement by saying that she felt educational research was like and individual trying to tell a mechanic how to change out an engine. This discussion changed the way I understood this quote, but did not significantly change the manner in which I discussed her analogy of teaching to car mechanics.

Discussing my analysis with Mrs. Lewis was enlightening. Her thoughts confirmed that my analysis had not misrepresented her ideas or teaching practice and our discussions deepened my understanding of her ideas.

## Case Summary and Implications

Understanding the connections among Mrs. Lewis' teaching situation, practice and personal theories illuminated my understanding of her perception and interpretation of various aspects of the ITS Center's PDE. The concept transmittal and mastery view of chemistry that drove her practice was far removed from the vision of reform promoted by the ITS Center's PDE and appeared to make it difficult for her to engage with the ideas presented in the educational readings. Observing her teach and speaking with her about her teaching practice demonstrated that she did not seem to formatively assess or reflect on her students' understanding and rarely changed her plan to accommodate their progress. These characteristics seemed to carry over to her design and implementation of her IF and ARP where the focus was on reinforcing a singular concept and assessing retention of that concept.

Although the ITS Center's PDE had encouraged Mrs. Lewis to integrate additional technology into her teaching and involve students in a valuable project connecting their understanding of solubility outside of the classroom, her learning did not seem to reflect an understanding of any of the deeper elements of reform. Her views of learning, teaching and science did not appear to have changed and her practice remained very traditional. It appeared that having Mrs. Lewis design and implement her IF and ARP based on her interpretation of inquiry as hands on science, of conceptual understanding as concept mastery, and of transfer as retention had reinforced her belief that educational research and the ideas of reform were not practical for her to use to help her think about her classroom practice.

It appeared to me that Mrs. Lewis' teaching practice and her learning from the ITS Center's PDE were connected by a common, yet missing, thread: reflection. Mrs. Lewis seemed to accept what Dewey (1933) would call a "spontaneous interpretation" of her experiences. This was evident to me through both her teaching and learning. In her practice she seemed to accept that her general chemistry students were unmotivated, since they were not planning on going to college, and she planned her instruction without pausing to consider other possibilities. In her learning from the ITS Center's PDE, she seemed to use her initial interpretation of the ideas she encountered, ideas that fit easily within the framework of her existing personal theories, without stopping to understand how those initial interpretations differed from those in the readings.

The parallels between the process of Mrs. Lewis' teaching and learning illuminated my understanding of the difficulties she faced in understanding the ideas of reform that relied on a reflective and adaptive approach to teaching. The ability and willingness to reflect and critically analyze learning of both herself and her students was an essential. Without some level of critical reflection, Mrs. Lewis did not seem to notice the differences in her understanding of the readings from the ITS Center's PDE. She was also unable to incorporate ideas that relied on many of the same skills that would have helped her understand the readings

The following two chapters present the cases of Mrs. Major and Mrs. Patton. In the same fashion as Mrs. Lewis, the data collected from each of their cases is explored, connected and discussed.

# CHAPTER V

## MRS. MAJOR WITHIN-CASE ANALYSIS

This chapter is the second of three case studies of the three high school science teachers ultimately chosen as participants for this study. The purpose of this case is to describe Mrs. Major, who also appeared to be a representative of the group of teachers who had difficulties in understanding the ideas presented in the conceptual frame of the ITS Center's PDE. Through my analysis, I came to understand that Mrs. Major held a very traditional view of teaching. She felt strongly that her students could only handle small "chunks" of information at a time. She discussed that her instruction was based on concepts that she had determined, through years of experience, to be reasonable to cover in a single track and would help keep all students on track. She presented concepts through didactic methods of lecture, practice, and hands-on laboratories. These teaching methods focused mainly on lower-order skills of memorization and application. My analysis indicated that Mrs. Major perceived the new lab activities she learned and her renewed motivation to change parts of her curriculum the most valuable parts of the ITS Center's PDE. Mrs. Major's IF described a cycle in which the main activity was students gathering information from the Internet. Her ARP described a loose plan to assess how this experience had affected students' conceptual understandings. These analyses indicated that Mrs. Major's interpretations of various concepts including inquiry, conceptual understanding, and cooperative learning were closely aligned with her personal theories and practices.

Much like the last chapter, the presentation of the case study of Mrs. Major uses the first research question and its four sub questions as an outline. It includes: (1) a brief introduction to Mrs. Major and a discussion of the process that led to her selection as a participant in this study, (2) a description of the school context in which Mrs. Major taught, (3) a description of my classroom visits including the resulting M-SCOPS Profiles and brief interpretations of them, (4) a description of what I learned about Mrs. Major's methods of planning and teaching and her personal practice theories from our discussions, (5) a description of the performance artifacts that resulted from Mrs.

Major's participation in the ITS Center's PDE, (6) a description of Mrs. Major's perceptions and interpretations of constructs from the ITS Center's PDE, and (7) my analysis of these experiences and artifacts, which relates the data sources to a unifying theme, allowing me to derive some insight regarding the relationships among her thoughts, perceptions, and actions.

## Introduction

At the time of this study Mrs. Major was a freshman biology and integrated physics and chemistry (IPC) teacher in her $15^{th}$ year of teaching. She was in the middle of her third year teaching at Becker High School, a school that served about 2000 students in a medium-sized town with a population of about 30,000 (2000 census data). This town was located about 10 miles outside of a small urban community with about 100,000 residents where Mrs. Major previously worked, for 12 years, teaching biology, chemistry, and IPC. Both towns revolved around a large military base where Mrs. Major's husband and many of her students' parents worked and/or served in the US military.

Mrs. Major had an unexpected and unique background. She had completed a B.S. in biology with a minor in chemistry. After college she worked for a few years at a mental health clinic. While working at the clinic she met and married her husband, who was in the military. Mr. Major's military occupation required them move on a regular basis. Mrs. Major found it difficult to find a steady job since they were seldom in one place for long. She began substitute teaching on the various military bases they lived on, many of which were overseas. Through substituting, Mrs. Major found that she enjoyed teaching and when her husband was stationed stateside she went back to college at a large university for two years and completed a second B.S. in education, with a minor in mathematics.

As Mrs. Major was finishing her second degree, her husband's job was transferred and they prepared to move again. Mrs. Major filled out an online application to be a science teacher at the high school in the town they were moving to and completed an interview over the phone. The first day they arrived in the new town, Mrs. Major went to the school for a face-to-face interview, was hired on the spot, and began teaching even before they had moved into their new home.

In the ITS Center's PDE, Mrs. Major was a member of the Molecular View of the Environment science team. The morning sessions were led by two geologists and two chemists and focused on exploring connections between current research in both areas. Two graduate students led the afternoon discussion groups, one who was working on a Ph.D. in geology and the other who was close to finishing her Ph.D. in science education.

In order to answer the research questions, the three teachers were selected based on the understanding of the readings from the ITS Center's conceptual frame reflected in their performance artifacts and exit interviews (as inferred by the researcher). From this selection process, Mrs. Major was placed in the lowest category of alignment with the ITS Center's conceptual frame. This placement was due to several factors, including the way in which her IF aligned with the Etheredge and Rudnitsky (2003) inquiry frame, the coherence and consistency of her ARP, and her discussion of what she valued from the ITS Center's PDE. All of these sources of data indicated that Mrs. Major's interpretations of the ITS Center's conceptual frame and other ideas from educational research were far removed from the original philosophies on which they were based.

## School Context

As was mentioned before, Becker High was a large school in a mid-sized suburban community where most residents worked or served in the military at a nearby military base. The student population of Becker high was 55% White, 28% African American, and 13% Hispanic at the time of this study. About 25% of students were considered to be economically disadvantaged and over 50% of students were considered "at risk."

Mrs. Major taught freshman science. Incoming students were evaluated based on their middle school performance and tracked into different disciplines. The top 10% were placed into biology, while the remaining students were placed into IPC. In response to the No Child Left Behind Act (2001) Mrs. Major also had a handful of "inclusion" students, or students who had not been mainstreamed prior to high school because of behavioral and/or learning disorders, in her IPC classes. An aide was present during these classes to facilitate the transition of these students into the mainstream classes. Mrs. Major's teaching load consisted of one section of biology and four sections of IPC. Classes were organized on an A/B block schedule where they met for 90-minute periods every other day for the entire school year.

Three years prior to this study Becker High School had been ranked as "unacceptable" by the state based on standardized test scores in science. This rank meant that fewer than 25% of the students tested at Becker High passed the test. The school had taken action to change this rating and hired some new teachers, one of whom was Mrs. Major. The year following, the school's test scores rose 12 points and brought them into an "acceptable" range. Wanting to improve even more and possibly become "recognized," the school hired a curriculum coordinator who attempted to standardize teaching through the use of curriculum guides and benchmark tests at six-week intervals. The curriculum coordinator employed these efforts in an attempt to ensure teachers were moving through course content efficiently and effectively.

Mrs. Major explained that, in order to prepare students for these exams, the science teachers met for 25 minutes every Wednesday afternoon. During these meetings they would look through the curriculum guides and decide which topics they would cover the following week, keeping in mind the next benchmark exam. Once topics were decided upon, the teachers were free to decide how they would go about covering them in their classes, but were required to upload their lesson plans and the objectives they covered onto a web-based TaskStream site.

## Classroom Observations

I made two trips to Mrs. Major's classroom in order to observe her actual classroom practice. During each visit I observed a single class. During my first visit I observed one of her IPC classes and during my second her only Biology class.

*Observation 1*

Monday, November 13, 2006

After a very long day, I was finally turning off the highway I'd been on for three hours to begin the last leg of my journey to Becker High. I turned west onto a smaller highway and headed toward the town where Mrs. Major lived and taught. I was starving, but I wanted to get there and find a hotel to stay at and call Mrs. Major, as she had asked, before I did anything else. I could only hope that the town was big enough to have a hotel in it and that I wouldn't have to head back to the larger city I had driven through about ten miles back to find somewhere to stay.

When the countryside ended and things began looking like civilization again, I was pleased to see a large hotel. I stopped, procured a room, and dragged my suitcase and computer inside. Once in the room I called Mrs. Major, who was disappointed I had arrived so late and she was unable to show me around the town. My observation was scheduled for 9:30 a.m. the next morning, so I found a decent chain restaurant across the street, grabbed dinner, read a book for a while, and went back to the hotel to sleep.

About 8:00 a.m. the next morning I got all of my stuff into the car again, grabbed something to eat from the hotel's continental breakfast, and left. I didn't know exactly how difficult it would be to find the school, but I had once again printed off what looked to be reasonably clear maps and thought that I should be able to find it easily.

In the daylight, I got a better feel for the town, which was unlike any other I had ever been in. The streets that the houses lined ran diagonally to the main highway that was littered with older strip malls filled with small businesses. I made my first turn off of the highway and onto one of the diagonal roads. The map made it look as though this road would get me relatively close to the school and I hoped for the best.

I wound up driving through what seemed to be a main street and then a couple of neighborhoods. None of the streets seemed to go in a straight line and the way I took seemed a little more complicated and out of the way than it had to be, but I made it to the school. I drove almost all the way around the school until I found the entrance.

The campus was closed and gated. I drove up to the security guard, told her my business, and after waiting for approval from the office, was directed to the visitors' parking spaces. The school's office was not clearly visible from the parking lot and I had no idea which door to take. I was woefully underdressed for the cold weather I had driven into since leaving my home the day before and as I gathered up all of my stuff I prepared myself for the blast of cold air that would inevitably hit as I opened the car door.

I opened the door to my car and caught my breath as the cold hit me. I hurried to pick up all of my equipment and quickly made my way over to the two sets of double glass doors that I thought were my best bet to get to the office. A student exited one set of doors and I asked where the office was. Although he stared at me a bit, he pointed in the direction of another set of doors.

I entered the building and looked around. Nothing that really seemed to be an office was visible, so I made my way to the first hallway and looked down it. There was a "campus security" office where uniformed security guards sat talking. I inquired about the front office and one of them pointed me further down the hall where a small street-like sign saying "office" protruded from the top of a doorway.

The office was small and dark and a lone secretary sat at a desk behind a glass display case. She asked me to sign into a book, handed me a nametag, and gave me a blurry photocopy of a campus map. She drew a zigzagged line with half a dozen turns in it, highlighting the path to the chemistry wing. I thanked her, and being careful to keep my bearings as I left the office, set out to find Mrs. Major's classroom.

As I walked, I noticed a lot of students who seemed to be marching to class, and a lot of teachers standing around chatting and monitoring them. I made the first four turns through hallways lined with lockers, student work, and murals. My next turn led me into a construction zone where the hallway was covered with blank pieces of wood and plastic tarps covered entrances that looked like they led to unfinished hallways. The construction zone effect was enhanced by places with wires hanging down from the ceiling. I hoped I was going the right way and, thankfully, stumbled on a few classrooms after a couple more turns.

Mrs. Major's first period class was completing a lab. She saw me peer through the door and let me in. I awkwardly stood out of the way for a minute behind a VCR/TV cart observing the unorganized chaos of the class. I saw a spot in the far corner of the room that looked like a promising place to set up. I asked if I would be in the way there and was told that I would not, so I made my way through the classroom, set up my video camera, and sat down to watch the end of the current class.

As I waited I looked around the relatively ordinary classroom. Six lab tables jutted out from the two sidewalls, and a few bookcases and desks with dividers lined the back wall. A large whiteboard covered the front of the room with a demonstration lab table in front of it. A TV was mounted over the left side of the whiteboard and to the right Mrs. Major's desk, complete with computer, sat facing the classroom door. I was surprised by was the presence of another adult in the room. I wondered if she was another teacher and made a mental note to ask about her during our interview.

The classroom was in relative chaos, with students doing a variety of activities. Some were working at their desks, others at lab tables, many were standing around gossiping, and still others were asking Mrs. Major about making up quizzes and assignments. I didn't have long to wait before the bell signifying the end of class rang and the students stormed out of the room. Mrs. Major excused herself to go stand out in the hall for "hall duty" (which I realized must have been the reason for the other teachers monitoring the halls on my way to her class) and she returned to a class of students who were doing anything but sitting in their seats.

Mrs. Major asked students to sit down and take out their notebooks before the Pledge of Allegiance and morning announcements came over the intercom. While some students complied, most did not. Over the din of student conversation, she made a couple of announcements about handing in past assignments and fielded a few questions about handouts before she made a second attempt at beginning class. This time, most students sat down and began taking out their notebooks as the intercom buzzed and the Pledge of Allegiance and morning announcements began.

Ten minutes after the bell rang the announcements concluded and Mrs. Major began her lecture, writing terms with a black marker on the white board as she spoke. The lecture reviewed some concepts about non-metals gaining or losing electrons. She prompted students to answer lower level questions. The same three or four students consistently answered. She also reviewed the difference between subscripts, superscripts, and coefficients. She began demonstrating how students could use the "criss-cross" method to determine how many atoms of a particular element were present in an equation and how they would name the compounds once they were created.

Students dutifully responded to her prompts as she progressed through a few examples on the board. She then listed on the board all of the non-metals and how their names would change once they lost their valence electrons and became part of a binary compound, asking students to help her name them along the way.

The lecture lasted about 10 minutes. After it was done, she handed out a couple of worksheets and she asked students to get into groups. Once in groups, the students worked on naming binary compounds and calculating numbers of atoms in chemical equations. Mrs. Major walked among the groups, asking and answering questions. I was surprised to see how many of the students were helping their peers understand how to go about answering the questions on the sheets. After about 35 minutes, the concentration levels of the groups began to wane and many students began gossiping and talking about unrelated topics.

After about 15 more minutes Mrs. Major asked if they were about done with their worksheets and called them back to their seats. Although students moved their desks back into rows, they did not stop talking. With a command to quiet down, Mrs. Major began making some announcements about quizzes, grade sheets, missing assignments, finishing up the worksheets, and future class topics. Once her announcements ended, the relative chaos I had seen with the previous class ensued as even more students got off task and talked animatedly about everything but chemistry.

During this time, which comprised the final ten minutes of class, Mrs. Major answered individual students' questions about missed assignments, making up quizzes, and the like. Ninety minutes after the first bell had rung the second sounded, and students stormed out of the classroom.

Much like the other teachers, I had come to observe a class after which Mrs. Major had a free period. She asked me if I would like to go with her to monitor the halls in between classes and pick up some photocopies. I accepted and we walked outside the classroom and stood making pleasant conversation until the next bell rang. We then took a walk through the building to the copy room, where Mrs. Major picked up a stack of photocopies and filled out a request for more. Eventually, we made our way back to her classroom and began our interview.

*M-SCOPS Profile Interpretation*

The M-SCOPS Profile representing my first observation of Mrs. Major's class can be found in Figure 5.1. This 90-minute lesson consisted of seven segments. The two segments at the beginning and end of class, which composed 19% of the total class time, were segments in which all students were off task. These segments were intentionally left blank since neither the teacher nor the students were focused on class material. The remaining 81% of class time was broken into five teacher-directed segments. During four of these five segments (20% of class time) Mrs. Major lectured students about naming various elements and compounds. This activity was indicative of an instructional scaffolding level of "5/1." During the remaining segment (61% of class time) students worked in groups to complete a teacher crafted worksheet, which reinforced the concept they had learned through lecture. The instruction scaffolding level of this segment was a "4/2."

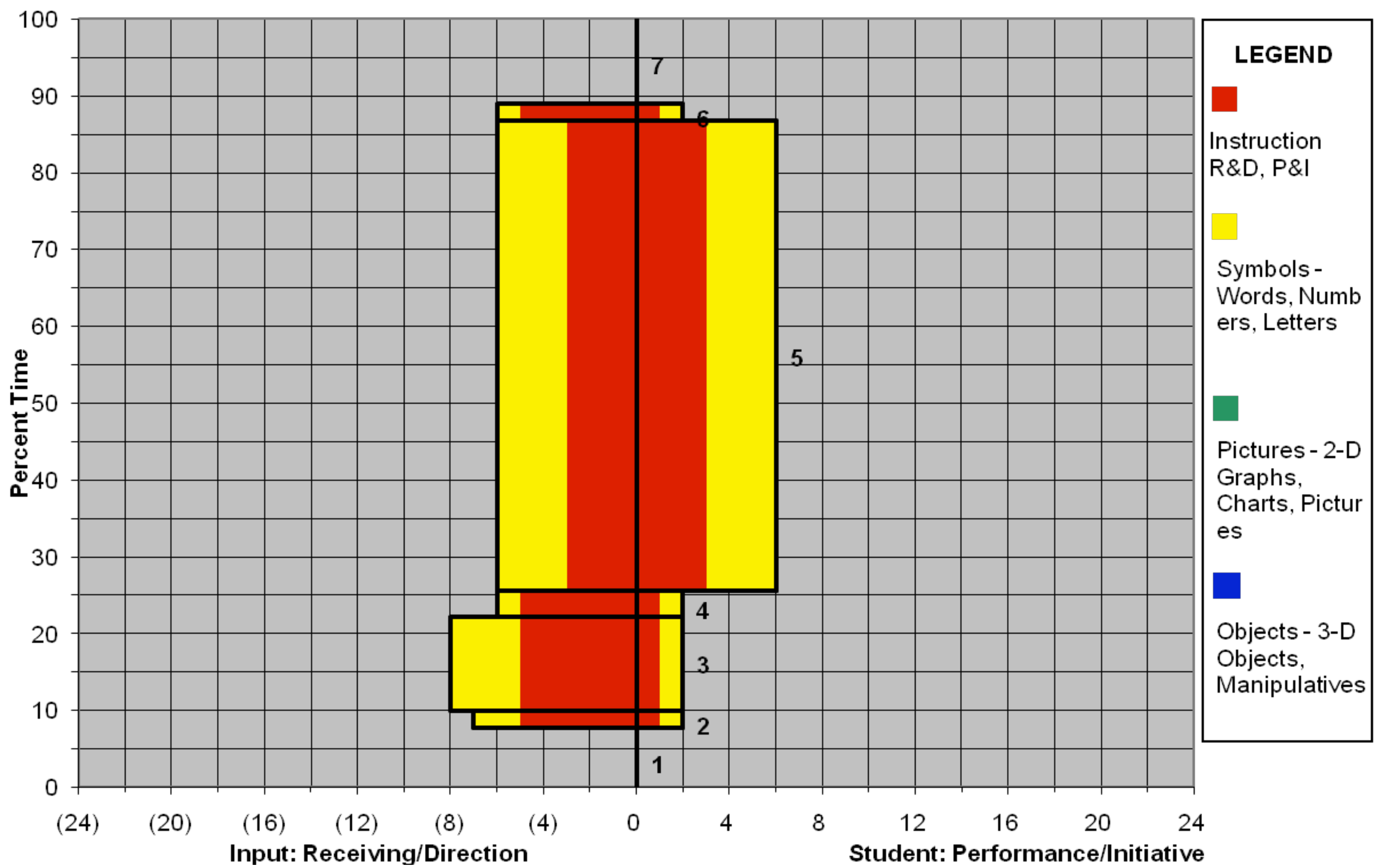


FIGURE 5.1 M-SCOPS Profile from the first observation of Mrs. Major's class.

During the five instructional segments students received verbal and symbolic information about naming elements and compounds. Students received information at complexity levels of 1 (6%), 2 (2%), and 3 (73%); while acting on information at levels of 1 (20%), and 3 (61%). Student learning was focused solely on words and symbols; no manipulatives were used. While the lesson ended in with Mrs. Major announcing what would transpire during the following class, there was no time provided for students to synthesize and reflect on their own learning.

*Observation 2*

Wednesday, December 6, 2006

Much like I had with the other teachers, I asked Mrs. Major if I could come and observe a different class than the first one I had seen. Since I had first observed one of her IPC classes, she eagerly agreed for me to come to her Biology class which, she told me, was comprised of the top 10% of the freshman class and was her last class on a Thursday.

I left my house mid-morning and arrived at Becker High School a bit early. I made my way past the security guard, signed in at the office, and navigated the maze of hallways, a bit more confident of where I was going this time. I found Mrs. Major alone in her room setting up the lab the biology class would be doing that day. She explained to me that she had been lecturing her students about DNA for a few classes now. She decided to do a lab that day because she wanted to show the students that DNA was actually a real thing, so it wouldn't seem as abstract, and let them get out of their seats and do a lab for a change of pace.

She went on to explain that she was going to have her students extract DNA from onion root cells, an activity she had seen at a workshop but had never tried to do. She followed the instructions she had, exclaiming that whoever had written them had left out at least one step that she knew of, and hoped there were no more missing. She was unsuccessful in extracting the DNA from the onion roots herself and left for a minute to consult with another teacher a few rooms down. She returned no more enlightened than she had left and told me that she hoped the students could do it better than she had.

She went on to tell me that she was having the students begin working on the project for the Action Research Plan (ARP) she designed during the second summer of the ITS Center's PDE. She was worried her research questions, which concerned whether Black and Hispanic male students learned better working in groups than by themselves, would not apply to this class as well as they would have the year before. The reason for her worry was that, the previous year her Black and Hispanic male students had been among her worst students and this year they were among her best, and she wasn't sure the groups were going to have as much effect. The biology class was to be her "control" group. They were going to complete the project she had designed individually while some of the students in her IPC classes would work in groups to complete their projects. I did not remember the specifics of her IF and had little idea of what she was going to do with the students as an inquiry project.

Students began to trickle into the class, loudly gossiping and joking with each other. The bell rang, and students sat around talking, laughing, and yelling at each other for a good five minutes before Mrs. Major asked them to take their seats.

The first few minutes of class were composed of some announcements about homework and quizzes. Then Mrs. Major walked the students through a review of a video about skin cancer they had watched the period before in order to kick off the project they would be beginning today. Students recalled the answers to her questions, laughing and yelling in between. Mrs. Major then fielded boisterous protests as she handed out a quiz that was to be the pre-test for her ARP.

The students quickly completed the quizzes she had handed out, seeming to put little effort into them. Mrs. Major then launched into a description of what the students needed to do to complete the project on ozone that she assigned. She handed out a list of questions and instructed students that their "mission" would be to answer all of the questions on the paper she had just given them in a PowerPoint presentation. She proceeded to read them all of the questions on the paper, which included questions like: What is ozone? How is ozone formed? What are all of the chemical reactions involved in this process? Where in the atmosphere is ozone found? And what are some factors that affect the decomposition of ozone?

After she finished reading them the questions she directed their attention to a rubric on the back of the paper from which they could see what the requirements were for getting an “A.” The categories in the rubric included: Internet use, quality of information, organization, scientific knowledge, and diagrams and illustrations. She then fielded many questions about the construction of the PowerPoint presentations and how they would be graded.

She instructed the students to put the project requirements away and not to lose them. She announced that she had graded the exams they had taken the previous week and that Ian had been the high scorer again with a 94. Then she began explaining the lab.

Mrs. Major began her explanation of the lab with the following dialog:

> Mrs. Major: Alright, let’s get started, so listen, we’re finished with our DNA section and we’re going to take a look at some actual DNA, hopefully this extraction of the DNA works today. I tested it a little bit, we don’t know for sure if it’s going to work, so maybe yours works a bit better than mine. So listen, we’ll be extracting some DNA from some onions okay?
>
> Students: Oh man. I’m allergic to onions. Those burn don’t they?
>
> Mrs. Major: I’m going to go through the procedures with you, I’ll be putting them over here, um, so this is just to pick up your information and I want you to take those to a lab station and make sure you clean up and put everything back over here when you’re done. It should only take about 30 minutes and when you’re done with your DNA you can pick up your computers and start your research. Okay? <long pause as she hands out papers with directions on them> Okay, it says the introduction: This laboratory exercise is designed to show that DNA can easily be extracted from onions. It includes an optional test for the presence of the DNA so hopefully we can see it. Mine didn’t get very long strands though.
>
> Students: Laughing
>
> Mrs. Major: Okay, you’re going to take 4 or 5, Shhhhh, you’re going to take 4 or 5 pieces of onion and macerate them in the mortar and pestle, uh, this is your detergent and salt solution which you’re going to pour over the onions just enough to get it in there to cover the onions, take the

> mortar and pestle and crush the onions up into a solution. You're going to take that information and filter it, the 100mL beakers, you're going to take that pour it into filter paper, coffee filter paper, and squeeze it through into one of those 100mL beakers. Take that and add 3-4 drops of the enzyme solution which is over there, we have some meat tenderizer make sure you stir it up before you take your drops, take that liquid and put it into a test tube, you only need to put a portion into the test tube, swirl the test tube, there's an ice bath over there with the alcohol in it, just set your test tubes down in the ice bath and leave it there for 5 minutes, okay? The alcohol has to be ice cold, so I've put it in the freezer already, it's been in there all morning, the graduated cylinders are there you need to take 10mLs of the ethanol and pour it down the side of the test tube, it's going to form a layer on top, okay? And then you just let those sit in that ice or 5 minutes okay? Take that and you're going to swirl it a while and we're going to put a couple of drops of universal indicator and see how they interface, here, let me show you what happens (takes out her test tube she was working on before class and demonstrates standing in front of class) So this is the solution of the onion and this is the alcohol on top, so when you pour that on top its gonna layer itself out, so when you add the universal indicator this is the section where the DNA should be, okay? So when you get it in there we're gonna give you a wood, uh, like a wood splint, one of these items, what is it called
>
> Students: A toothpick?
>
> Mrs. Major: Like a big Q-tip, put it down in that section and try to swirl up the DNA, so go ahead and do it, huh?
>
> Students: You can see DNA with the naked eye?
>
> Mrs. Major: Uh huh, so go ahead and do it. (Observation 2, 27:30-33:20)

Once she completed going through the above dialog, the class erupted in a cacophony of noise. Clinking, joking, yelling, and questioning filled the classroom as students rushed to grab their equipment and raced to their lab tables. Leaders in many of the groups quickly took over and ordered the other students around as they completed the bulk of the lab procedures while the others watched. It soon became apparent that two of the groups were racing to see who could complete the lab in the least amount of time.

Mrs. Major stationed herself at the lab table at the front of the room and administered alcohol, enzyme, and indicator solution, mixed with various repeated instructions. The first group successfully extracted DNA from their onions in about 25 minutes and yelled for Mrs. Major to unlock the mobile laptop station so they could get their computers. Once they got their computers, they sat in their seats and turned them on while the rest of the class completed their lab and slowly trickled to a similar, computer-grabbing end.

For the remaining 45 minutes of class a few students worked on their PowerPoint presentations in their seats, while the vast majority carried on loud conversations about bands, concerts, and cool websites. Mrs. Major paid little attention to the students with computers as she helped the lagging students complete their lab and began cleaning up the lab materials.

About five minutes before the bell, Mrs. Major announced it was time to begin shutting down computers and putting them away. Some students exclaimed that the computers were so slow they hadn't even gotten to the website on the handout. In these last minutes the class got even less focused as students put away their laptops and began to gossip even more loudly than they had before. The bell finally rang and Mrs. Major was assaulted with questions as students asked about quizzes and make up assignments.

I asked her if she might have time for a quick interview and, sounding a bit perturbed, she mentioned that she hadn't know I would have to interview her again and she had to attend an after school club meeting, but would have a bit of time afterward. I agreed to come back, gave her my cell phone number so she could call me once the meeting was over, and left to hunt down a late lunch.

Mrs. Major called me about an hour later, as I was finishing up a sandwich, and I rushed back to her school to complete the interview and get us both out of there at a reasonable hour. The interview was relatively short, lasting only about 30 minutes.

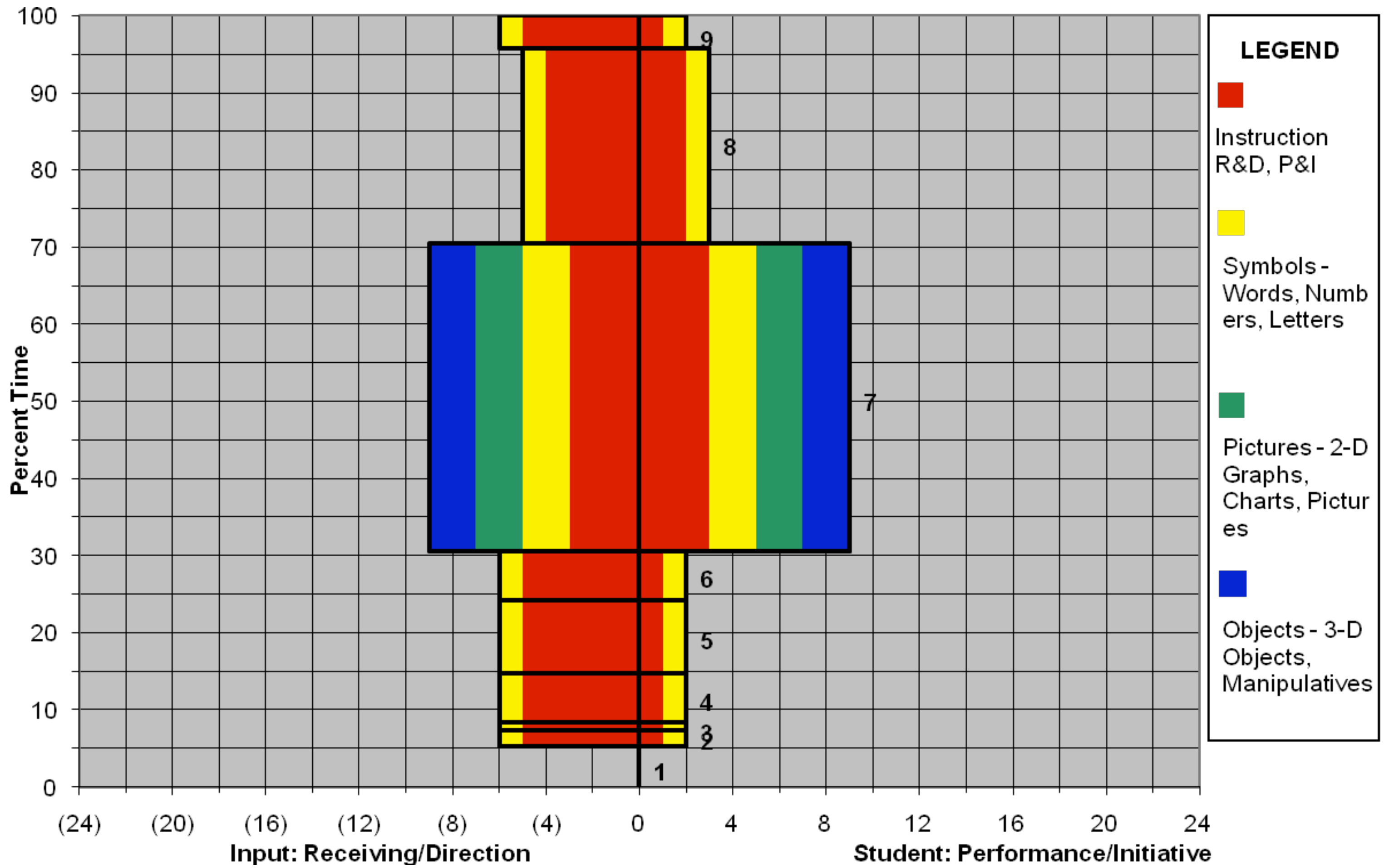


FIGURE 5.2 M-SCOPS Profile from Mrs. Major's second observation.

*M-SCOPS Profile Interpretation*

The M-SCOPS Profile representing my second observation of Mrs. Major's class can be found in Figure 5.2. This 90-minute lesson consisted of nine segments. The first segment, which composed 5% of the total class time, was a segment in which all students were off task. This segment was intentionally left blank since neither the teacher nor the students were focused on class material during this time. The remaining eight segments demonstrated a very teacher-directed emphasis. Although the flow in the lesson moved from teacher- to student- to more teacher-directed activities, demonstrating instructional scaffolding levels of "5/1" (30%), "4/2" (25%), and "3/3" (40%), students had little choice or initiative in what they were doing.

During the instructional segments, students received verbal and symbolic information (55% of the time) and used pictures and manipulatives (40% of the time) to replicate the laboratory procedures of the DNA lab (segment 7) that Mrs. Major had previously demonstrated (segment 6). Students received information at complexity levels of "1" (attend) 55% of the time, and "3" (rearrange) 40% of the time, while acting on information at levels of "1" (attend) 55% of the time, and "2" (replicate) 40% of the time. The class opened with a review of a movie that had been shown the class prior and progressed to the projects they would begin that day. The class concluded with Mrs. Major asking students to put away their laptops. There was no time spent in closure or opportunities for students to synthesize and reflect on their own learning.

## Personal Practice Theories

After each classroom observation I conducted a semi-structured interview with Mrs. Major. The list of questions I followed can be found in Appendix B. During these interviews I learned a great deal about how Mrs. Major went about organizing, planning, and teaching her classes as well as the personal theories that guided her practice. In particular, I discuss four themes that emerged from my analysis: Mrs. Major's focus on "one concept per day" (POI1, L212) in an effort to not overwhelm her students, her view of teaching as providing students with information and opportunities to reinforce that information, her consistent reference to learning as "gain in information," and her understanding of how science was done in the real world. The first two of these themes are embedded in my discussion of planning and teaching while the second two are discussed independently.

*Planning and Teaching*

The emphasis of Mrs. Major's teaching was on content delivery and providing opportunities to practice using new knowledge and skills. Mrs. Major told me she felt as though her major responsibility as a teacher was to break the subject matter down into chunks that were manageable for the students to thoroughly understand in one sitting. She felt that her students could only handle "one little thing per day" (POI1, L386) and that she needed to make sure they learned that information before moving on to the next topic. She had learned from both personal and professional experience that if she did not cover information at a rate that students could keep up with, they would become lost and frustrated and would eventually "shut down." She demonstrated this personal practice theory in her response to my question about what she thought the most important part of her job as a teacher was. She answered:

> Making sure they understand. I can tell when they get frustrated and they want to shut down. A lot of them if they don't understand what to do they'll shut down. That's why I try to only teach them one concept per day because the way I have it set up, if I teach them a concept one day and then quiz them on it the next day to make sure they understand and then we pull them all together before we test. That way they're only focusing on one thing. I don't try to throw too much at them at one time, unless it's necessary to teach them that way, but just making sure they understand and are not giving me that look of "what in the world is she talking about?" because I know how I am when I don't understand something, I'll shut down too and I'm like there's no way I can keep up with this, just keeping them all on the same page, making sure they're not lost and shutting down on me. (POI1, LN210)

She went on to tell me that in a typical class period she first gave her students a quiz to make sure they understood the material from the previous lesson and then divided the rest of the 90-minute period into two or three sections. In the first of these sections she would present a lecture on a new topic, after which students would be provided with opportunities to practice using the new information by completing worksheets in groups or hands on laboratory activities. In this manner, Mrs. Major saw the responsibility of her job as deciding how to “break the information down for students” and determining the best forms of practice she could give students to reinforce the chunk of information she focused on that day.

The curriculum guides and benchmark exams, which teachers at Becker High were required to follow, largely dictated the chunks of information or “concepts” Mrs. Major covered each class. When I asked her how she went about planning for each class she told me:

> I do my planning, we do our planning on what we call TaskStream and we’ll look in our curriculum guide and it tells us what they want covered, in a specific amount of time or this particular six weeks and I break it. I sort of scan through and see what those topics include and I break it apart and just plan it out like that. (POI1, LN646)

As this quote demonstrated, Mrs. Major would look over the topics the teachers had decided to cover the following week, break them down into chunks she felt she could sufficiently cover in one class period and plan her lectures and activities accordingly. She went on to discuss that she chose the activities she would use to reinforce the chunk she was teaching through a process of trial and error. She stated:

> I take a look at what I’ve done previously and what’s worked and what hasn’t and I try and notice which things get the kids stuck so I sort of change up things to make up for problems that I notice. I always show them okay this is what kids will normally do that I’ve noticed before and some of them will still make those mistakes but I try and stop it you know with some of the others so yeah just sort of what’s worked before and what hasn’t worked I sort of toss that out and find new things. (POI1, LN639)

As she ended this statement, Mrs. Major proceeded to show me a compilation of all the lesson plans, laboratory procedures, and worksheets the teachers at Becker High had put together during a workshop the previous summer. She discussed how it was a great resource for finding new things to try with her students to reinforce the topics she needed to cover. As the quote demonstrates, she planned her individual lessons by thinking about how different activities had worked for her class in the past and utilizing the ones that had worked again, or trying new ones if the others had not worked well.

Mrs. Major's personal theory that students could only handle "one concept per day" (POI1, L212) often made her feel pressed for time. She indicated that she believed that with a little more time, more of her students would be able to understand the information she was teaching them, which would help increase their scores on the tests they had to take. With the block schedule utilized by Becker High, Mrs. Major discussed feeling as though she should be covering "two days worth of information" but did not feel her students could handle that much information in that short of a time period. She stated:

> I think we move them so fast sometimes that we don't give them a chance to digest the information because every day they come in it's a different topic and I think some of them need more practice than just one day of actually applying that information and if they don't go home and practice on their own, which most of them won't, they're not going to get really good at it so that's why they don't retain the information I think as long as they should. With some of them I could spend two weeks on some of the stuff and some of them still wouldn't get it or wouldn't know it after we taught it, tested it, and re-taught it again they still you know wouldn't score any higher but, I just think some days they need a little bit more time on some topics. (POI1, LN553)

This statement indicated that Mrs. Major felt that, by offering her students more time either through "re-teaching" or offering more opportunities to practice applying the information, the amount of information students retained would increase. Thinking of this in light of what else I had learned about Mrs. Major's teaching, led me to believe that she felt that "breaking down the content" so it was as easily understandable as possible, adding on one little thing per day so students could see how it fit together, and offering them time to practice the new information was the best method to increase student learning and retention and therefore their test scores.

*Learning as a "Gain in Information"*

Through the analysis of my interviews with Mrs. Major, I noticed that she often discussed her students learning as "getting the information." She said that she saw the goal of teaching and assessment of student learning as monitoring student learning and retention of "information." She also appeared to see the different methods of "information reinforcement" as beneficial to "increasing the amount of information" students learned in her class.

As I reflected on Mrs. Major's interviews with this idea in mind, a statement she made became more interesting to me. Mrs. Major stated:

> I tell them they're going to forget all the little stuff that they're testing them on every day. They're only going to remember those big concepts. I don't necessarily teach them, I don't want them to know the terminology. I said you're going to forget all of that anyway. I want them to know how to do it; I want them to know the skills of science are just basic skills. If they know those skills they can take those skills and put them in any science class. So I do a lot of testing on their skills along with the terminology. I usually give multiple choice tests and then I'll give them something where they have to show me that they know how to do it. They usually have two test scores for each topic for me. They'll have something like a multiple-choice test that says the atomic number is the, or what's located in the nucleus, protons and neutrons that type thing. Then on my test they'll have to, I'll give them a periodic table and I'll ask them questions like what does that number represent, give me the protons neutrons electrons, draw me a model of that atom and show me which ion forms and why is it going to bond with that one. So it's not just knowing that, they have to show me how they're going to use it. (POI1, LN334)

While interviewing Mrs. Major I thought this statement was rather astute. Her idea that students were "only going to remember those big concepts" sounded like the concept of planning lessons around "big ideas" discussed in various reform documents such as the NSES. From her statement, it seemed as though Mrs. Major saw these "big concepts" as skills, such as being able to read the periodic table and not the more fundamental ideas about science and inquiry promoted by reform.

Also, Mrs. Major's statement: "I don't want them to know the terminology. I said you're going to forget all of that anyway," was in direct conflict with what I had seen her teach during my first visit to her classroom. During this visit she had gone over how different elements names would change as they bonded with other elements. She had then given students a worksheet that had them name compounds on their own. It seemed to me that the students were focused on terminology for an entire 90-minute block period, and I wasn't sure that her ideas about what she should teach were translating well into her classroom practice.

*Science, Research and the Real World*

During our first post-observation interview I asked Mrs. Major if her ideas about the science she taught had changed after spending time with the scientists in the morning sessions of the ITS Center's PDE. In response to this question, she reminded me that she was "really a scientist from the beginning and had gone back to education" and her ideas had not really changed much. This comment seemed at odds with some of her ideas about science that she revealed in her interviews. Even though Mrs. Major believed she was a scientist, I saw many misconceptions about how the ideas she taught were organized, what scientists did, and how the science she taught applied to the real world.

Mrs. Major told me that she considered herself a "life-long learner" and tried to attend as many professional development opportunities as possible. She also told me that, although the ITS Center had been a wonderful experience, she had attended several other PDEs where she had similar experiences. She specifically mentioned two other summer programs she had attended where she had worked closely with scientists learning about the actual research they did. Because of this, Mrs. Major was grateful for the insight into the research she had seen the scientists working on in their labs, but believed that she understood their work prior to this experience.

Even though Mrs. Major had worked with scientists multiple times over the last few years, she appeared to hold misconceptions about their work and how the science she taught fit in with it. One of the main misconceptions I came across was expressed in a comment she made during the exit interview, when she was asked how the ITS science faculty influenced her learning. She stated:

> You start to see things in a much, much bigger, broader sense and see where before, you think about doing science you're talking about going into a lab and setting up glassware and mixing chemicals and stuff and its much broader than that and the way they're doing research and collecting data I didn't really see that that all was part of the science process, and when the biochemist we talked to see a broader sense of how research fits

> in to the overall economic aspect of it you know what goes on there, which I'm sure a lot of people don't have a clue about, I know I didn't, and that would be interesting to get out there. (EI, LN112)

This comment demonstrated to me that, even though Mrs. Major considered herself a "scientist from the beginning," and even though she stated that the scientists had had no major impact on her thinking about science, they had some impact on the way she viewed the research they did. The comment she made about "doing science" as "going into a lab and setting up glassware and mixing chemicals" demonstrated that she had a lack of understanding about how authentic research was done in real world contexts. Her realization that the research she discussed with the scientists during the ITS Center's PDE was tied into the "overall economic aspect of it" seemed to be a beginning realization of the complexity of the scientific enterprise, an understanding she did not have before.

This new understanding about science in the real world did not seem to translate into Mrs. Major's thinking about her classroom practice. During our first post-observation interview I asked Mrs. Major if she "felt it was important to discuss with her students how real scientists go about doing science." She responded:

> Oh of course, yeah, I tell them that all the time and we when we're doing different things or if I'm teaching them I'll, if we're doing empirical formulas or something like that I'll say this is what you would be doing if you were working in a lab at CSI and they're like man I might like doing this, so yeah we try to make everything relevant to what they would be doing in the real world. (POI1, LN773)

I was a bit surprised by this statement. I had expected Mrs. Major to relate her ideas about science back to the ITS Center's PDE or one of the other experience she had had working with scientists. Instead, she had chosen to relate her ideas to a fictional television show where she believed the science she taught became relevant to her students and had some connection to the real world.

Another statement Mrs. Major made, which was not in response to a direct question, further clarified her understanding of how the science she taught applied to the real world. She stated:

> A lot of [my students] will ask: “When are we ever going to use this?” and I said if you’re a nursing student or you want to be in pharmacy. I said as soon as you go to your first year of college. And they’re like but what if you’re not and I’m like, it’s always good to know. Some of this chemistry stuff they probably wouldn’t use in everyday life. You know just to know it about valence electrons and all that stuff but if they, I tell them they never know what they’re going to change their minds and go into. Yeah because they, people as they get older they change their mind and say hey I want to major in this or I want to be this instead so it’s always good to have that good background. (POI1, LN190)

From this quote, it seemed to me that Mrs. Major only saw the science she was teaching as directly applicable to students’ success in college science courses. The examples of relevance she provided her students were of things that they might “want to go in to” rather than examples of how science actually applied to their everyday lives. This connection, or lack of connection, made me think that Mrs. Major did not have a firm understanding of how the science she taught connected to students’ lives outside of school.

## Performance Artifacts

Mrs. Major’s performance artifacts provided valuable insight into her understanding and interpretation of the ITS Center’s PDE. In analyzing her writing, I had the added advantage of having observed her beginning to implement her ARP on my second visit to her classroom. As I describe Mrs. Major’s performance artifacts, I relate what I read to what I observed occur in her classroom, what she told me about what she had done in her interviews, as well as the ideas of the authors on which she based many of her ideas.

### *Instructional Framework*

Mrs. Major’s IF depicted an activity that was not highly connected with the research she had been immersed in during the ITS Center’s PDE. Her writing demonstrated some understanding of the educational research literature, but this understanding did not translate into the design of her IF activity. In this activity her students would watch a video about the harmful effects of ozone and proceed to answer a list of teacher dictated questions in a PowerPoint presentation that would eventually be presented to the entire class.

In reading Mrs. Major's IF I noticed a distinct disconnect between her discussion of the literature presented during the ITS Center's PDE and the intervention she had constructed. Her summaries of the authors' ideas seemed clear and well constructed; they reflected my own understanding of the literature. The ways in which those same ideas were translated into the intervention she planned did not reflect the same understanding. This disconnect was so prominent that I wondered if the graduate student campus resource persons (CRPs) that lead her group had heavily edited her paper and I was reading more of their ideas than those of Mrs. Major.

This thought prompted me to call the CRPs of Mrs. Major's group. On speaking with them, I learned that they had indeed spent a great deal of time editing Mrs. Major's paper and felt that the portions of her writing that summarized the literature contained more of their ideas than hers. They also indicated that the ideas about the instructional procedures Mrs. Major had crafted to use in her IF had been hers and hers alone. They had attempted to help her better align the ideas in her instructional procedures with those of the readings she cited, but their attempts had been largely unsuccessful because Mrs. Major felt the way she had constructed her IF would work best for her class.

Mrs. Major introduced her Instructional Framework (IF) with the following paragraph:

> When teachers around the world were asked the question, "What do you want students to learn?" Their response was that they wanted their students to think critically; to analyze and ask questions; to be able to express themselves; and to gain some interpretative skills (Kagan & Kagan, 1998). I am no different from other teachers; I want the same results for my students. I would like to see my students improve/enhance their critical thinking and problem solving skills so that they are prepared for today's changing workplace. (IF, Page 2)

This introduction was based on some great ideas, ideas that formed the basis of the education reforms on which the ITS Center's PDE was based. Improving and enhancing students' critical thinking and problem solving abilities was exactly what an inquiry-based approach to instruction aimed to do.

Mrs. Major goes on to detail the problem she is trying to solve in her classroom. She states:

> My students were doing labs on a regular basis. They would all be fully engaged in the lab, following procedures and working, but when they were asked about the meanings or relevance of the concept, they were unable to do so…Through this course, I found developing conceptual understanding about how the world works can be best displayed by using scientific inquiry and information technology. (IF, Page 2)

This statement demonstrated Mrs. Major's understanding that her students were not developing the understanding or connections she hoped they would from the labs she used in her classroom. This statement also demonstrated that Mrs. Major believed that the ITS Center's PDE detailed methods that would encourage the development of the types of understanding her students are lacking: scientific inquiry and information technology.

The portion of Mrs. Major's writing heavily edited by her CRPs reflects a thorough understanding of the importance of and the reasons behind an inquiry approach to science teaching. The following excerpts from her writing demonstrate this:

Making science learning better resemble science practice has been a common goal among education reformers at least since Dewey (1964). The potential benefits are clear. Students become active learners, they acquire scientific knowledge in a meaningful context, and they develop styles of inquiry and communication that will help them become lifelong effective learners (Edelson, 1997).

> One of the central goals of science education is to promote scientific reasoning in students (AAAS, 1993; National Research Council, 1996). Authentic science inquiry refers to the research that scientists actually carry out. Authentic science inquiry is a complex activity employing expensive equipment, elaborate procedures and theories, highly specialized expertise, and advanced techniques for data analysis and modeling (Dunbar, 1995; Galison, 1997; Giere, 1988). Schools lack the time and resources to reproduce such research tasks. Instead educators must necessarily develop simpler tasks that can be carried out within the limitations of space, time, money and expertise that exist in the

> classroom. The goal is to develop relatively simple school inquiry tasks that, despite their simplicity, capture the core components of scientific reasoning. Through carrying out these tasks, students are expected to learn to reason scientifically (Chin & Malhotra, 2002). (IF, Page 22)

The above excerpts reflected the ITS Center's PDEs goal of helping teachers understand the science they were seeing in their morning teams and develop "relatively simple school inquiry tasks that, despite their simplicity, capture the core components of scientific reasoning," which were detailed in their IFs.

The activity Mrs. Major designed for her students did not reflect inquiry nor use information technology. Although she had attempted to base her IF on Etheredge and Rudnitsky's (2003) inquiry cycle structure, the activity she designed did not capture the essence of the steps discussed in their writing. She began her IF with an immersion experience and the majority of time was spent with students gathering information using the Internet. There was no opportunity for students to develop their own researchable questions and there was no consequential task in which they were asked to apply their understanding. The activities students did were highly structured by Mrs. Major and provided little opportunity for student discussion.

The immersion experience Mrs. Major described in her IF consisted of a pretest and the showing of a video on sun safety. She asked four questions on the pretest she constructed:

> 1) What is ozone?
> 2) Draw the ozone molecule?
> 3) On a graph, sketch what you think the trends of ozone levels have been like in the past 50 years.
> 4) What do you think are the causes of these trends? (IF, Page 4)

Mrs. Major described the utilization of the sun safety video as a way to "get students interested in the topic." It seemed that she believed using ozone as a platform for discussion and showing the video about sun safety to her class would situate their learning in a real world problem context. This video had been shown to her honors Biology students the class before I came for my second observation. She began the class I observed with a brief lecture that highlighted the main points of the video. During this lecture she asked her students to recall the video through a series of questions where they responded with one or two word answers. Although she described giving students time for discussion in her IF, there had not been any opportunity for students to discuss their ideas, reflect on what they had learned from the video, or talk to one another. The type of "discussion" Mrs. Major had led did not offer them much opportunity to actively engage with the material and think of researchable questions.

After this lecture, she had handed out the pre-test. Students loudly complained about taking this test and most completed it in under a minute's time. The four questions Mrs. Major asked on this pre-test focused on factual information that her students would need to recall. The questions did not seem to focus on students' "conceptual understanding of the real world" or on their "abilities to think critically, to analyze and ask questions, to be able to express themselves, and to gain some interpretative skills," which were some of the reasons Mrs. Major described as the goals of using scientific inquiry in the classroom.

The next step in Mrs. Major's IF called for her students to create a PowerPoint presentation that answered a series of questions she provided using information they gathered through the Internet. In her written IF she stated that she would give the students the following "scenario":

> You're probably aware of some damaging effects of ultraviolet radiation from the sun if you ever suffered a sunburn. Over exposure to ultraviolet radiation is also harmful to plants and animals, lowering crop yields and disrupting food chains. Living things can exist on earth because of ozone, a chemical in the earth's atmosphere, absorbs most of this radiation before it reaches the earth. (McLaughlin & Thompson, 1997) (IF, Page 5)

This scenario was intended to engage students in a brief discussion and then give them their "mission," which was "to research ozone and find out how it protects the earth." To complete this "mission," students were to do the following:

> The students will begin their research just like other scientists, finding information about their topic. To keep them focused, I will provide them with a list of questions they are to answer using a PowerPoint presentation. These questions are:

> 1) What is ozone and how is it formed? Include all of the reactions in the series.
> 2) Which layer of the atmosphere is it normally found?
> 3) Why is the amount of ozone in the earth's atmosphere important to us?
> 4) What are some factors that affect the production of ozone?
> 5) What do scientists believe decomposes in the atmosphere to destroy ozone? Explain
> 6) Give a series of reactions for these substances. (Reason of #5)
> 7) What are the potential problems of controlling the amounts of these substances in the atmosphere?
> 8) Provide experimental evidence found to help support your answer.
>
> Part of the student's assessment will be a PowerPoint presentation of their findings. I want them to realize that there is no real answer for question #7, it is up to them to research and come up with a possible answer and defend that answer as a scientist would have to defend his/her findings. (IF, Page 24, emphasis in original)

Mrs. Major wrote that she would give her students two weeks, or five 90-minute periods, to complete their PowerPoint presentations. Once completed, each student, or group of students, would be required to present their presentation to the class.

Students were provided with the following rubric on which their PowerPoint presentations were graded:

| Category | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| Content Accuracy (All questions answered) | All content throughout the presentation is accurate. There are not factual errors. | Most of the content is accurate but there is one piece of information that might be inaccurate. | The content is generally accurate, but one piece of information is clearly flawed or inaccurate. | Content is typically confusing or contains more than one factual error. |
| Sequencing of Information | Information is organized in a clear, logical way. It is easy to anticipate the type of material that might be on the next card. | Most information is organized in a clear, logical way. One card or item of information seems to be out of place. | Some information is logically sequenced. An occasional card or item of information seems out of place. | There is no clear plan for the organization of information. |

| | | | | |
|---|---|---|---|---|
| Effectiveness | Project includes all material needed to gain a comfortable understanding of the topic. It is a highly effective study guide. | Project includes most of the material needed to gain a comfortable understanding of the material but is lacking one or two key elements. It is an adequate study guide. | Project is missing more than two key elements. It would make an incomplete study guide. | Project is lacking several key elements and has inaccuracies that make it a poor study guide. |
| Graphics | All graphics are attractive (size, and colors) and support the theme/content of the presentation. | A few graphics are not attractive but all support the theme/content of the presentation. | All graphics are attractive but a few do not seem to support the theme/content of the presentation. | Several graphics are unattractive and detract from the content of the presentation. |
| Scientific Knowledge of the Topic | Explanations by all group members indicate a clear understanding of the scientific principles. | Explanations by all group members indicate a relatively accurate understanding of the scientific principles. | Explanations by most group members indicate relatively accurate understanding of scientific principles. | Explanations by several members of the group do not illustrate much understanding of the scientific principles. |

(IF, Page 15)

During my observation Mrs. Major had implemented this step of her IF. Once the pre-test was completed and collected, Mrs. Major distributed copies of the instructions to her students. On one side of the paper was the “scenario” along with the list of eight questions Mrs. Major detailed in her IF. On the opposite side of the paper was the rubric with which students’ presentations would be graded. To introduce this step to her students, Mrs. Major read all of the information on both sides of the sheet out loud to them. After she finished reading, she fielded some questions from disgruntled students about due dates, time to work in class, etc. She went over procedures for signing out the laptops from the Computers on Wheels (COW) unit she had in her classroom and told the students they could begin working on their presentations as soon as they finished their DNA lab. She also reminded them not to lose the instructions or they would not know what they needed to put into their presentations. Again, there was no opportunity for discussion, sharing of ideas, or reflection.

Once they had completed the DNA lab students were free to check out a laptop from the COW and begin their research. During our interview, Mrs. Major indicated that the rest of the class time students would be given to work on their PowerPoints would be similar to what I had observed.

While Mrs. Major's IF provided her students with a different learning opportunity than they normally received in her classroom and allowed them to use technology, it was far from the vision of inquiry using information technology portrayed in the ITS Center's PDE. The activity her students were engaged in was more like a session of structured information gathering rather than research revolving around answering student-generated questions. Students were all working to answer the same eight questions, written by Mrs. Major, and focused on factual information gathered from various resources. Students did not use technology in the information technology sense discussed during the ITS Center's PDE, but rather for information gathering and presentation purposes.

*School Year I Summary Paper*

Mrs. Major's SYI summary paper portrayed the same disconnect between her ideas about inquiry and her actual implementation of it that was evident in her IF. In addition, her ideas about what she believed her students would learn from their completion of their research projects did not seem to accurately reflect what I believed they would learn.

She opened her paper by stating that the "enduring understanding" she was focusing her project on was "to use scientific inquiry to advance [students'] understanding about chemical reactions taking place in the atmosphere and how it affects their daily lives." She went about realizing this goal through the methods detailed in her IF. Students were given the copies of the scenario, questions and rubric and were instructed to create a PowerPoint presentation that answered the questions they were given. It did not seem likely to me that students would make the difficult connections between the information they had gathered from the Internet and their daily lives without help. During my observation, Mrs. Major was not seen helping students to make these connections nor did she ever mention that the connections between the information students were looking up on the Internet and the "enduring understanding" she hoped to encourage were made explicit.

In her written reflection, Mrs. Major analyzed the problems she encountered and the things she would do differently if she did the project again. This analysis focused on procedural issues and not on students' understanding. She mentioned the difficulties she had in completing the projects: reserving the computers for use in her classroom for two weeks, complaints from other teachers about the length of time she was exclusively using the computers and the amount of time it took for students to complete their research. She also discussed how she handled these problems respectively: through asking the principal for permission to use the computers, telling the other teachers the principal had given her permission, and telling the students to work more efficiently in class.

She continued her reflection by discussing the students' performance on the project. She stated she was impressed with the amount of creativity her students had demonstrated in their PowerPoint presentations. I was not surprised by this amount of creativity since this was the only outlet for independent thought in Mrs. Major's assignment. She also detailed the results from her pre and post-tests, which I assumed to be the same set of questions, since nothing to counter this idea was mentioned. Mrs. Major had noted a "knowledge gain" of 85% from the post-tests and commented that these were the best test results she had had all year.

The final portion of her reflection paper was dedicated to a discussion of what she would do differently if she implemented the project a second time. Again, she only discussed procedural issues. Those things she did mention were: giving students more time to complete the projects and having them work on their projects outside of class, either at home or in the library. She also mentioned that she would add instructions for students "to make predictions for the future of the earth's environment, if the trends that are taking place continue" (SYI Summary, Page 4).

I felt as though the disconnect between Mrs. Major's ideas about inquiry and the design and enactment of her IF were made even more obvious through her summary paper. The learning goals that she had for her students involved critical thinking and asking questions about the world around them, things they were never asked to do in the completion of their projects. The project they were asked to complete focused on information gathering in order to answer teacher-determined questions, activities that did not explicitly engage nor encourage the types of skills she was attempting to foster in her students.

*Action Research Plan*

Much like her IF and SYI Summary Paper, Mrs. Major's ARP demonstrated a disconnect between the literature she cited in support of her project and the way she interpreted it into the context of classroom practice. The rationale that began Mrs. Major's ARP focused on the difficulties that faced minority students and how collaborative work may help improve their learning. Her research question deepened this disconnect as it, unlike her rationale, focused on the incorporation of inquiry and information technology to improve conceptual understanding.

The rationale with which Mrs. Major began her ARP focused on the causes for underachievement and learning preferences of Black and Hispanic male students. She continued this section with a discussion on the types of learning experiences that help students acquire powerful domain knowledge, including authentic inquiry experiences that actively engaged students in collaboration within meaningful contexts. The transition from, and connections between, her discussion of minority students and her discussion of learning environments was unclear. The research question Mrs. Major posed for her ARP was:

> Does the use of IT and inquiry-based activities impact the conceptual understanding of chemical reactions in the atmosphere for African American and Hispanic American males in the Integrated Physics and Chemistry (IPC) Biology classroom? (ARP, Page 5)

Mrs. Major's ARP continued with her research methodology. In order to answer her research question she would administer a pre-test:

1. What is ozone?
2. Draw the ozone molecule.
3. On a graph, sketch what you think the trends of ozone levels have been in the

past fifty years.

4. What do you think are the causes for these trends?
5. Where is the ozone hole? (ARP, Page 9-10)

As well as a post-test that would consist of ten open-ended questions to "allow [her] to know exactly what [her students had] learned from their experience." Scores from these two tests would be combined with Mrs. Major's classroom observations, which she stated would focus on "student participation levels, actual time on task, and the amount of work accomplished each day" (ARP, Page 8) as well as her students' final PowerPoint presentations to answer her research question.

Aside from the disconnect that could be seen between her rationale and research questions, I saw two other notable issues with Mrs. Major's ARP. First of all Mrs. Major's IF, which formed the basis of her ARP, did not use inquiry or information technology, nor did it focus on conceptual understanding in the ways the literature intended. Secondly, even if Mrs. Major's IF had been focused on inquiry, information technology and conceptual understanding, the methods she intended to assess her student's learning did not assess what she intended. Her pre-test and, presumably, the unwritten post-test, assessed rote recall knowledge and not conceptual understanding. Her classroom observations focused on "student participation levels, actual time on task, and the amount of work accomplished each day" all of which were relatively superficial measures and would not help to determine student's conceptual understanding.

The parts of Mrs. Major's ARP were not well connected and her writing demonstrated many misconceptions about the literature she used to frame her IF and ARP. She demonstrated misconceptions about inquiry, information technology, and conceptual understanding, all concepts that were vital to the activity she created as well as her research plan.

## Perceived Impacts of the ITS Center's PDE

Through my analysis of the interviews I conducted with Mrs. Major I uncovered four main impacts she attributed to the ITS Center's PDE. These impacts were: accelerated curriculum modification, new lab activities, reduced use of "cookbook" type labs with her "upper level" students, and an increase in the amount and a change to the structure of the group work she involved her students in. I also found her discussion of how she viewed the education research she had read during the ITS Center's PDE interesting.

*Accelerated Curriculum Modification*

During her exit interview, Mrs. Major commented that one of the most valuable aspects of the ITS Center's PDE were the resources she learned about, focusing only on those she received from the scientists. This comment aligned with a statement she made during our first post-observation interview. During this interview I asked Mrs. Major what she thought the biggest thing the ITS Center's PDE had contributed to her teaching was. She responded:

> The fact that they offered new activities for my labs. Different ways to show, different demonstrations, different ways to show, because we, when you get into teaching you have a tendency to do things one way. I think they gave us a different perspective on what's another way we could teach this or break it down to the students. (POI1, LN800)

These interview excerpts also aligned with another of Mrs. Major's comments from the exit interview, when I asked her if she believed her teaching practice would continue to change as a result of the ITS Center's PDE. She responded:

> Yeah it's definitely going to keep changing. I mean, I keep looking for the magic bullet. You know? Try this and if it doesn't work try something else. Keep modifying. This program just accelerated the modification for me. It wasn't going as fast as it probably should have been. I was determined to get in my little rut. I was going to be one of those teachers who'd been doing it for 20 years and by God it's good enough, and I'm seeing now that I've got to modify. (EI, LN58)

*Decreased Lab Activity Structure*

A second impact Mrs. Major perceived from the ITS Center's PDE was the encouragement to decrease the structure of her lab activities. She focused on this idea for the better part of our exit interview. Mrs. Major seemed to believe that by not giving her students directions they were given the opportunity to explore, making her activities more inquiry-based. This perception became clear when I asked Mrs. Major what she learned from the ITS experience that had changed her teaching or how she thought about teaching. She responded:

> My lab activities are not as structured as they used to be. I was real big on cookbook labs and I've just about cut those out. Lower level kids still have to do them, they're not equipped yet to do that, but with my upper level, my pre-AP chemistry and my AP chemistry, I don't necessarily give them a lab procedure at all. I just tell them overall here's what we're going to do, here's what you're going to use, figure it out and for the most part it works well. They generally do figure something out eventually or one person gets something and they tell everybody else what to do, but it's getting better. I have more fun with it and I teach a physics class as well and a lot of the times I don't even tell them what they're looking for. I just tell them here, go play and it's amazing some of the stuff they come up with. It's amazing some of the misconceptions they come up with but it's still fun. (EI, LN31)

*Incorporation of Cooperative Learning*

This final impact Mrs. Major perceived came directly from the thoughts she formed through the reading she had done while constructing her ARP. From this research and reading, Mrs. Major interpreted the literature she had read about Black and Hispanic students as stating that they learned better through cooperative group work. Because of this, she decided to modify the cooperative learning techniques she had used with prior classes and try to make them work once again. She stated:

> I've done cooperative learning before when I taught all Biology, which was easier for Biology but I didn't do a lot of it before because it just makes for, sometimes it just, it doesn't work correctly. They use it as a way to copy and I don't want them to copy. I want them to help each other out and learn the information. So I designed it this time where the team leader was someone who was very strong in science already. I scored them on a couple of tests before a chose the team leaders. I gave the support group, I didn't want to stick them with really, really low level kids and I let them choose who they wanted to work with. It ended up perfectly because I told them they had to have heterogeneous groups and have both male and female there. They sort of, they picked people who normally they wouldn't work with. I think they've been working out well. I told them I don't want you to let them cheat I want you to teach them and I said it's your responsibility that they know how to do this on tests and they're like "man really?" so they've been helping them out quite a bit. (POI1, LN869)

*Education Research*

When asked if the education research we offered her during the ITS Center's PDE had influenced her teaching Mrs. Major responded:

> The readings to be honest with you really haven't influenced my teaching at all. They may have at an unconscious level but I don't like reading educational articles like they're not written to me. They're not written for me apparently because they're using a whole terminology I don't get and you know if you can't communicate with your target, the audience you're trying to reach, to me you're not doing the job properly. That's what I see is wrong with that aspect of it. They're writing to the other professors in the other universities but they want to talk about the teachers in the high schools and middle schools and elementary schools but they won't write to them. So no, they don't influence me much at all. I didn't enjoy the readings, don't like those readings, ha ha. (EI, LN84)

This lack of understanding and appreciation for the education literature that formed the basis for the ITS Center's conceptual frame was in line with what I had seen throughout Mrs. Major's performance artifacts and the ways in which she learned from the ITS Center's PDE.

## Analysis

When asked what the most important part of her job as a teacher was Mrs. Major responded:

> Making sure they understand. I can tell when they get frustrated and they want to shut down. A lot of them if they don't understand what to do they'll shut down. That's why I try to only teach them one concept per day because the way I have it set up, if I teach them a concept one day and then quiz them on it the next day to make sure they understand and then we pull them all together before we test. That way they're only focusing on one thing. I don't try to throw too much at them at one time, unless it's necessary to teach them that way, but just making sure they understand and are not giving me that look of "what in the world is she talking about?" because I know how I am when I don't understand something, I'll shut down too and I'm like there's no way I can keep up with this, just keeping them all on the same page, making sure they're not lost and shutting down on me. (POI1, LN210)

This statement demonstrated that Mrs. Major held a very traditional view of teaching, where she maintained authority and responsibility for student learning. In planning for her lessons, Mrs. Major discussed breaking down the content into concepts she had determined, through years of experience, students could grasp without becoming overwhelmed. She then used activities that worked well in the past to reinforce these ideas. The instructional techniques she discussed were highly structured and teacher directed and included lectures, worksheets, and hands-on activities. Her attempts to make sure students understood were also pervasive in my observations of her classroom practice and on her perceptions and interpretations of various aspects of the ITS Center's PDE.

*Connections to Planning and Teaching*

Mrs. Major maintained authority in her classroom and took the responsibility for providing her students with the best learning experience possible to heart. In her planning and teaching she strove to streamline her students' learning process and, as she told me, make sure they were "all on the same page" (POI1, LN219) and not "shutting down" (POI1, LN211). Mrs. Major went to great lengths to make sure her students were not overwhelmed through her methods of planning and teaching. This effort was evident in the way Mrs. Major deconstructed her subject matter into singular concepts and in the highly structured and teacher directed ways she presented material to her students.

During our interviews Mrs. Major's brought up her method of breaking down the subject matter into concepts she felt her students could handle multiple times. This method was first apparent in her response to my question of what she thought the most important aspect of her job as a teacher was (see above quote). The method was central to her discussion of planning. She told me she that met weekly with other teachers to decided which topics in the curriculum guide they would focus on in the coming week and then broke the topics down into smaller concepts she felt her students could handle in a single sitting. Once she had mapped out the concepts she would teach, she would decide on the activities she would use to provide students with practice applying them.

Mrs. Major's strong belief that students could only handle a single concept in one class caused her some measure of dissonance. Her discussion of the 90-minute block schedule her school utilized was evidence of this. She told me she knew that the longer classes meeting every other day meant that she should be "teaching two days worth of information" (POI1, LN548) but struggled with this schedule since it meant she had to teach more information than she felt students could handle at one time. Her discussion of the curriculum guides and benchmark tests further reinforced this internal conflict. Mrs. Major lamented the fact that the benchmark exams put her on "someone else's schedule" (POI1, LN313) and made sure she was in a "specific place at a specific time" (Interview 1, Line 317). These constraints did not allow for adequate time to be spent on topics or for "re-teaching" (POI1, LN315) topics her students did not understand the first time.

In addition to Mrs. Major's effort to help her students learn by focusing her lessons on single concepts, her methods of instruction were highly structured and teacher directed. She told me that she usually presented new information to students through short lectures and then offered them extensive opportunities to practice applying their knowledge. The practice opportunities Mrs. Major utilized most often included the completion of worksheets, often in groups, and the completion of hands-on laboratories. My analysis of observations and interviews revealed the high level of structure, focus, and control Mrs. Major built into these activities.

One of the main places these characteristics were revealed was through Mrs. Major's discussion of her worksheets and quizzes. She told me that she had a hard time finding worksheets that would provide students with "enough practice" and that also provided them with enough explanation. She stated:

> Today the worksheet we did was totally designed on word. I just insert these charts and made up my own worksheets because I can't find things that will give them enough practice with all of the different types of things that they'll see and explain that hydrogen would be both ways so I had to make up a lot of my own worksheets. (POI1, LN644)

Our interview revealed that the worksheet she had given students that day had them "count all the atoms and add up how many atoms are in the formula" (POI1, LN398).

This statement demonstrated that Mrs. Major focused her students' learning on a very small concept and structured the worksheet so the concept would be clearly presented to students. Their practice then built in difficulty over a series of examples.

The levels of structure, focus, and control of Mrs. Major's lessons was also apparent in the ways she presented the DNA lab and the IF from the ITS Center's PDE. Her presentation of the laboratory included going over the procedures students would need to follow step-by-step at the front of the room, to make sure the students knew exactly what they would be doing once they began the lab. Her presentation and the students' subsequent race to complete the lab demonstrated that the students' focus was procedural, little thought was given to what they were doing or why. The presentation of her IF was equally as structured, and teacher directed, resulting in the same surface level focus. Mrs. Major read the handout she passed out to the students that detailed the scenario, the questions students would answer and the criterion on which they would be graded. The structure of this task focused students on searching for information to answer teacher generated questions that relied on known facts and formulas and not on the "why's" or "how's" behind the information they found.

The way in which Mrs. Major structured her lessons led to her students focusing on lower-order skills and procedures. This trend is most easily observed by looking at the M-SCOPS Profiles of my two observations (Figures 5.1 & 5.2). These Profiles revealed that the complexity of information students received stayed at levels of arrange, replicate and rearrange throughout the two lessons. It appeared that the focus and method of Mrs. Major's classroom practice did not help students develop a conceptual understanding of the subject matter. Their learning appeared to be surface level and they struggled with concepts that required a deeper understanding of the content. One comment Mrs. Major made during our first interview illustrated this:

> They have a tendency to go back and change when they learn something new. Every time they learn something new it's like the old stuff has gone away for some of them. If I did molecular alone with the binary ionic they would start adding in mono- and the di-, they'll call it di-aluminum tri-nitride or something. So they just get all confused and they'll mix them all up so that's why I do them separately. (POI1, LN510)

Mrs. Major's comments of the "old stuff going away every time her students learned something new" and the confusion her students experienced when naming compounds demonstrated to me that her students' learning was surface level. The focus of her instruction on procedures did not provide students much opportunity to see connections among concepts. The high level of structure Mrs. Major provided her students with did not provide them with opportunities to wrestle with ideas and understand the relationships among them. Had her students' learning been focused on the larger concepts on which the procedures were founded, they may have noticed these connections, retained their new learning longer and been better equipped to apply their information to new situation.

The high level of structure, limited conceptual focus, and low level of complexity of Mrs. Major's lessons also may have contributed to the amount of off-task behavior I observed during my visits to her class. During each of my observations, Mrs. Major's students seemed unruly and disruptive. She gave them large amounts of time to settle down at the beginning of class and both classes ended with students chatting and gossiping with one another in a relatively unfocused and unproductive manner. I believe this behavior would have been decreased if her students were engaged in more cognitively demanding tasks.

Mrs. Major's classroom practices were well aligned with her belief that her students could only handle small amounts of information at a time. Mrs. Major's focus on singular concepts led to her highly structured, controlled, and focused activities. These activities lead to procedural, surface-level learning and contributed to the students' off-task behavior. Mrs. Major's methods of teaching, and the theories that guided them, influenced the ways in which she perceived and interpreted various aspects of the ITS Center's PDE.

*Connections to Perception and Interpretation of the ITS Center's PDE*

Mrs. Major's personal theories influenced her planning and teaching and her perception and interpretation of the ITS Center's PDE. What she perceived as valuable from the PDE, as well as they ways in which she interpreted the educational research she read, stemmed from her belief that students could handle only a single concept at a time and reflected the procedural focus and high level of structure of her classroom practice. Mrs. Major perceived the push to continue to modify her curriculum and the new laboratory activities she had learned about during the ITS Center's PDE to be the most valuable aspects of the experience. She also attributed the ITS Center's PDE with helping her understand how student learning could be enhanced by decreasing the structure of her laboratories and including opportunities for collaborative learning in her practice. Mrs. Major perceived the educational research that had been a focus of the ITS Center's PDE as being "not written for her," a perception I attributed to the differences between her ideas and those of the articles' authors.

The focus of Mrs. Major's performance artifacts further demonstrated the influence of her personal theories. The design of her IF focused students on information gathering and presentation through the creation of a PowerPoint that answered factually oriented teacher-generated questions. The design of her ARP focused on measuring the "knowledge gain" of her students resulting from their IF experience. Mrs. Major's discussion and interpretation of educational research in her IF and ARP also demonstrated alignment with her personal theories and teaching methods.

**Perceived Impacts**

Mrs. Major perceived the ITS Center's PDE as having three main impacts on her teaching practice: it had accelerated her curriculum modification, decreased her lab structure, and encouraged her to incorporate opportunities for cooperative learning. Mrs. Major's discussion of the first of these impacts demonstrated a strong focus on singular topics and mirrored her personal theories and methods of planning and teaching. Mrs. Major's discussion of the other two impacts demonstrated some interesting misconceptions that seemed to arise from her translation of the ideas of student-direction and cooperative learning into her personal theories. Mrs. Major's perceptions of education research as "not being written for her" did not surprise me once I understood how different her ideas were from those of the science education research community.

The first impact Mrs. Major perceived from ITS Center's PDE was that it "accelerated her curriculum modification" (EI, LN60). Her discussion of this modification included a focus on new laboratory activities, demonstrations and new ways to "teach or break things down for the students" (POI1, LN803). Since Mrs. Major focused her planning on breaking down concepts and finding and testing new practice activities, it followed closely that she focused on obtaining these new activities as the "biggest thing" she took away from the ITS Center's PDE.

Mrs. Major's discussion of her curriculum modification included the notion of a "magic bullet." Based on what I learned about Mrs. Major's teaching beliefs and practice, this notion of a "magic bullet" (EI, LN59), which I interpreted to mean a lesson or activity that would teach students a concept in the best way possible, fit within my understanding of her personal practice theories. Her way of looking at learning as a "gain in information" and planning her lessons by taking a look at "what's worked and what hasn't" showed that she may believe there could be a perfect activity, or in other words a "magic bullet" that would help her students learn as efficiently and easily as possibly.

In her discussion of this impact Mrs. Major commented that her curriculum modification "wasn't going as fast as it probably should have been" (EI, LN60) and that "when you get into teaching you have a tendency to do things one way" (Post Observation Interview1, Line 802). This indicated to me that she had found activities that seemed to work reasonably well to her and she had slowed down the process of "modifying her curriculum." These comments indicated that Mrs. Major believed that her curriculum could reach an end-state where she was using the best activities possible and no longer needed to modify her lessons from year to year.

The second impact Mrs. Major saw the ITS Center's PDE as having had on her teaching was in the ways she had decreased the structure of her labs. I assumed this idea stemmed from the emphasis the readings from the ITS Center's PDE had on the role of student direction for their own learning in inquiry instruction. We advocated offering students more opportunities to take initiative for their own learning, thereby learning science process and metacognitive skills. Mrs. Major seemed to equate the idea of decreasing the structure of the "cookbook labs" she had been using in her classroom to these ideas about student initiative. Understanding the theories that drove Mrs. Major's planning and teaching made me see this misinterpretation as likely

The final impact Mrs. Major attributed to the ITS Center's PDE was that of encouraging her to retry incorporating cooperative learning into her classroom. While we discussed the concept of the community-centered perspective of the How People Learn Framework (Bransford et al., 2000), cooperative learning was not specifically addressed. Because of this, I assumed Mrs. Major's understanding of cooperative learning had been largely derived from the research she had done for her ARP.

During my first visit to her classroom, I had observed one of Mrs. Major's cooperative learning activities, which gave me some insight into her thinking about its use. The activity consisted of her giving small groups of students time to complete a worksheet she had designed. This worksheet asked students to write out the names to various compounds and count the numbers of atoms in chemical formulas, activities that employed low order skills of comprehension and application. Mrs. Major discussed that she had constructed the groups and assigned a "group leader" to each. The role of the group leaders mirrored the role that Mrs. Major assumed in the classroom in that they were expected to help the other students understand the topic.

This type of activity left little room for discussion or collaboration amongst the members of the group. There was no need for students to share their ideas or to entertain the opinions of others. The worksheet reinforced and provided practice on the single concept that was the focus of Mrs. Major's class. These discrepancies demonstrated that Mrs. Major had not understood the concept of cooperative learning or community-centeredness.

Analyzing Mrs. Major's performance artifacts, as well as understanding her personal practice theories and her perceptions of the ITS Center's PDE's value and impact on her teaching, helped me understand her disposition toward educational research. She stated that she had not enjoyed the education readings, felt as though they had had no conscious influence on her teaching, and perceived them as not being written for her. I could understand why she felt this way, as there were fundamental differences between her ideas about education and the ideas presented in the education readings. These differences could make the ideas seem disconnected from her classroom practice, as if the intent of the researchers was only to communicate to one another and not classroom teachers.

**Instructional Framework**

The design of Mrs. Major's IF was not well aligned with the vision of inquiry-based science promoted by the ITS Center's PDE. The activity she designed could be better described as a session of structured information gathering. The activity began with her students watching a brief video on sun safety. Then she passed out a handout detailing a brief "scenario," a list of eight teacher-generated questions that focused on factual information about ozone and the rubric on which their projects would be graded. Students were given laptop computers and instructed to search the Internet to answer the questions and create PowerPoint presentations with their answers.

While this activity did incorporate elements that Mrs. Major would not have used had she not attended the ITS Center's PDE, it was largely aligned with her personal theories and classroom practices. I saw three main ways this activity represented a departure from her normal teaching style. First of all, she reduced the amount of structure and increased the amount of freedom her students had while working on her IF, a change I attributed to her understanding of inquiry and student initiative. Secondly, her IF included the opportunity for her students to use technology, something she told me she probably would not have done without the ITS Center's PDE. Lastly, she had given her students an extended amount of time to work on completing their project, more than likely due to our assertion that quality inquiry experiences took an extended amount of time and our insistence that the IFs should span at least two weeks. Even though these elements differed, the high level of structure she built into her IF, the singular concept it focused on, and the low-level skills on which it focused reflected what I had learned and observed of Mrs. Major's teaching.

**School Year I Summary Paper**

Mrs. Major reflected on the experience of implementing her IF in her School Year I Summary Paper. This reflection demonstrated, much like her teaching, a focus on surface level procedures and students "gain in information." She discussed the problems she encountered during implementation, focusing on logistical issues rather than student learning. She did discuss student learning as assessed through the pre- post- test she had designed, asserting that she had seen a "knowledge gain" of 85%, the highest she had seen all year. She also discussed the changes she would make to the project the following year, which included giving students more time to complete the projects, having them work on their projects outside of class either at home or in the library, and adding instructions for students "to make predictions for the future of the earth's environment, if the trends that are taking place continue" (SYI Summary, Page 4). This final recommendation was the only change she discussed that would change the focus of her students.

**Action Research Plan**

Mrs. Major's ARP used the activity she designed for her IF as an intervention and, much like her IF, her ARP demonstrated a focus on assessing student "knowledge gain" using the same pre-test she designed for her IF the year before. Although her pre-test had not changed, she referred to the five factual recall questions it contained as assessing "conceptual understanding" rather than "knowledge gain," a term she used previously. This substitution demonstrated that Mrs. Major had integrated some of the terminology used during the ITS Center's PDE, but did not understand how it differed from the focus of her assessment tools.

In addition to the pre- post-test, Mrs. Major stated that she would also assess "student participation levels, actual time on task, and the amount of work accomplished each day" (ARP, Page 8). These aspects of student work seemed a bit difficult to assess without some sort of instrument to guide and characterize observations, and Mrs. Major did not specify how she would go about assessing these aspects. Additionally, at the end of her ARP, Mrs. Major wrote that a major limitation of her study was that it would be "hard to differentiate between the students actually collaborating as opposed to off task behavior" (ARP, Page 11). This statement reflected the opportunities for group work I had observed in Mrs. Major's class. The opportunities Mrs. Major offered her students focused on low-level skills, leaving little opportunity for students to have alternative views they could share with other students. The structure of her IF was similar in that the students who worked together would collaborate by helping each other find and compile information, not critically think or analyze issues.

In addition to the influence Mrs. Major's personal theories had on the design of her ARP, the influence of her school's push to increase the achievement of minority students could be seen through the focus of her literature review on the learning styles of Black and Hispanic male students. During our first post-observation interview, Mrs. Major made the following statement:

> Last year our principal said that if one more Black, economically disadvantaged male, if we could get just one more Black male to pass that TAKS test per class that we could be exemplary or whatever and I'm like well you know so I can target those because they're already an area that we're looking at here on campus so I can really use that. (POI1, LN935)

This statement demonstrated that the focus of Mrs. Major's IF had been related to the efforts of her school to improve the TAKS scores of students, as well as her personal practice theories.

## Member Check Interview

Mrs. Major declined to participate in the member check interview, stating that she felt she was too busy to do so. She was invited to contact me at any time in the future if she felt she had more time and wanted to do so. I did not hear back from her before this dissertation was completed.

## Case Summary and Implications

Understanding the connections among Mrs. Major's teaching situation, practice, and personal theories illuminated my understanding of her perception and interpretation of the ITS Center's PDE. Her description of the educational research as "not being written for her" made sense once I realized how different her ideas about teaching were from the ideas of reform promoted by the ITS Center's PDE. Observing her teach and discussing her teaching practice with her revealed that she focused on mistake-proofing her curriculum, removing most opportunities for active learning. What resulted from this instruction were understandings that were shallow and unconnected, demonstrated by Mrs. Major's comments that her students were not able to see connections among ideas and did not understand the material, no matter how long she spent on it.

It appeared that, even though Mrs. Major reflected on her curriculum and her students' understandings, modifying lessons that did not work well, or re-teaching concepts students had failed to grasp, the focus of her reflection was narrowly placed on "information gain." This limited focus appeared to limit the instructional decisions she made as well, focusing her efforts on finding better activities and breaking down concepts in different ways, looking for that ever elusive "magic bullet." While these efforts were made with good intentions, they overlooked the critical aspect of students thought processes about the material and further eliminated opportunities for them to think.

Mrs. Major's perceptions and interpretations of the ITS Center's PDE appeared to be limited by this narrow reflective focus. The IF she designed was highly teacher-directed and the experience allowed little room for her students to exercise independent thought. The impacts she noted: accelerated curriculum modification, decreased lab structure, and the inclusion of cooperative learning, mirrored her discussion of her usual lesson planning routines. She did not notice the underlying emphasis in the educational readings on engagement of student prior knowledge, student thinking, and active learning. Instead, she interpreted the readings in a manner that presupposed her personal theories and teaching practices were correct.

The chapter that follows presents the final within case analysis. In the same fashion as this chapter and the last, the data collected is explored, connected, and discussed before all three cases are brought together in chapters VII and VIII.

# CHAPTER VI

# MRS. PATTON WITHIN-CASE ANALYSIS

The purpose of this case is to describe Mrs. Patton, a bright, young, and energetic physics teacher who appeared to have understood and integrated many ideas from the ITS Center's PDE into her teaching practice well. My analysis revealed that Mrs. Patton had a clear vision of both the conceptual understanding and metacognitive learning goals on which she based her instruction. She was highly reflective and constantly assessed her students' understanding in relation to her learning goals and her teaching methods. Mrs. Patton's understanding of her learning goals and her reflective approach to teaching also extended to her thinking about new instructional methods and her perception and interpretation of various aspects of the ITS Center's PDE. The discussions we had during our interviews demonstrated her ability to critically analyze and innovatively adapt ideas from both the ITS Center's PDE and elsewhere to support and enhance her students' learning experiences.

Much like the preceding two chapters, the presentation of the case study of Mrs. Patton uses the first research question and its four sub questions as an outline. It includes: (1) a brief introduction to Mrs. Patton and a discussion of the process that led to her selection as a participant in this study, (2) a description of the school context in which Mrs. Patton taught, (3) a description of my classroom visits including the resulting M-SCOPS Profiles and brief interpretations of them, (4) a description of what I learned about Mrs. Patton's methods of planning and teaching and personal practice theories from our discussions, (5) a description of the performance artifacts that resulted from Mrs. Patton's participation in the ITS Center's PDE, (6) a description of Mrs. Patton's perceptions of the ITS Center's PDE, and (7) my analysis of these experiences and artifacts, which relates the personal theories and habits of mind I described in other sections to Mrs. Patton's personal theories, classroom practice, and learning from the ITS Center's PDE. From this analysis, I derived some insights regarding the relationships between her practices and her thoughts, perceptions, and actions.

Introduction

At the time of this study Mrs. Patton was one of two physics teachers at one of the two high schools in a small urban community. She had been teaching at Frawley High for five years. Over the course of her 11-year career in teaching, she taught both chemistry and physics at three different high schools, all in similar locations and of similar size.

Mrs. Patton did not go into a whole lot of detail about how she had decided to become a teacher, but she did tell me that she had gotten a degree in Biochemistry from a major Research-1 University and intended to go to medical school. After finding out that she had not been accepted to medical school, she decided to “do what she was good at” (POI1, LN49) and attended a smaller college to complete a traditional post-baccalaureate teaching certification program. For this program, Mrs. Patton completed 26 teaching credit hours. She felt as though teaching was “what she was supposed to do”(POI1, LN51). Mrs. Patton told me that she chose to work at Frawley High because it was large and there were enough students to necessitate multiple sections of a single subject. This allowed Mrs. Patton to focus on her area of expertise: physics.

Mrs. Patton told me that her favorite aspects of being a teacher were the challenging and constantly changing environment and the opportunity to get to know her students on an individual basis. She enjoyed the fact that no two days or two classes were the same and she could watch her students’ understanding evolve and adapt her teaching practice to this understanding. She added that she also enjoyed understanding where her students wanted to go in life and seeing them succeed.

From our discussions, it appeared that Mrs. Patton had a very clear picture of herself as a teacher. She was confident in her abilities and knowledge and in complete control of her classroom and her identity. She knew what she was good at, how her skills could be maximized, and why she was there. She did not dwell on the negatives, but appeared to enjoy her job, and the challenges that came along with it, fully.

During the ITS Center’s PDE Mrs. Patton was a member of the Science and Technology at the Nanoscale science team. One mechanical and three chemical engineers led this team. The focus was on properties of matter at the nanoscale, particularly from the fields of colloidal science and fluid mechanics. Two graduate students led the afternoon discussion groups, one was working on her PhD in geology and the other was working on a PhD in science education.

Mrs. Patton's written work from the ITS Center's PDE reflected an in-depth understanding of the ITS Center's conceptual frame and an alignment with a constructivist epistemology. She had crafted an IF that reflected a firm understanding of nanoparticles, mirrored the techniques scientists use in their work, and was well aligned with the Etheredge and Rudnitsky (2003) frame. Her ARP also described a well thought out research design that was both meaningful and practical. Both of these pieces of written work demonstrated a deep understanding of the educational readings and used them in insightful ways that enhanced the delivery of her ideas. Our discussion during the exit interview reinforced these ideas as Mrs. Patton mentioned that the education readings from the ITS Center's PDE had helped her reflect on and think about the ways in which she incorporated inquiry into her classroom. These thoughts included giving her students more control over their own learning, as well as spending more time listening to and probing their ideas. These factors caused Mrs. Patton to be the only high school teacher placed in the highest category of alignment with the ITS Center's conceptual frame and therefore chosen as a participant in this study.

## School Context

Frawley High was one of two large high schools in a small urban community with about 85,000 residents. The student population of Frawley High was about 58% White, 26% African American, and 14% Hispanic. At the time of this study, about 27% of students were considered economically disadvantaged and about 53% were considered "at risk."

Frawley High utilized a block schedule in which classes met for 90-minute periods every other day and spanned the academic year. Mrs. Patton taught two sections of AP Physics, two sections of pre-AP physics, and a remediation course for students who had failed to pass the state science exam.

When asked how much control she had over her curriculum, Mrs. Patton told me she wrote her own curriculum and no one looked over her shoulder. She went on to say that they let her do what she wanted to in her classroom because 100% of her students had passed the state science test, 70% had been commended for their performance on it and 65 of the students who had taken her class had passed the physics AP exam during the last school year.

Classroom Observations

I made two trips to Mrs. Patton's classroom in which I observed her classroom practice. During my first visit I observed an AP Physics class and during my second I observed a pre-AP physics class.

*Observation 1*

Monday, October 30, 2006

I had gone to bed rather late and gotten up rather early in order to be ready to take off on my first trip to observe and interview the first of the teachers included in my dissertation study. The first leg of the trip was not short, but was rather easy. Three relatively large highways and the first part of Alexandra Fuller's *Don't Let's Go to the Dogs Tonight* on audio book got me where I needed to go. I arrived in the town about two hours before my observation was scheduled and found the location of the high school, which, I was pleasantly surprised to find, was across the street from one of my favorite chain restaurants.

I had a light lunch on the restaurant's patio while I enjoyed the weather that was cooler and less humid than the town in which I'd begun my day and read a book for a bit to pass the time and calm my nerves. About 30 minutes before the class I was scheduled to watch began, I made my way across the street to the high school. Getting into the parking lot was a bit tricky. The lot was gated and the only way in was through a security guard. I told them who I was there to see, waited a few seconds while they relayed my request, and was given quick directions to the visitor's spots and the front office.

The school had what I might call an "open" design to it. None of the buildings were more than one story high and they were spread out so that students had to walk outside between the buildings to change classes. The front office was easily visible, as it occupied its own building facing the parking lot. Students littered the front of the school and crowded the courtyard in the center of the buildings. Cars that were picking up students lined the circular one-way path, interspersed, to my surprise, with several police cars.

I hopped out of my car and double-checked that everything I needed was in the laptop bag. I grabbed the bag, the camera, and the tripod and crossed the parking lot to the office. Once in the office I signed in and asked where Mrs. Patton's classroom was located. The secretary behind the desk gave me a blurry and complex photocopy of the school grounds, and highlighted the path I was to take to the physics wing of the science building. I studied it for a moment, asked which way I should begin heading, and, with a point from the secretary, I set off.

The map was rather intimidating, but I found the classroom relatively easily. There were quite a few teachers and students in the classroom when I knocked (apparently on the back door) and Mrs. Patton, lunch in hand, greeted me and ushered me to a back corner where I could set up. She apologized for the mayhem in the room. She stated that her room had somehow become the "hangout room" for lunch period and some of the students were completing assignments on the computers, or sitting at desks eating their lunch and chatting. The teachers all looked like they were enjoying a friendly conversation and finishing up their undoubtedly rushed lunches. In between bouts of talking with teachers and grabbing bites of her lunch, Mrs. Patton fielded questions from students about "internet homework" and promised to go over a problem in more depth during class.

The large classroom I walked into was at least double the size of others I had seen. It seemed as though the laboratory and the "sit-down" portion of a classroom were combined into one long room. The room consisted of a bench lining the back wall with four large lab tables taking up the room's laboratory half. Microscopes, papers, metal weights, scales, and other various objects littered the bench. Each table was adorned with an incline track, a laptop computer, and a graphing calculator. On the other side of the classroom about 30 chair-desks were set up in front of a lab bench with a large blackboard behind it. Two projector screens were pulled down over the blackboard, one with an overhead projector focused on it and another screen consumed by the light of an LCD projector. Ten old, but functional, computers lined the wall to the right of the desks where students were busily working.

A bell signifying the end of lunch rang and students began filtering into the classroom as the "hang out" students and teachers began filtering out. Mrs. Patton had to ask a few of the students who were not in the class to get going to where they needed to be; a couple asked if they could stay and work on the computers, which she allowed. A few final students trickled in as she began going over organizing details about homework, upcoming events, and the like. The bell that signified the beginning of the 90-minute class rang.

Mrs. Patton quickly turned off the lights and began class by going over the problem from the "internet homework" the girl had asked about during lunch. It concerned "Forces of Friction," and students gave short answers, leading her to what step to take next, as she completed the problem on a tablet PC, which was then projected onto one of the screens. While writing in black and white she was able to accent parts of the problem with colored highlights through the laptop-like computer.

After all the students seemed satisfied with the solution from the homework problem, Mrs. Patton moved on to a new topic, which seemed to be very similar to the homework problem she had just completed, with a few additional steps. This new topic she titled "Boxes on Inclines," which I, although a bit foggy on my physics, believe added the element of movement to the problem she had just gone over. Again using the tablet PC, she drew the X- and Y-axes and added all of the parts the problem gave and went on to identify the unknown quantities they needed to solve for. Arrows indicating the normal force, the mass, and the velocity of the box were drawn on the diagram. Once she had all the parts of the problem in place she went to the board and, using two rulers held as an X, demonstrated that the bit of trigonometry they needed to calculate to solve the problem would shift the incline to a flat line along the X-axis (Figure 6.1a). She reinforced this point a second time with colors and directions through the tablet PC (Figures 6.1b & 6.1c).

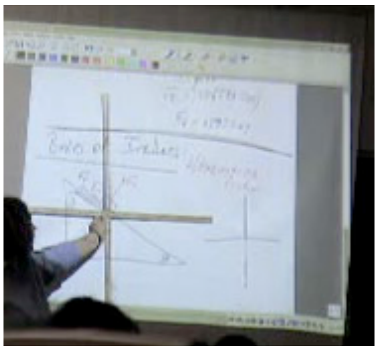
Figure 6.1a

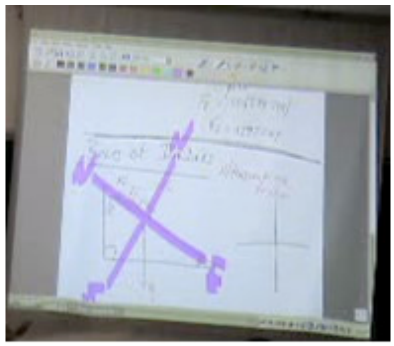
Figure 6.1b

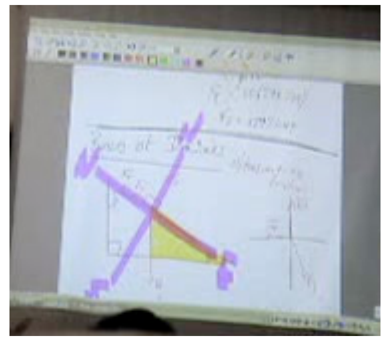
Figure 6.1c

FIGURE 6.1 Stills from Mrs. Patton's first observation.

After each step in the problem Mrs. Patton asked for clarification of understanding from the students. A few times she had to go back and explain the steps she was taking and the calculations she was making, until students agreed that they understood. Three similar problems were completed in this fashion. During each problem Mrs. Patton would ask students to tell her what the next step should be until the numbers had been manipulated to a point where the mathematics were familiar and doable for the students.

Once students were reasonably comfortable with the steps she took to get the answer in the first problem, Mrs. Patton presented a new problem that would lead to a hands-on activity. She opened this problem with the following dialogue:

Mrs. Patton: Alright, here's your task for today, y'all good?

Students: Yeah

Mrs. Patton: What is frictional force equal to?

Student: Force normal times M

Mrs. Patton: M times normal force, right. In science what are we worried about a whole bunch, no that's a bad way. Science is all about studying relationships right?

Students: Right.

Mrs. Patton: So if we wanted to calculate the μ value of something unknown, how could we do that? <pause, no answer> If we knew the normal force and the frictional force we could calculate μ, right?

Students: Yeah

Mrs. Patton: This is your task. You are going to design a lab in which you calculate the μ value of A1. Your materials will be an inclined plane which you can see on all the back tables, you are also going to have a device that we haven't played with before, it is going to be the force probe, they're in the box right there, [student hands her a probe] okay, this is the force probe right here, you're going to attach a string and when you pull this the probe will automatically read the value of the forces. So we can calculate the force of tension. Do you know how to calculate the normal force?

Students mumble an acceptable answer.

Mrs. Patton: Okay so this is your task: design a lab in which you calculate the μ value of a block of wood, when I approve your lab format you get the materials. You need to take multiple data points. You need to think about how to calculate the multiple data points. Do it with your lab group. Okay, go forth, talk, talk, and I'll be around to analyze your thinking. (Observation 1, 45:00 – 48:00)

From this point the students quickly moved to their lab tables and began discussing how they would go about designing the lab. I focused the camera and the majority of my attention on the workings of the group at the lab table in front of me. It seemed as though the groups were all on task for the majority of the time. The group I was focused on debated where the best place to start was and how they would calculate the necessary values. They pulled out some loose-leaf paper and scribbled some thoughts down.

After about five minutes, Mrs. Patton stopped by their bench, looked at what the group had written on the paper, and briefly questioned them about how they were going to use the materials to calculate the variables they needed to figure out the unknown. The group unanimously agreed they could calculate everything, but could not come to a complete answer about how. Mrs. Patton told them they were on the right track but they were missing one key thing. She gave them some quick advice, and left them to try to figure it out on their own.

After about 25 minutes and three visits from Mrs. Patton, the group had developed a satisfactory plan. Mrs. Patton told them to write it up quickly so everybody would know what they did and they set off to accomplish this new goal. They found a few more flaws in their design as they were writing it up and visited with Mrs. Patton a couple more times. Mrs. Patton reminded them of units and calculations they needed to include.

About two minutes before the bell students were hurried back to the chair-desks, and some quick but complex questions were asked and answered regarding what their diagrams should look like and how the $\mu$ values from various experiments (if plotted) should form a straight line. Mrs. Patton summarized the work the groups had done by stating that no two groups were going to conduct their lab in the same way, and she was interested to see how consistent the data would be when they collected it the following lab period.

Students were instructed to get to the lab tables and begin collecting their data immediately during the next class. When she asked, the students assured her they were comfortable with conducting the lab and they could do it quickly. Mrs. Patton then gave some last minute instructions on internet homework due dates, asked if there were any final questions, while she answered a few about test corrections, the bell to end class rang.

Mrs. Patton apologized again for the mayhem of her day and I brushed off her apology; I completely understood and expected the chaos. She told me prior to my observation that the next 90-minute period was her conference and asked if I would mind staying to interview her then. I was grateful she had set aside the time for me and told her to take her time finishing up whatever she needed to before attending to me. After a few minutes we arranged ourselves onto stools at the lab table I had been focused on all class and, as I downloaded the video to my laptop, we began our interview.

*M-SCOPS Profile Interpretation*

The M-SCOPS Profile representing my first observation of Mrs. Patton's class can be found in Figure 6.2. This 90-minute lesson consisted of six segments and progressed logically from teacher-directed to student-directed activities. During the first half of the class Mrs. Patton led a problem solving session at the front of the room. This session was not completely teacher-directed, as students were often asked to engage at a level of "4/2" as they discussed what the next step would be. During the second half of the class students applied the concepts they had reviewed during the first half as they worked in teams at a level of "2/4." In teams students discussed the design of a laboratory investigation demonstrating their understanding of two-dimensional forces. These periods of higher order student-centered engagement were logically opened, closed, and redirected through short purposeful teacher-directed, "5/1," segments.

During the six segments all students were focused and on task. The majority of class time (88%) students were working at higher order thinking levels of "4" (transform) and "6" (generate). A variety of representational scaffolds, including words, symbols, pictures, and objects, were strategically used to enhance the students' learning experience. Student learning was focused on words, symbols, and pictures during the problem solving session in the first half of the class. Objects were added to the repertoire of representations as students began on to generate ideas and designed a laboratory investigation demonstrating their knowledge of two-dimensional forces.

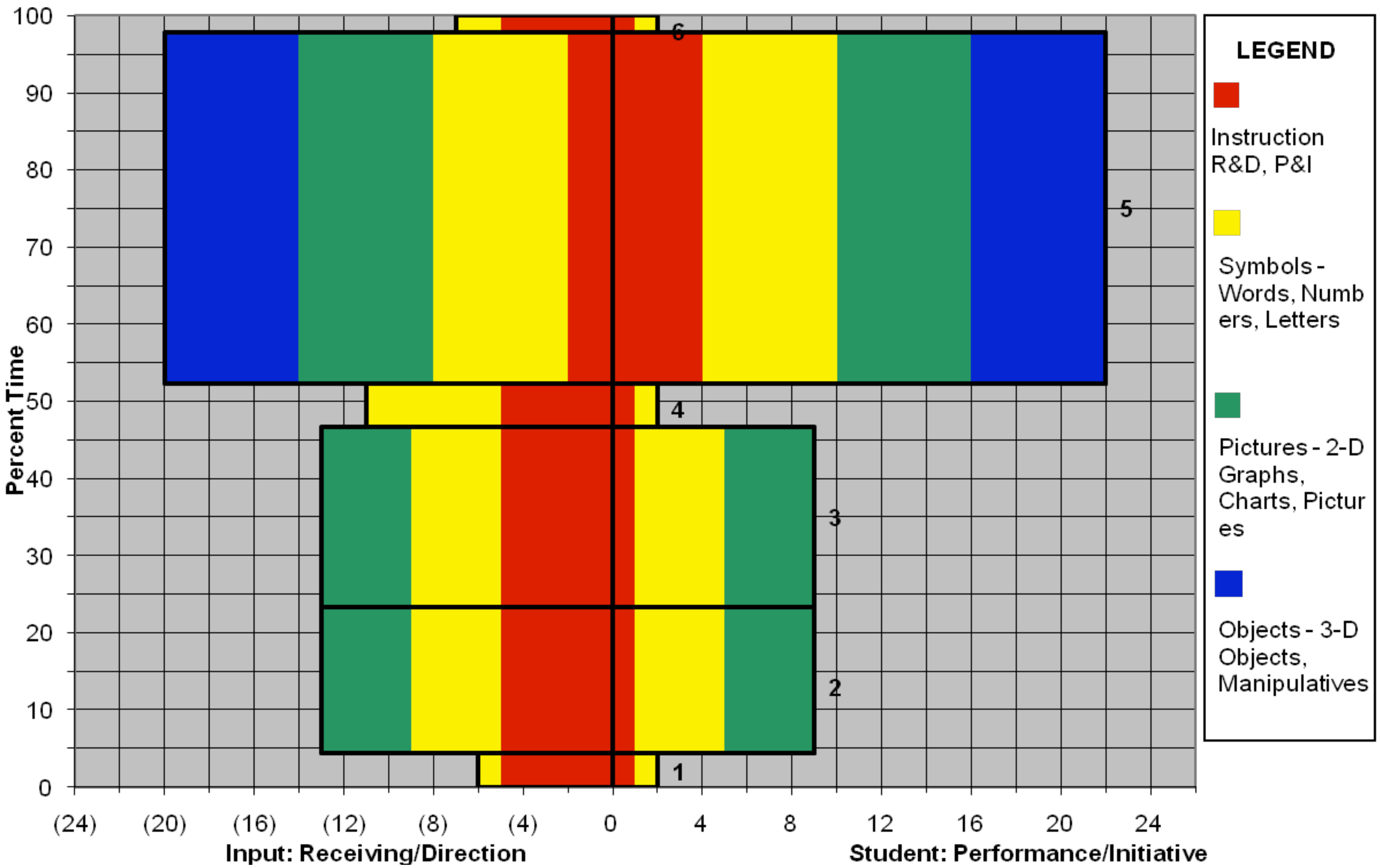


FIGURE 6.2 M-SCOPS Profile from the first observation of Mrs. Patton's class.

*Observation 2*

Thursday, November 16, 2006

Before embarking on my second trip I had asked Mrs. Patton if I could observe one of her AP classes since I had previously observed a pre-AP class. Mrs. Patton's AP Physics class met at the end of her day, so I embarked on my trip mid-morning in order to make it there in time.

With 200 miles of road and a good chunk of Michael Crichton's novel *Prey* on audio book behind me, I arrived at Frawley High, made my way past the security guard, signed in at the office, and walked to Mrs. Patton's classroom with time to spare. The AP class was after Mrs. Patton's conference period, so I had ample time to set up my equipment and get settled on a stool in the corner. Much like before, the LCD projector was set up and focused on a screen behind the demonstration lab table and incline planes, computers, calculators, and probes littered the lab benches.

Students began to filter into the classroom and they took their seats as the bell rang. Mrs. Patton soon began class by introducing the two observers that were in the classroom: me and someone from the school district. She then moved on to review a problem on projectile motion from the internet homework that a few students had questions about.

She set the problem up by drawing a visual representation of it on her tablet PC and adding the data given. The students then walked her through the first few steps of solving the problem and setting up a T-table that listed all of the variables and unknowns. After it was set up, she gave the students a few minutes to work out the problem with their neighbors before she went over the solution on the tablet PC.

After the problem was successfully solved, all questions were answered, and the class indicated they understood the process, Mrs. Patton went about explaining the challenge that they would spend the rest of the period on. The students were to predict where a ball launched from an incline plane would land by utilizing their knowledge of projectile motion. She set the lab activity up in the following way:

Mrs. Patton: Now, were going to actually see how well this equation actually works, can we apply this to real life and it actually works. What was one of the major things y'all argued about this stuff?

Students: (jumbled, many talking at once, but the gist was) A bullet that's dropped would hit the ground at the same time as one shot up in the air.

Mrs. Patton: So, why don't y'all like that, why does that bother you?

Students: Because you shoot a gun, the bullet is going to be going up, the one dropped only goes down do its gonna hit the ground first (more jumbled comments) but that's only in a perfect physics world.

Mrs. Patton: Okay, perfect, what happens in our perfect physics world?

Students: There's no friction and the shot would probably go on forever.

Mrs. Patton: Okay, so we're now going to sit outside of our perfect physics world and we're going to do a lab and we're going to see how our perfect physics world compares with our everyday experienced world. What I want you to do is you're going to get a little ball bearing, which is this little metal circle here, and you are going to actually predict, this is the purpose of the lab, where it's going to hit off of this table. Okay? So we want to calculate where's going to hit off of this table. What path is it going to take?

Students: Parabolic.

Mrs. Patton: Parabolic little path, so you should be able to calculate the displacement of the X, how can we going to calculate the displacement of the X, what are some of the things we're going to need to know?

Students: Height.

Mrs. Patton: You want to measure the height of the table, how are you going to do it?

Students: Take a meter stick and measure it.

Mrs. Patton: We're going to take the meter stick and measure it, good job, what else do we need to know?

Students: Velocity, initial velocity.

Mrs. Patton: Somehow we need to calculate the initial velocity it comes of the table at.

Students: Water Probe.

Mrs. Patton: We're going to use something newer than the water probe, we're going to use something called a photo gate and a photo gate is a more precise measurement device than the motion detectors. And what a photo gates are, are these two little gate looking things and it measures the ball as it goes through here and the computer's going to actually show up nice and easy with what velocity that it goes through. If you knew the initial velocity and you knew this displacement in the Y you can very easily calculate the displacement of the X. That is what you are going to do. When you have got this value you'll say Mrs. Patton we're ready to test, here is the magic target (holds up the bottom of a Styrofoam cup) you're going to place this target on the floor where you think it's going to hit. If it hits the target on the first try you get +10 on your lab.

Student: Wait, how do you know how hard you're going to throw it, is there something that's going to be throwing it for you?

Mrs. Patton: There's going to be a ramp.

Student: Oh, okay.

Mrs. Patton: And if you hit it on the second try after you make your adjustments you get +5 on the lab. You only get 2 tries. Now listen carefully, as you're trying this out we're going to take the average velocity you're going to run it through here about ten times. I better not hear the marble hitting the floor so you can kinda see where it's hitting so you can cheat and put the cup right there. So when you're doing the lab somebody better be a good catcher, football player (points to a student). Does everybody understand how they're going to calculate this? Yes?

Students: Yes.

Mrs. Patton: Okay, this lab is a formal lab write up, it's gonna go into your lab notebook. This one will be pretty easy to do and you've got lots of opportunities for bonus points if you hit the magic little cup. This is a new six weeks so we do get new jobs.

Students: New Jobs! (Joking conversation)

> Mrs. Patton: Okay I'm going to call three of you up here and you will be the team leaders and you will pick your people. (Observation 2, 19:20-24:00)

Mrs. Patton proceeded to place index cards, with student names on them, face down on her lab bench. She randomly picked three cards as team leaders and each leader proceeded to choose a few more cards to find out who would comprise their lab group. Then, with a few last minute questions and instructions, they were off.

Students quickly clustered around their lab tables and began rolling the ball bearings down their inclined planes. I was amused watching the other observer with her official-looking checklist walk around and ask the students questions about what they were doing and why. Her lack of understanding was clearly evident. The groups answered her questions, often laughing and shaking their heads as she moved away, and refocused themselves on their work.

The students quickly realized they needed to drop the ball from the same place on the incline to normalize its velocity as it left the table and then they calculated the average velocity. All of the groups worked diligently, measuring, testing, and calculating for about 30 minutes before one of them announced that they were ready to test. Mrs. Patton placed the bottom of the Styrofoam cup on the small piece of tape the group had placed on the floor to mark the exact spot their calculations had predicted the ball would land. They double-checked that everything was in place for their first test and released the ball. Low and behold, it landed squarely in the cup. The other groups had all been watching, they cheered and quickly moved back to the tables to finalize their own calculations.

A second group signaled they were ready to try after a few minutes, and Mrs. Patton again placed the cup over the tape. This group failed to hit the cup on their first try but, after a bit of adjustment, they got it on the second. The third and final group soon followed and they, like the first group, hit the cup on their first try.

After all of the groups had been successful in calculating the projectile motion of the ball bearing they helped Mrs. Patton put the ramps, probes, calculators, and laptops away. After everything was cleaned up, they resumed their seats at the "sit-down" end of the classroom.

Mrs. Patton gave some instructions about what was to be included in their lab write-ups. Students wrote down much of what she said, but seemed to be familiar with the protocol. After fielding a few questions about report details, Mrs. Patton began a surprisingly historical and philosophical conversation with her students. She asked them many questions, including:

> Why do you think I teach you physics in the perfect physics world? Do you think we should teach it that way or should we jump in with the real world stuff? How do you think they actually came up with the formula? How do you think the scientists from the 1600's and 1500's did it? When you say "they" who are you talking about? When Newton published all of his work do you think it was easily accepted? How do we determine if something is right or not? What happens when your experiences go against what's theoretically right? Can science ever find the real truth? Is physics that was taught in classrooms 50 years ago the same physics that's taught now? (Observation 2)

The students responded to her questions loudly and animatedly, coming up with many admirable answers. She seemed to guide their banter, offering them new questions that complimented those they were struggling with, but she never gave direct answers.

The discussion eventually wrapped around to the question that was raised at the beginning of the lab experience: Why would a bullet shot up hit the ground at the same time as one dropped from the same height? Mrs. Patton launched into the calculations to show the students how the two bullets would hit the ground at the same time. The students noisily offered advice to her as they hastily tried to complete the problem before she solved it on the screen. The problem was rushed through its final stages and, as the bell rang, Mrs. Patton shouted out some last minute instructions about test corrections and homework as the students took off to head toward their next class.

Mrs. Patton excused herself to tie up some loose ends and came back to set a student up to complete an unfinished lab. Another teacher sat at a nearby lab bench to work on her computer. She interrupted our interview every now and again to ask questions about a PowerPoint she was making. Mrs. Patton fielded both her questions and those of the student during our interview.

This interview was shorter than the first and we were done within an hour. I left as last rays of sunlight began to fade and headed north. I had a reservation at a small bed and breakfast Mrs. Lewis had recommended and I was anxious to get there and settled before the small town shut down and I was out of luck for dinner.

*M-SCOPS Profile Interpretation*

The M-SCOPS Profile representing my second observation of Mrs. Patton's class can be found in Figure 6.3. This 90-minute lesson consisted of 11 segments. Multiple short segments focused on solving problems about projectile motion preceded the main focus of the class, a laboratory investigation. Students used their knowledge of projectile motion to calculate where a ball bearing would hit the floor after being rolled down an incline plane. A segment of engaging discussion on the nature of science followed the laboratory activity.

During the 11 segments all students were focused and on task. A variety of representational scaffolds, including words, symbols, pictures, and objects were strategically used to enhance students' learning experience. The first main portion of instruction (segments 2-4) focused on a teacher-led problem solving session using words, symbols, and pictures at representational scaffolding level of "3" (rearrange). A shift to a more student-centered segment (segment 3) occurred as Mrs. Patton gave students time to work on solving the problem with their neighbor before being brought together to complete it as a group. The problems solved during these segments focused on the concept that was the focus of the laboratory activity, projectile motion. This progression provided students with a chance to review the knowledge that would be needed in the laboratory activity.

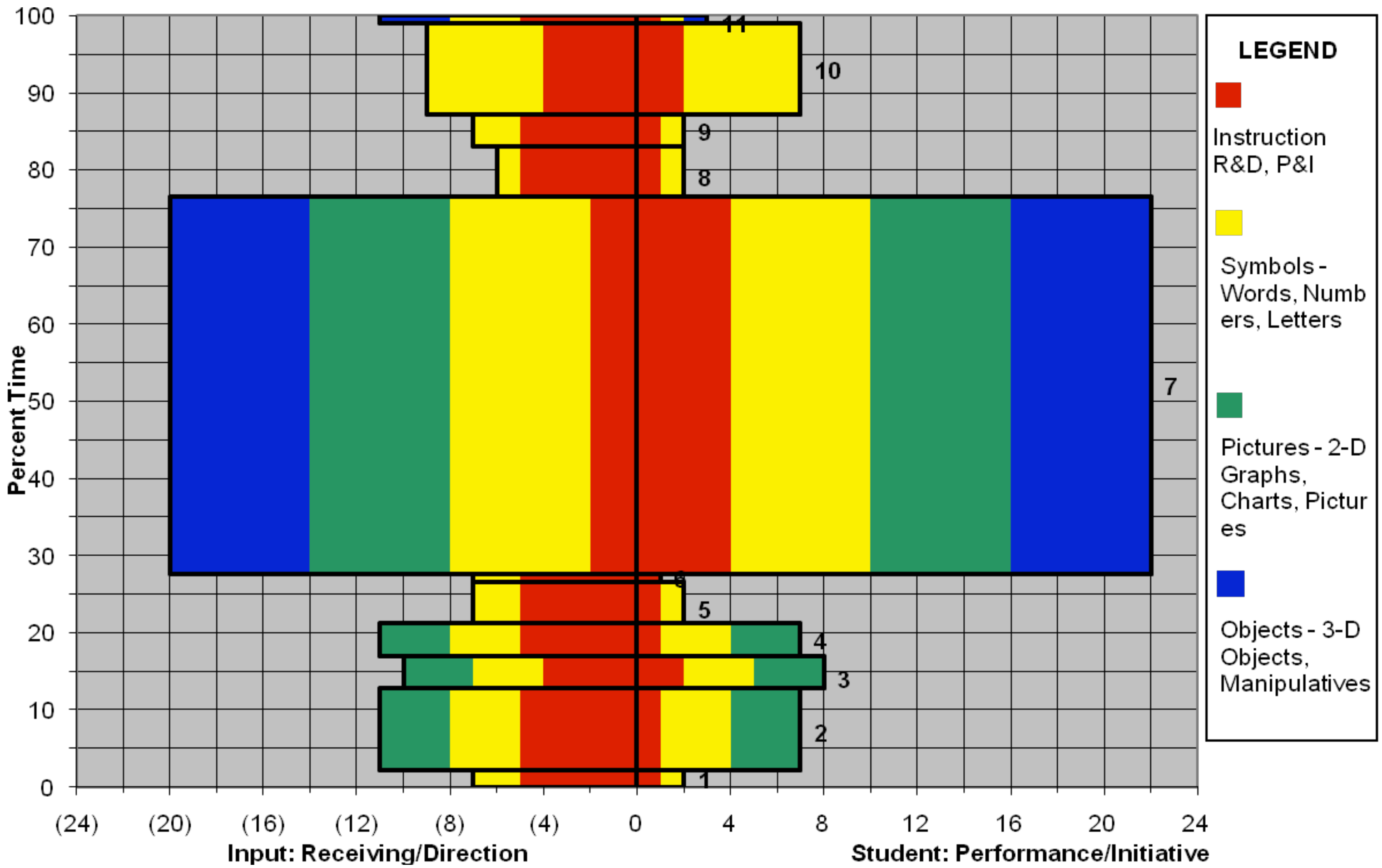


FIGURE 6.3 M-SCOPS Profile from the second observation of Mrs. Patton's class.

The majority of class time (49%) was spent on the projectile motion laboratory (segment 7). During this segment students took a large amount of initiative for their own learning at an instructional scaffolding level of “2/4.” They used words, symbols, pictures, and objects at the highest representational scaffolding level of “6” (generate). Students worked in teams to design a setup and calculate where a ball bearing would hit the floor based on the forces they could measure using the tools and technology provided.

## Personal Practice Theories

I learned a great deal about Mrs. Patton’s personal theories, and how they related to her classroom practice, from our interview-based discussions. I found Mrs. Patton’s methods of planning and teaching complex. Her methods were intertwined and embedded in the reflective and adaptive manner in which she approached teaching. Because of this, I did not describe Mrs. Patton’s planning and teaching methods separately, as I had done with the other two teachers. Instead, I described her methods within the context of the five themes that emerged from my analysis. These themes were: making thinking visible, reflection in action, use of technology, adaptive use of ideas and tools, and involvement in extracurricular activities. The rest of this section describes these themes and the relationships among them.

### *Making Thinking Visible*

Through many of my discussions with Mrs. Patton I noticed that she had a clear vision of both the learning goals she wanted her students to attain and what the attainment of those goals looked like. Her constant probing of student understanding provided her the opportunity to compare what she saw to the learning goals she had set, reflect on what her assessments told her about how the students were progressing, and adapt her classroom practice to move students closer to her goals.

Although Mrs. Patton did not specifically discuss this process with me, much of what I had observed during my visits to her classrooms and many of the discussions we had during our interviews indicated that these thought processes were taking place. She mentioned various methods of assessment throughout our discussions including homework assignments, quizzes, tests, and lab write-ups. She also assessed students through more abstract measures, like the questions they asked and the looks of understanding she saw in their eyes.

As may be apparent from the above description, Mrs. Patton's assessment of her students' learning was complex. During one portion of our first interview Mrs. Patton and I discussed her use of the "internet homework" she utilized in her classroom:

> Mrs. Patton: They have internet homework. They work the problems and its immediate feedback, they plug it in and they get it right or wrong and then they get 7 more chances to get it right. It came with the textbook and it's free and it's better than (web assign) because it's free, if it wasn't I'd have to pay for each kid. And I set up the problems basically out of the text book so its, its without text book and they just work their problems and they either get it right or wrong and I always give them at least 2 days to get it done so they can come to tutorials where they need help.
>
> Me: Oh cool, so do you see their work then on the Internet?
>
> Mrs. Patton: No, that's the only bad thing, so I try to follow up with a quiz the next day or thereabouts so I can see their work, and to ever get my help they have to show me their steps, I won't help them unless I see step by step what they've done, so its plus and minus. The problem is with it that it takes them so long for them to work one and if you work three hours and don't know they have it right and by the time I look at it, grade it, they've forgotten their processes so its eh eh, and each kid gets their own unique homework which is another part that I like so there's no copying going on, its randomly generated numbers.
>
> Me: Oh, that's cool
>
> Mrs. Patton: Well it's good and it's bad. I mean, that's a definite thing, that's why I try to follow up with the quiz so I see their steps and what they're doing.
>
> Me: Because the collaboration thing might be good but then, yeah, pros and cons, ah, it goes both ways eh, what are you going to do, there's gotta be some easy way, but I would assume like even if there are different numbers the problems are similar enough.
>
> Mrs. Patton: Right, they can sit together, they work together as a group, this is the stuff, but they've still gotta go back and plug in their own numbers, get their own answers, so… (Phase 2, Interview 1, Line 300)

This discussion revealed the complex thinking behind Mrs. Patton's use of internet homework and demonstrated that she had given a lot of thought to the impact of her assignments on student learning. She saw value in the immediate feedback and multiple chances the program offered her students. She also appreciated the way the randomly generated number sets in the problems focused students' discussions on underlying concepts rather than calculations. Mrs. Patton had weighed the pros and cons of using this program over others, had adapted it where she could, and had combined it with other assessment practices so she could gain a more complete picture of her students' understanding.

One of the main benefits Mrs. Patton mentioned about the internet homework was that it provided her students with immediate feedback and multiple opportunities to check their answers. This feedback allowed students to know instantly if they had worked the problem correctly and gave them the opportunity to determine where they had gone wrong if they had not. This process saved Mrs. Patton valuable time answering questions and allowed students the opportunity to develop strategies with which they could assess their own thought processes.

Another of the benefits of the internet homework was that it provided similar problems with number sets that were unique to individual students. This characteristic of the program offered students the opportunity to work together to solve the problems but would require them to calculate answers on their own. This procedure forced students to focus less on their calculations and more on the concepts and procedures behind the numbers. This focus allowed students to form deeper, more flexible understandings of the concepts and made it easier for them to apply these concepts to new problems.

The one problem with the internet homework was that it did not provide Mrs. Patton a chance to see and assess the steps and thinking processes behind the answers students submitted. To assess these thinking processes, Mrs. Patton gave quizzes and exams where students had to show their work. She also mentioned that students were required to bring their work to her if they needed help in solving a problem. By assessing her students' work, and not just their answers, Mrs. Patton could determine the misconceptions that underlay the issues and help them to understand where they went wrong. Viewing their work also allowed her to be certain that her students had thought about the problem and reflected on the solution before they came to her.

Mrs. Patton's use and adaptation of the internet homework, paired with quiz assessments, provided a valuable demonstration of the complex way in which she planned and taught her class. It demonstrated that there was more to the assignments she gave her students than simply offering them opportunities to practice concept application. The learning experience that the internet homework provided fostered conceptual understanding and offered opportunities for student collaboration, reflection, self-assessment, and self-learning. This experience taught the students a method of problem solving and thinking that involved much more than physics concepts and computational efficiency alone.

Mrs. Patton saw value in scaffolding her students learning and providing her students with opportunities to apply their understanding. These opportunities provided Mrs. Patton with a different look at the thought processes of her students and therefore a more complete picture of their learning. The problem-solving sessions followed by hands-on activities I had observed during my two visits to her classrooms were examples of this. During these activities she ramped up the complexity of concepts as she offered students the opportunity to apply them in different situations. She began both of these sequences with homework and in-class guided problem-solving sessions and followed these activities by asking students to apply their understanding to more ill-structured real-world problems. Students were engaged and challenged at every step of this process. As they collaborated with each other in order to determine the best solution to the problems, Mrs. Patton probed and assessed their thinking, providing them with enough help and encouragement to keep them challenged and prevent them from becoming frustrated.

These two examples provide an illustration of the complex ways in which Mrs. Patton thought about her teaching. The complex decisions on which she based the variety of assignments she used made her students' thinking visible. She was able to quickly modify lessons to ensure her students were progressing towards the learning goals.

*Reflection in Action*

My analysis of interview and observation data indicated that Mrs. Patton had a deep conceptual understanding of her subject. She planned both long term and moment-to-moment based on her continuous assessment of student understanding. Her depth of understanding of her subject, her curriculum, and what students understanding looked like had been refined through years of practice. She created problems that reinforced concepts or challenged students understanding as she reflected on her students' progress in action.

The ways in which she responded to many of my questions reinforced this idea. For example, when asked how her thoughts about teaching had changed since the beginning of her career she answered:

> The further I go in school and the more years I teach, the more I realize how you've got to break down things for these kids. The first year I did this I assumed they knew sine cosine tangent and I hopped in right here and boy howdy, was that a rude awakening. So I-you reevaluate your curriculum. You set things up so one thing scaffolds onto the next thing and you do a lot of scaffolding. This class, as I said before, I'm taking 9 hours and not thinking real clearly, I threw a problem in that was way up here and the difficulty level was the first thing they saw and I had to spend the two days fixing it because I didn't start off with the easy problem. It was the eyes, they shut down they quit thinking on me and I was just like oh boy did I screw up. Well my other period on the next day, I did it the right order and they got it and of course the test averages indicated that as well. So I think the biggest thing is realizing where the kids are, what their misconceptions are and teaching in a format that handles those misconceptions and scaffolds the learning more, because I mean I know they can't see that XY axis being shifted so what do I do, I try to do visual things so they can see how it shifted and you know it took, 5 minutes that you saw, but they're going to remember that, because they're going to say oh yeah. (P2I1, L466)

This statement indicated that Mrs. Patton thought about both the overall structure of her curriculum and how the concepts she taught fit together, as well as how her students' learning was progressing moment-to-moment. It also indicted that she used multiple sources of data to substantiate her instructional decisions. Her belief that the biggest thing was “realizing where the kids are, what their misconceptions are and teaching in a format that handles those misconceptions and scaffolds the learning more” indicated a broader understanding of how she structured her curriculum to scaffold student learning across topics. Her mention of throwing a “problem in that was way up here” in one class and having to “spend the two days fixing it” along with her discussion of doing it in the “right order” with her other class indicated that she did not stick to a rigid schedule. Mrs. Patton planned her day-to-day instruction according to her assessment of students understanding.

These observations were reinforced by Mrs. Patton’s response when asked how she planned for her lessons. She stated:

> My pre-AP is such that I can do it without thinking. I can get up there and make up problems and blah, blah, blah. When I first started it was the script. This is what I’m going to do; I circled the problems I was going to work from the book and blah, blah, blah. I taught it enough years now I can do it on my feet and I never understood that when I started because Ms. Morrow who’s been here, she’s taught AP chemistry for 20 years and she doesn’t play games, she just goes the way the kids can do it but I could never understand that. I was like how in the world, but the more years I teach the more you know which way to go with this. (Phase 2, Interview 1, Line 505)

This statement reinforced my assertion that Mrs. Patton had a clear vision of both the learning goals she wanted her students to attain and what student attainment of those goals looked like. It also reinforced that she clearly understood how the concepts of her subject fit together and what student understanding of the concepts looked like. These understandings, coupled with her methods of assessing from multiple angles, allowed Mrs. Patton to ensure her students thoroughly understood each concept before moving on to the next.

Mrs. Patton’s description of how she structured a typical class for her students also demonstrated that she assessed and reflected in action and taught for understanding. She stated:

> I usually try to break [my class] into 3 distinct methods since this is a block schedule. I usually spend at least 20, 15 minutes reviewing what we've done, going over what happened then doing the new stuff. Then we'll do some guided practice where I hop around the room making sure they're okay. Then we'll usually, if it's a problem-solving day, come to the back lab tables and work a set of problems together. So they've got the group practice in and they'll have their internet homework, which is unique to each person. So they have to do that and that's basically my cycle. Then we'll throw the lab in there and it works, it works for me at least. (Phase 2, Interview 2, Line 174)

This statement coupled with my analysis of the M-SCOPS Profiles from my two observations of Mrs. Patton's classes demonstrated that she deliberately structured her lessons in short segments and varied the degree of student initiative required to complete the tasks. She logically scaffolded them from more teacher-directed to more student-directed activities. Mrs. Patton provided her students with opportunities for teacher-directed practice, guided practice, group practice, and less structured practice in the form of laboratory activities. This variety offered Mrs. Patton opportunities to assess student understanding and offered her students opportunities to assess their own understanding as they moved through activities with varying levels of structure

Mrs. Patton's discussion of her planning seemed to account for every moment of class time and left almost no time wasted. In my observations, housekeeping details were quickly mentioned before and after the bell and students spent the entire class period efficiently engaged in a variety of activities that stretched their understanding and improved their metacognitive skills.

*Technology Use*

The use of technology permeated Mrs. Patton's classroom and the two lessons I observed. She adapted technology for use in her classroom in multiple ways to help her students see things that were not easily seen without it. Technology gave the students opportunities to assess their own learning. The internet homework was just one example of Mrs. Patton's use of technology. Other examples included the instructional technology she used to deliver her problem solving sessions and the multiple technologies students used during the laboratory investigation to measure forces.

The tablet PC Mrs. Patton had utilized to work problems was one of the most obvious uses of technology. The modified laptop computer enabled her to write out problems in much the same way as an overhead projector, but in a cleaner, more efficient manner.  As I saw during my first observation, the tablet PC could also be used to highlight and demonstrate concepts in an effective way. During this observation, Mrs. Patton had used her tablet PC to demonstrate the basis of the calculations students would do as they solved a certain type of problem. Mrs. Patton had drawn a graph and plotted the problem on it, highlighted the axis the problem would be shifting to, and reinforced this shift by using rulers to demonstrate it in the classroom. The pictures in Figure 6.1 illustrate this process. This made the concepts behind the calculations clearer. I appreciated it all the more since it illuminated a concept I had failed to grasp during my two semesters of college physics.

During our interview after class, Mrs. Patton explained to me that the tablet PC also allowed her to save her lecture notes after class and upload them up to her website. In this manner, students who had missed class or needed to review the problems could access the notes whenever and wherever they needed to.

Technology was also an integral component of the two labs I observed during my visits to Mrs. Patton's classroom. During my first observation students were asked to design a lab that demonstrated the concepts they worked on at the beginning of class. They used a force probe, an incline plane, and a block of wood to plan out a testable laboratory investigation. Students were asked to think about and write out how they could use these materials to solve a physics problem based in the real world. This allowed students to understand how the numbers in the physics problem applied to actual forces in, what Mrs. Patton called, the "real physics world." The lab also provided Mrs. Patton with insight into how well students actually understood the concepts she taught as she monitored their ability to apply their understanding to the ill-structured problem.

During the second class I observed, students were using velocity probes to determine how fast a ball bearing moved as it left the table. Students used the velocity, and other variables, to calculate where a ball bearing would strike. Much like the last lab, this activity allowed students to test their understanding of physics through a problem situated in a real world context that was less structured than the word problems they worked on in class.

The use of technology during labs allowed students to measure quantities that would be difficult, if not impossible, to do without it. Technology allowed students to take the force and velocity measures they needed to complete calculations as they applied their understanding outside of the “perfect physics world” (Comment from Observation 1).

*Lifelong Learning*

Mrs. Patton was constantly looking for learning opportunities and was on the alert for new ideas that may improve her classroom practice or enhance her students’ learning experiences. Her involvement in extracurricular activities, her incorporation of ideas from the ITS Center’s PDE, her graduate classes, and her use of technology were indicators of this quest for knowledge. Underlying these examples was Mrs. Patton’s ability to reflect on new ideas, see how they could fit into or enhance her classroom, and adapt or incorporate them in ways that best fit her teaching practices and benefitted her students.

Mrs. Patton discussed being heavily involved in education related activities outside of school. She utilized the funding provided by the ITS Center to return to school and completed her master’s degree during the spring semester of 2007. At the time of this study she was taking nine credit hours from a university that was four hours away from her home. In addition to her graduate studies, Mrs. Patton presented AP materials to a consulting board and hoped to become a College Board consultant for AP as soon as she completed the paperwork. She also presented her research from the ITS Center’s PDE at the state science teacher conference the week after our first interview. The time these activities took out of her already busy schedule and family life demonstrated a real dedication to her profession and a disposition as a lifelong learner.

Through an analysis of my classroom observations and interviews, I could see that Mrs. Patton analyzed and incorporated concepts from the ITS Center’s PDE and her graduate studies in thinking about her teaching. She used the terms inquiry, scaffolding, and transfer frequently during our interviews. Her use of these terms indicated that she was thinking about how the terms applied to her teaching practices.

A few of her comments also demonstrated that Mrs. Patton did not accept ideas at surface value, but seriously thought about their worth and how they could be applied to her teaching practice. The below comments illustrated this idea:

> [Inquiry] takes a little longer and that's what's coming out in my own mind as I go through all this inquiry stuff, is it worth the time effort to get them where they need to go? And, I hope, and I try to do one inquiry-based lab 6 weeks, and so they go through the inquiry type thing and it's hard, it's much harder for them to do that than just following these worksheets, but, I don't know. (POI1, LN384)
>
> This inquiry stuff, I mean I'm still not sure I agree with all of it, but some of its good and getting those kids to think and process and so in that aspect. (POI1, LN620)

These comments demonstrated that Mrs. Patton seriously thought about the benefits and drawbacks of the incorporation of inquiry into her classroom practice. She was testing them and evaluating the ways in which the activities impacted her students learning and how it fit into her overarching learning goals.

Finally, Mrs. Patton's multiple and varied uses of technology demonstrated that she often incorporated new ideas into her classroom. I assumed that many of the technologies she used, such as the tablet PC, the website she uploaded her notes to, and the internet homework were relatively new additions to her practice, since they had not been readily available or cost effective until recently. The time she took to learn how to set them up and her use of them to facilitate her classroom practice indicated a predisposition to learning about, understanding, and incorporating new ideas.

<u>Performance Artifacts</u>

Mrs. Patton's performance artifacts provided a valuable view into her understanding and interpretation of the ideas and constructs we discussed during the ITS Center's PDE.

*Instructional Framework*

Mrs. Patton's IF outlined an intervention that was well in line with the conceptual frame of the ITS Center's PDE. The Etheredge and Rudnitsky (2003) inquiry frame formed the basis of her intervention and the lenses of the HPL framework were also integrated well. Mrs. Patton also demonstrated her understanding of the other readings the ITS Center's PDE had focused on in support of the design of her IF. In addition to discussing the inquiry experience she designed for students in her classroom, she used the IF provided to reflect on the ITS Center's PDE and explained how she believed the concepts impacted her thinking about her teaching.

Mrs. Patton's IF began with a reflection. In this section she discussed how she perceived the various portions of the ITS Center's PDE. She did not see the morning and afternoon sessions as two separate entities. Mrs. Patton discussion of the sessions was well aligned with the way we, as designers of the experience, had intended, as complementing each other to model the process of inquiry. She wrote:

> What I have enjoyed most about this program is that the afternoon class was set up in an inquiry style framework. The professors and staff modeled the inquiry method to perfection. I must say that this process worked for me. At the end of these three weeks, I am amazed at the knowledge that I have gained. This knowledge was not obtained through typical lecture classes. The responsibility for learning was shifted to the student. I was responsible for my learning. This is the exact method that I want to replicate in my classes. (IF, Page 1)

From this statement I could see that Mrs. Patton understood the underlying goal behind the design of the ITS Center's PDE. Our intention was to create a student-centered learning environment that communicated our understanding of the HPL framework and demonstrated what its effective use would look like. Mrs. Patton understood this and had thought about connections to her own classroom and her own instructional goals.

The IF Mrs. Patton created combined her understanding of the HPL framework with her understanding of the rest of the readings presented during the ITS Center's PDE. Her interpretation and use of these readings and ideas in her IF was well in line with what we had envisioned as an ideal product from the ITS Center's PDE. Mrs.

Patton took ideas from the various education readings and adapted them to a research project that incorporated aspects of what the scientists were doing in their labs and would work with her students to accomplish specific learning goals.

Mrs. Patton's IF began with an immersion experience. This experience involved her students watching a video of the colloidal particles found in a coffee stain. Mrs. Patton had created this video using video microscopy over the first summer of the ITS Center's PDE and it was similar to what the students saw when they used the microscopes. After viewing the video, students discussed the various macro- and nanoscale forces that acted on the particles. This discussion was followed by a benchmark lesson on colloids, van der Waal forces, and Brownian motion. After the lesson, students used digital microscopes to watch particles undergoing Brownian motion and developed questions about them that could be researched.

The process of students crafting researchable questions that stemmed directly from the observations they made appeared to be in line what Etheredge and Rudnitsky had in mind as they described the ideas behind their inquiry framework. Students needed to use their experiences and observations, much like scientists would, in order to develop ideas about a phenomenon. Since their research questions stemmed directly from their own observations, they were based on and therefore connected to real experiences that were directly investigated through the use of IT in her classroom.

The next step in Mrs. Patton's IF was to divide students into groups with similar interests and questions. These groups used the digital microscopes to observe particles in more depth and collected data from their observations. This data was analyzed and written up as a formal lab report that served as a form of summative assessment.

After the experience of collecting and analyzing data and writing up their lab reports, students were given a consequential task through which the knowledge they gained could be applied. For this task, students were given data that mirrored what they had collected during their research and were asked to explain this new data set using their understanding of nanoforces. This consequential task helped students reflect on the understanding they gained as they completed their own research and focused them on the specific learning goals that Mrs. Patton had for their experience in completing the IF.

In addition to her use of the Etheredge and Rudnitsky inquiry framework to guide the design of this IF, Mrs. Patton also used the four lenses of the HPL framework (Bransford et al., 2000). She explained how she saw her intervention as fulfilling each lens:

> - The learned centered community is achieved by allowing this inquiry to be the bridge between two major topics. Students will come into this inquiry having mastered the concept of force of the macro-scale. This inquiry will further explore forces on the micro-scale.
> - The knowledge-centered lens has also been defined. Desired results are well thought out as well as evidence for understanding.
> - The assessment-centered lens is also displayed as students will be continually assessed in many different formats. Students will be questioned, turn in assignments, formulate a summative assessment, and have opportunities for daily reflections.
> - The community-centered lens of this inquiry is especially prominent. Students will act as a community of learners in a variety of contexts. They will peer review each other summative report, they will present data to college students in Tomball, they will peer review reports of other high school students in Houston, and they will also meet with professors at Texas A&M University. (IF, Page 4)

The ways in which Mrs. Patton explained her use of each lens demonstrated a firm understanding of each. In addition to the understanding demonstrated by this passage, I had witnessed her using a similar classroom structure during my observations of her class. During the two classes I had observed, Mrs. Patton had incorporated many aspects of each of the four lenses of the HPL framework. This experience, combined with my understanding of the statement in her IF, convinced me that she understood the principles behind each lens of the HPL framework and had applied them to her IF.

Mrs. Patton's IF reflected her understanding of the readings we had provided during the ITS Center's PDE, as well as the style of teaching that I had observed when I visited her class. She had understood and utilized both Etheredge and Rudnitsky's inquiry framework as well as the lenses of the HPL framework, to support the construction of her IF. She had used the experience provided by the ITS Center to illustrate the principles in action and had adapted her understanding of them to fit her teaching style and the learning goals she set for her students.

*School Year I Summary Paper*

Mrs. Patton's SYI reflection showed a depth of thought and an understanding and incorporation of the literature that had been the focus of the ITS Center's PDE. She focused her writing on detailing exactly how her IF had been carried out in her classroom and how her students' learning had differed from her past teaching experiences. As she discussed both of these things, she related her ideas to the readings from the ITS Center's PDE in a reflective style.

Her writing demonstrated a focused on some of the more subtle aspects of what the IF experience had done for the students in her class and how her classes differed from one another as she taught them. She wrote:

> The immersion experience was done in two different classes. The presentation was first done to my AP Physics B class. This is a smaller class (14 students) who for the most part are not grade oriented. I have a group of three boys that will give up and put their heads on the desk. This did not occur during this immersion experience. Students spoke up that had never spoken up before. The power point, which I expected to take 40 minutes, took the entire 90-minute class period. I have never seen my students so involved. The second class is my AP Physics C class, which has 26 stud90-minutes class is very big, very grade oriented, and for the most part, very arrogant. I expected this class to jump into this project. They were excited, but not to the extent that I expected. They wanted to do what was expected of them. (Reflection, Page 4)

She discussed details that illustrated some of the less than obvious impacts of authentic inquiry activities. These details included her observation of students who would usually put their heads down being engaged, students who did not often (or ever) participate joining into discussion, and differences between her two classes and their interest in the project.

Her writing also demonstrated that she had thoroughly read and thought about the education readings she discussed. Her mentioning of creativity in the following passage is evidence of this:

> One of the things I found most surprising was the creativity that was expressed throughout this project. As stated by Bransford and Donovan (2005), the use of imagination is one of the most important aspects of science, yet is it an area least emphasized. The student's ability to come up with their research questions showed wonderful creativity and imagination. The students thought of processes and methods that I would have never realized. Inquiry is a wonderful process to allow students to use their creativity and imagination. (Reflection, Page 5)

Mrs. Patton's experience in the nanoscale group may have been different from my own ITS experience. I had not see the idea of inquiry allowing students to use creativity and imagination as being a focal point during the ITS Center's PDE. Mrs. Patton's focus on this aspect demonstrated to me how thoroughly she had read and reflected on the ideas from the readings and how she had applied them to what she had observed in her classroom.

Mrs. Patton also detailed her assessment methods and what she gleaned from them in her writing:

> Understanding was assessed in several methods. Each group member was assigned a report at the conclusion of their work. This report was used to see if objectives were being met. Also, I observed the transfer of knowledge. As we moved to different topics in the curriculum, students would refer to their research and bring up the forces on the micro-scale. Students were also required to answer specific questions in a journal format at the end of each class period. This informal assessment allowed me to evaluate understanding.
>
> Another assessment occurred during the presentations. I was able to judge understanding from the thoroughness of the report. I was also able to assess understanding during the question and answer period. All students in the group were required to answer specific questions both of myself and questions proposed by the professors as we visited the University. (Reflection, Page 7)

This passage demonstrated that Mrs. Patton had utilized a variety of methods to assess her students' understanding and the broader impact of the inquiry project they had completed. She discussed assessing their understanding through their reference to the project during other topics in the curriculum, journal entries, the thoroughness of the presentations they had made, and their ability to answer questions from both her and the professors at the University.

*Action Research Plan*

Mrs. Patton's ARP focused on how students' motivation and epistemological beliefs changed after participation in an authentic inquiry project. Her rational was solid. It situated her project in current literature, as well as provided a logical basis for her research. The research methods she proposed were reasonable to evaluate and complete within the context of her classroom. The research questions she proposed were:

1. Does student motivation increase after participation in an inquiry-based laboratory experiment on forces at the nanoscale as measured by the motivated strategies for learning questionnaire (MSLQ) in high school AP Physics students and responses from student reflection journals?
2. Does participation in an inquiry-based laboratory experiment on forces at the nanoscale increase sophistication of student's epistemological beliefs as measured by the Epistemological Beliefs Assessment for Physical Science (EBAPS) and responses from student reflection journals in high school AP Physics students? (ARP, Page 4)

These questions, along with the support for them and methods detailed to answer them, demonstrated that Mrs. Patton thoroughly understood the purpose of her ARP and the limitations she faced conducting research in her own classroom. Each question focused on a single phenomenon: student motivation as measured by the MSLQ and epistemological beliefs as measured by the EBAPS, respectively. Her School Year I Summary Paper indicated that both of these ideas had stemmed directly from her observations and reflections on her IF implementation and were, therefore, relevant to her and to the literature she cited. Mrs. Patton's ARP was a concise and well put together document that demonstrated her understanding of the literature she cited, the concept of action research, and the limitations her classroom presented.

<u>Perceived Impacts of the ITS Center's PDE</u>

The ITS Center had offered funding for up to four semesters of graduate school to all of its participants. Mrs. Patton had taken them up on this funding, had gotten accepted to the graduate program, and was completing her third semester of graduate work towards her master's degree, obtained during the spring of 2007, at the time of this study. Her utilization of the ITS Center's funding and the time and effort she put into being a full time graduate student demonstrated just how dedicated and enthusiastic a teacher Mrs. Patton was.

Mrs. Patton's immersion in the world of educational research, both through graduate school and the ITS Center's PDE, made it hard for her to attribute her new ideas to the ITS Center's PDE alone. When asked if the ITS Center's PDE had any specific influence on the lesson I observed during my first visit to her class she responded:

> I don't know. I can't answer that. It's too much invading my mind. I have read so much junk with my graduate classes it is hard for me to separate what is coming from where. (POI1, LN633)

She did acknowledge, however, that the ITS Center's PDE had provided her with the foundation for, and the initiative to take on, the challenge of graduate school.

*Awareness and Justification*

Mrs. Patton perceived the ITS Center's PDE as having impacted her teaching, and thinking about her teaching, by providing an awareness of alternative ways to think about many of the things she was already doing. She demonstrated how her experiences had made her more aware of new ideas when she stated:

> So, yeah, much more aware. Even when I went for the ITS it was you know the scientific authentic learning and making that emphasis but now taking Dr. L's class, you realize now the importance of the nature of science and how the different aspects of that can be incorporated into the classroom. (Post-Observation Interview 1, Line 745)

This quote showed that Mrs. Patton had connected what she had learned about authentic science during the ITS Center's PDE to the class she was taking on the nature of science and to her classroom practice.

She also discussed how the ITS Center's PDE had provided her with a level of justification for the things she was already doing in her classroom. She stated:

> Basically it gave me educational backing to the things that were already working well in my classroom and then gave me the push to go a little bit further. I mean I know the hands on activities do best, the kids make

> more, and then I have justification why. (Post Observations Interview 1, Line 844)

This statement demonstrated that Mrs. Patton understood that her students learned something more or were able to apply their knowledge in different ways as they completed hands-on activities, as opposed to worksheets. As she stated, the ITS Center's PDE had given her "educational backing to the things that were already working well in her classroom" (POI1, LN844). The ITS Center's PDE, paired with her graduate classes had helped her understand why and how these activities helped students learn.

The remainder of this section focuses on four examples of how the ITS Center's PDE and graduate school had increased Mrs. Patton's awareness of new ideas and had provided justification for some of the things she was already doing in her classroom. These examples are: inquiry and the consequential task, technology, transfer, and action research. Each example demonstrates how Mrs. Patton perceived her learning from the ITS Center's PDE and graduate school, how she felt she was impacted by both experiences, and how she incorporated her new ideas into her thinking about teaching and her classroom practice. In addition to these impacts, I discuss the positive way in which Mrs. Patton perceived educational research as contributing to her ideas about teaching.

*Inquiry and the Consequential Task*

One of the things Mrs. Patton said she gained from attending the ITS Center's PDE was a depth of understanding of inquiry-based teaching and the idea of a consequential task. She stated:

> It gave me more depth on how the inquiry was and the biggest thing that was missing in my part was this consequential task. Finally realizing well this is all good and done, they still have to do something with it. That was a big ah-hah for me. For them to be able to put it all together because you know, so what? They come up with their own little ideas pull it together. Make sure they can transfer what they've done hands on, to what you want the lesson to be. (Post Observation Interview, Line 846)

I learned from previous statements that Mrs. Patton believed, prior to the ITS Center's PDE, that hands-on activities and group work were important parts to her students' learning. From the experience, however, she was made aware of Etheredge and Rudnitsky (2003) inquiry cycle structure and the idea of a consequential task. These ideas helped her see her classroom activities in a new light and adapt her thinking about inquiry teaching and the ways she went about it in her classroom. The idea that the inquiry in and of itself was not the end, but that it could be used as an extension of her lessons to help students pull their ideas and understandings together, was enlightening to her.

During the interview after my first classroom observation I asked Mrs. Patton if she thought she taught the lesson that day any differently than she would have before she attended the ITS Center's PDE. She responded:

> It might have been more of the cookbook lab, copying out of the physics or computers book and just having them follow a step by step what to do. (POI1, LN652)

I believed she meant that she wouldn't have asked her students to design the lab, but would have given them the procedures and had them complete it. Allowing her students to design the lab themselves was a much more open-ended task that forced them to think about the bigger picture behind the procedures, rather than just completing the mathematics. It focused them on the procedures of the problems they were working on and allowed them to develop a more conceptually based level of understanding that was easier to apply to other problems.

*Use of Technology*

Mrs. Patton discussed how the ITS Center's PDE had made her more aware of new technologies and justified their use in her classroom. When asked if the ITS Center's PDE had had any specific influence on the class I had observed during my first visit to her classroom, Mrs. Patton responded:

> I think the emphasis on technology, being up and out on the current things, was a big deal for me, and the ITS program went ahead and kind of justified why it's important, because kids need to be exposed to it. They're going to see it in college, they're going to see it in life, and any time I can do that, I'm going to. (Post Observation Interview, Line 616)

Mrs. Patton went on to tell me that she believed she would have used the technology before she attended the ITS Center's PDE, but the experience had provided her with a justification for using it.

Later she brought up how the ITS Center's PDE had made her more aware of technology that was available for use in her classroom. She stated:

> The other big thing is using the technology in the classroom. Seeing what's out there and then you know, this is pretty cool. They're doing stuff they're doing in Dr. Bevin's lab at A&M on these 100 dollar 20 microscopes and being able to do that and seeing really real research. (POI1, LN852)

*Transfer*

Mrs. Patton brought up the idea of transfer multiple times in our conversations. Much like the other ideas she had discussed, her ideas about transfer seemed to have been developing before she attended the ITS Center's PDE, but the experience had given justification to them and the "push to go a little bit further" (POI1, LN845). The following quote was previously used to illustrate Mrs. Patton's use of inquiry, but it also illustrates some of her thinking about transfer:

> It gave me more depth on how the inquiry was and the biggest thing that was missing in my part was this consequential task. Finally realizing well this is all good and done, they still have to do something with it. That was a big ah-hah for me. For them to be able to put it all together because you know, so what? They come up with their own little ideas pull it together. Make sure they can transfer what they've done hands on, to what you want the lesson to be. (Post Observation Interview, Line 846)

She brought up the concept of transfer again as she stated:

> That's one of the big things I'm after here lately is transfer, are these kids transferring what they do here [pointing to lab bench] to what's going on in the lecture, and I don't know if I can answer that. I'm trying to do a variety of methods to see if transfer is occurring. (POI1, LN661)

Being aware of the concept of transfer enhanced Mrs. Patton's thinking about her students learning and she readily applied it to her classroom practice.

*Action Research*

Mrs. Patton's thinking about action research was intriguing. When I asked her if learning about action research and implementing her ARP had had any influence on her teaching, she responded:

> Is it something I do pretty much regular? That's the biggest thing I got out of it. Action research is what you teach every day you just don't call it action research, because you're looking at kids are they getting it, are they not, are you going this way, are you going that way with it. You're just doing it all the time. You're just not doing the background reading for it basically. (POI1, LN1064)

This statement demonstrated that, although Mrs. Patton saw the act of "doing the background reading for" (POI1, LN1068) her ARP as an added step, she felt that the idea of systematically assessing and evaluating how her students were learning from a given intervention were common elements of her thinking about teaching.

*Educational Research*

Mrs. Patton regarded educational research as worthwhile and beneficial to her teaching practice. During her exit interview she demonstrated this when she said:

> The readings were good. They made me sit down and look at different styles of teaching, different philosophies of education, words that I had meaning for but there's a really educational term that I didn't know but the term was associated with it and you know especially having access to the A&M library. You have access to all these journals and I'm sorry we don't have it at our school's library and we never will in any of the libraries at our school so that has been valuable, downloaded a bunch.

This statement indicated that Mrs. Patton had seriously thought about the educational readings the ITS Center's PDE and her graduate classes had offered in respect to the personal theories that guided her classroom practice. It also indicated that Mrs. Patton had read those articles offered to her and had searched for more of her own.

## Analysis

When I looked back at all that I had learned from analyzing Mrs. Patton's data, I came to see Mrs. Patton's success at understanding and incorporating the ideas from the ITS Center's PDE as stemming from two parts. First of all, the ways in which Mrs.

Patton thought about and delivered her instruction were in line with the many of the learning principles that the readings from the ITS Center's PDE were based on. She focused her instruction on making her students' thinking visible. She tested and probed their understanding of concepts through complex activities where they were engaged in higher-order thinking skills. The complex thinking skills required to complete the activities she offered her students probed and tested their understanding. Having students apply their understanding in these ways provided a window through which Mrs. Patton, as well as her students, could see the strengths and weaknesses in their understanding. Once they had the opportunity to see how they were thinking about problems and reflect on their understanding, students were able to focus their learning on important aspect of the concept at hand and Mrs. Patton was able redirect her instruction to help them do so.

Secondly, many of the same skills Mrs. Patton demonstrated as a teacher had helped her succeed as a learner. She had approached both the ITS Center's PDE and graduate school with the same complexity of thought and reflective thinking with which she approached her teaching. Her understanding of her students and the way in which she organized her class had allowed her to understand many of the more implicit connections involved with the design of the ITS Center's PDE. The rest of this section elaborates and connects these ideas to Mrs. Patton's practice of teaching and learning and her perception and interpretation of the ITS Center's PDE.

*Connections to Planning and Teaching*

My observation of Mrs. Patton's teaching demonstrated that the structures of her lessons were complex. Mrs. Patton routinely moved her instruction through a logical progression of levels of student directedness. My observations also demonstrated that she focused her students on higher order thinking skills, where their knowledge could be applied and tested in ways other than simple application. Mrs. Patton's constant assessment, reflection, and evaluation led to her expert scaffolding of student learning, keeping them within their "zone of proximal development" (Vygotsky, 1978) where they were challenged, but not overwhelmed. This, in turn, led to students' constant engagement in her classes and allowed every moment of class time to be utilized to the greatest extent possible.

Through interviews, I learned that Mrs. Patton thoroughly understood how the different elements of her class worked together to encourage and enhance her students' understanding of concepts. She used these elements to make her students' thinking visible and she reflected on what she saw in action to enhance their learning experience. Her understanding of how the concepts in her course built on one another, and what student understanding of those concepts looked like, helped her to adapt her instruction to best benefit student learning.

Mrs. Patton's evaluation and use of technology demonstrated that she was constantly looking for and attempting to apply new ideas to her teaching practice. She learned about new ideas and reflected on how they might best be applied or adapted to her classroom practice. This observation, paired with her heavy involvement in extracurricular activities, revealed that she approached her learning with the same complexity of thought and reflective thinking with which she approached her teaching.

*Connections to Perception and Interpretation of the ITS Center's PDE*

My analysis of the impacts Mrs. Patton perceived the ITS Center's PDE and graduate school had on her teaching reinforced my ideas about her complexity of thought, reflective thinking, and disposition toward learning. Although Mrs. Patton did not claim to learn anything completely new from the ITS Center's PDE, she indicated that the experience made her aware of new ways of thinking about, and justification for, many of the things she was already doing in her classroom. Her discussion of ideas such as inquiry, the consequential task, use of technology, transfer, and action research were evidence of this.

Mrs. Patton's statement that the consequential task was the "biggest thing" that was missing from her use of inquiry and that "finally realizing well this is all good and done, they still have to do something with it that was a big ah-hah for me" indicated that she had reflected on and incorporated ideas from the ITS Center's PDE into her classroom practice. She had taken the idea, understood it, and applied it so that it enhanced her classroom practice. Her understanding and incorporation of this idea fit well with what I had learned about her as a reflective and innovative learner.

Mrs. Patton was also able to adapt what she had learned about the scientists' research for use in her classroom. She had been exposed to the ways in which real scientists used technology during the ITS Center's PDE and had adapted the scientists' research using multi-million dollar microscopes to something her students could do in her classroom with more affordable equipment. Even though she did not have access to the expensive equipment available in the scientists' labs, she understood the thought processes involved in authentic inquiry that she wanted to foster and was able to keep them intact in her classroom context.

Mrs. Patton's statements about transfer demonstrated that she was thinking about her students' ability to apply the concepts they were using to different classroom activities such as book problems, laboratory investigations, and more novel situations as well. Her thoughts about transfer and her application of the concept to her thinking about her practice were well in line with what I had learned about her varied methods of assessment and teaching. It seemed that the idea of transfer had justified the different techniques she was using in her classroom and had given her a way to express her thoughts about her teaching with others.

Mrs. Patton's comments about action research indicated that she felt she was systematically evaluating and assessing her students learning during her everyday classroom practice. The varied ways in which I had observed her continuous assessment, probing and reflecting on her students' understanding in order to evaluate and adapt her teaching practice to the needs of her students, were directly in line with this understanding. I could see how she felt that the only added step to action research was "doing the background reading for it" (POI1, LN1068).

Mrs. Patton's performance artifacts added to what I had already learned about her complex thinking, reflection, and disposition toward learning. Throughout her performance artifacts, her writing demonstrated her ability to reflect on and think critically about the concepts presented through the readings. The design of her IF demonstrated that she had adapted much of what she had learned from both the morning science and afternoon education sessions of the ITS Center's PDE for use in her classroom. The design of her ARP revealed a well thought out plan of systematic evaluation. The design of both her IF and ARP demonstrated her use of new ideas in innovative ways to enhance her instruction.

**Instructional Framework**

Mrs. Patton's IF demonstrated that she had reflected deeply on the ITS Center's PDE and had been able to understand and adapt many new ideas from both her work with the scientists and the ITS Center's conceptual frame to her classroom practice. The reflection with which she began her IF demonstrated that she had followed he parallels between the educational reading and the design of the ITS Center's PDE. The design of her IF further demonstrated that she had been able to apply this understanding to her thinking about her classroom and her students.

The inquiry Mrs. Patton designed for her students was well aligned with the Etheredge and Rudnitsky (2003) Inquiry Cycle and integrated the technology and research of the scientists well. Her IF engaged her students in authentic research that mirrored many of the core components of scientific research (Edelson et al., 1999). Her students used relatively inexpensive digital microscopes to observe and capture video of the movements and interactions of small particles. From their observations they developed research questions about what they had seen and devised methods of investigation. Once their research was complete, Mrs. Patton assigned them a consequential task so that students had to use their understanding of concepts and research methods in a new way. This activity mirrored the scientists' work and tools and the ideas of education research we provided to ground and justify the creation of these "school inquiry tasks" (Chinn & Malhotra, 2002). The alignment of the IF's design with both of these elements indicated that Mrs. Patton had approached her own learning with the same complexity of thought and reflection with which she approached her teaching.

**School Year I Summary Paper**

Mrs. Patton's SYI Summary reinforced her complex and reflective approach to teaching and learning as well as her clear vision of learning goals and her focus on making students' thinking visible. Her writing demonstrated her ability to reflect on her own learning and apply new concepts to her teaching situation. Her focus on making student thinking visible could be seen as she discussed the various assessment procedures she utilized to evaluate her students' learning from her IF implementation. Mrs. Patton's detailed description of the differences she saw in the two classes of students she implemented her IF in evidenced her complexity of thought.

**Action Research Plan**

Mrs. Patton's ARP outlined a meaningful and practical project that would add to her own understanding of her students' learning and was well aligned with the research she had consulted. Her ARP literature review and her use of instruments established that she was able to understand and apply ideas from the research she read on her own during the second summer experience, just as she had with readings that were a focus of the first summer's discussions. Her focus on motivation and epistemological beliefs indicated that she had crafted questions directly from her observations, much like her students had been asked to do in the design of her IF. This demonstrated that she was able to apply the ideas from the inquiry cycle not only to her thinking about her students' learning, but also to her own learning. These elements combined to form a coherent research plan that she could implement, gather meaningful data from, and utilize to answer the research questions she posed.

<u>Member Check Interview</u>

Mrs. Patton responded to my first email and agreed to participate in a member check interview. A copy of Chapter VI was sent to her shortly after. A second e-mail was sent to her at the beginning of January to try to set up a time for an interview. She responded that she was very busy at that time and would be in touch when she found time to review the chapter. I did not hear back from her before this dissertation was completed.

Case Summary and Implications

The connections among Mrs. Patton's teaching situation, practice and personal theories and the vision of reform-based teaching promoted by the ITS Center's PDE were numerous. Understanding these connections helped me to better understand her perception and interpretation of the ITS Center's PDE. The complex and reflective manner in which she approached her teaching paralleled the manner in which she approached her own learning. My discussions with her revealed that she constantly probed her students understanding and adapted her teaching practice to challenge her them. She offered her students opportunities to understand their own learning and revise their ideas when necessary. Observations of her classroom demonstrated that her students were seldom passively receiving low levels of information. Mrs. Patton's students were using and applying necessary information to complete a variety of tasks that varied in their level of structure and revealed, challenged, and enhanced their understanding.

Mrs. Patton's IF was a well-constructed inquiry cycle that utilized the science she had learned from her morning team. Her ARP demonstrated a meaningful and practical plan. Many of her comments about ideas from the ITS Center's PDE and graduate school demonstrated that she did not accept ideas at surface value, but tested them out in her classroom, probed her understanding, and sought out more information when necessary before accepting or rejecting them.  These characteristics indicated that Mrs. Patton was highly reflective and that this ability permeated both her teaching and her learning.

The last three chapters have revealed how the teaching situations, practices, and personal theories of each teachers were connected with their perceptions and interpretations of the ITS Center's PDE. Yet how do the three teachers compare in their characteristics of teaching and learning? The chapter that follows brings the cases of Mrs. Lewis, Mrs. Major and Mrs. Patton together to explore this question before discussing how current research may inform this understanding and what implications can be drawn for the design of PDEs for teachers of science and directions for future research.

# CHAPTER VII
# CROSS-CASE ANALYSIS

As a multiple case study, this dissertation aims to provide an understanding of the relationships within the individual teacher's classroom contexts, practices, personal practice theories, and perceptions and interpretations of the ITS Center's PDE. This paper also strives to compare the similarities and differences of the three teachers in respect to the aforementioned characteristics. This methodology was chosen because comparisons can often illuminate details that are difficult to see in isolation (Lieberson, 1992; Stake, 2006). Choosing three teachers who learned differently from the ITS Center's PDE maximized what could be learned about the variety of teachers who were participants in the ITS Center's PDE. This chapter is a comparative analysis of the three cases of Mrs. Lewis, Mrs. Major and Mrs. Patton. This in-depth comparison addresses research question 2 and its three sub-questions:

2. How were the three teachers similar and different in their various attributes and their perceptions and interpretations of the ITS Center's PDE? Specifically:
   a. What similarities and/or differences in the school contexts and classroom practices of the three teachers were observed?
   b. How were the personal practice theories that emerged from interviews with the three teachers similar and/or differ? and
   c. How were the values, perception and interpretations of the ITS Center's PDE similar and/or different among the three teachers?

Using these questions as guide, this chapter is divided into eight main sections. These sections include: (1) a discussion of the differences noted among the three teachers that led to their selection as participants in this study, (2) a comparison of the school contexts in which the three teachers taught, (3) a comparison of the classroom observations of the three teachers, focused around their M-SCOPS Profiles, (4) a comparison of the CLES survey completed by the three teachers' students and a discussion of how the results from this survey related to my classroom observations, (5) a comparison among the main themes that emerged from my analysis of the teachers' planning and teaching characteristics and their personal practice theories, (6) a comparison of the performance artifacts that were products of the three teachers' participation in the ITS Center's PDE, (7) a comparison of the perceptions and interpretations of the ITS Center's PDE of the three teachers and, (8) my analysis of these experiences and artifacts, which brings the various themes together, allowing me to derive some insight regarding the relationships among the thoughts, perceptions, and actions of the three teachers and relate them to one another.

The purpose of the first seven sections is to describe the differences and similarities observed among the three teachers. The eighth section brings these descriptions together to illuminate the differences among them.

## Selection Characteristics

As detailed in the methodology, the three teachers who took part in this study were selected based on how well the ideas expressed in their performance artifacts and exit interviews aligned with the ITS Center's PDE conceptual frame (as inferred by the researcher) as well as characteristics of the schools in which they worked. Mrs. Major's ideas appeared to be the least aligned with the ITS Center's PDE conceptual frame and so she was placed in the lowest category of alignment. Mrs. Lewis' ideas only aligned slightly better, resulting in her placement the second lowest. These placements reflected that both teachers appeared, at least superficially, to be representatives of the group of teachers who had difficulties in understanding the ideas presented during the ITS Center's PDE. Mrs. Patton, on the other hand, was a teacher whose ideas appeared to be highly aligned with the ITS Center's conceptual frame, which indicated that she understood the ideas better than many of the other teacher-participants. These characteristics are discussed briefly in this chapter and visually represented in Table 7.1. More detailed descriptions can be found in the within-case analyses.

TABLE 7.1
Comparison of Selection Characteristics

| *Teacher* | *Rank* | *E&R Inquiry Cycle Alignment* | *Information Technology* | *Design of ARP* | *Subject(s) Taught* | *School Context* |
|---|---|---|---|---|---|---|
| Mrs. Major | Low | Not with structure or learning principles | Not IT | Neither meaningful nor practical | 9th grade IPC and biology | Suburban and diverse |
| Mrs. Lewis | Medium Low | With structure but not learning principles | Approaching IT | Practical but not meaningful | All levels of chemistry and physics | Rural and mostly white |
| Mrs. Patton | High | With structure and learning principles | IT | Meaningful and practical | Pre-AP and AP physics | Urban and diverse |

Mrs. Major and Mrs. Lewis were marked as good choices for inclusion in this study due to the different ways in which they understood many of the ideas of reform and the different school contexts in which they taught. Mrs. Major appeared to have misinterpreted ideas from the educational research readings. The design of her IF was far removed from the structure and learning principles on which the Etheredge and Rudnitsky (2003) inquiry cycle was based, and her description only addressed the immersion portion of the cycle. In addition, the technology Mrs. Major incorporated into her IF did not align with the definition of IT focused on in the ITS Center's PDE. Mrs. Major chose to integrate laptop computers, which enabled students to conduct Internet searches and create PowerPoint presentations. Mrs. Major's ARP indicated that she was attempting to measure what she termed "conceptual understanding" through a series of teacher-designed assessments focused on factual recall. She also mentioned utilizing other assessments, such as "amount of work completed each day," that were not easily measureable.

Much like Mrs. Major's, the design of Mrs. Lewis' IF was removed from the intention of the Etheredge and Rudnitsky inquiry cycle. Even though she did not thoroughly understand any of the aspects, her design followed her interpretation of the steps of immersion, development of researchable questions, research, and consequential task. Her IF began with a discussion of thermal fish kills, moved to a series of confirmatory labs and concluded with her students researching cases where solubility affected everyday life. The technology Mrs. Lewis chose to integrate into her IF included CBL2 Probes, which enabled students to collect solubility data from the confirmatory labs they completed, Excel, with which they graphed the data they collected, and computers, on which they created and presented PowerPoint presentations on their research projects. These uses of technology did not capture the core components of scientific reasoning involved in authentic scientific inquiry (Edelson, 1997; Edelson et al., 1999), but they did begin to approach ways in which they could. Mrs. Lewis' ARP outlined a workable research plan, but indicated that she was interpreting the concept of transfer as "retention" as she detailed the pre-, post-, and removed post- tests she would administer to students over the course of the two semesters.

Mrs. Patton was marked as a good choice for participation because she was the only teacher placed into the highest level of alignment with the ITS Center's conceptual frame. The design of her IF engaged students in an activity that mirrored the four steps of the Etheredge and Rudnitsky inquiry cycle. Her students watched a video, observed particles under a microscope, asked questions about their observations, conducted research to answer their questions, and were asked to apply their new understanding through the completion of a consequential task. The main technology used in Mrs. Patton's IF was digital computer-operated microscopes. With these microscopes, students were able to record and analyze particulate motion through short segments of video. This type of technology mirrored what the scientists were using in their laboratories and captured many of the core components of scientific reasoning as they were applied to the students' research. Mrs. Patton's ARP outlined a practical research plan that focused on measuring changes in student motivation and epistemological beliefs through two validated surveys.

These three teachers were also chosen for participation in this study because of their similar content areas but varied school contexts. Mrs. Lewis taught all levels of chemistry and physics in a small rural school with a predominantly white population of students. Mrs. Major taught freshman IPC and Biology in a relatively large suburban school district with a diverse population of students. Mrs. Patton taught pre-AP and AP physics in a large urban school district, also with a diverse population of students. It was hoped that the different contexts and similar subjects of these three teachers would allow comparisons among their teaching styles and personal practice theories to be made, while also illuminating the different influence of diverse contexts.

The preliminary observations made during the selection analysis proved, as was hoped, to be good indicators of the differences among the teachers' personal theories and classroom practices. This allowed for a broader understanding of how the experience impacted teachers with different orientations toward reform and reinforced my thought that relationships between the teachers' learning and orientation existed.

## School Contexts

Although contextual characteristics such as subject, grade level, school size, and diversity were important factors in the selection process, my observations and interviews revealed that the school contexts of the three teachers differed in more ways. Some of the main differences with the three teachers' contexts were in their class schedules, the amount of control they had over their curriculum, and the nature of the opportunities they had to collaborate with other teachers in their schools. A visual representation of these characteristics can be found in Table 7.2.

TABLE 7.2
Comparison of School Contexts

| *Teacher* | *School Population* | *Ethnic Composition* | *Schedule* | *Curriculum Control* | *Collaboration* |
|---|---|---|---|---|---|
| Mrs. Major | 1900 students | White – 55.3%<br>Black – 27.5%<br>Hispanic – 13.2% | 90-minute blocks every other day for the year | Dictated by guides and benchmark exams | Focused on topics and activities; no mention of outside planning |
| Mrs. Lewis | 400 students | White – 87.1%<br>Black – 3%<br>Hispanic – 8.1% | 75-minute blocks every day for the semester | Teacher control | Focused on coordinating; mentioned learning from other teachers during ITS |
| Mrs. Patton | 2600 Students | White – 57.8%<br>Black – 25.6%<br>Hispanic – 14% | 90-minute blocks every other day for the year | Teacher control | Focused on learning; sought collaborative opportunities outside of school |

One of the most obvious places similarities and differences could be noted was in the three teachers' schedules. Both Mrs. Major and Mrs. Patton's schools were on alternating block schedules, meaning that their classes met for 90-minute periods every other day for the year. Mrs. Lewis' school worked on a single semester reduced block schedule. She met with her students every day for 75-minute periods for a single semester.

The amount of control the three teachers had over their classroom curriculum was also a good place for comparison. Mrs. Patton and Mrs. Lewis had complete control over their curricula. Mrs. Patton mentioned that even though she was subject to regular evaluations, she was "free to do what she wanted" (POI1, L787) since her students were so successful. Mrs. Lewis discussed that her district had a single curriculum director who oversaw all grades K-12. The curriculum director knew little about high school science, and her students did well on the TAKS test, so she was free to plan her own curriculum. Unlike the other two teachers, Mrs. Major's school took a great deal of control over her curriculum. Her school hired a curriculum coordinator who implemented benchmark exams to assess students' progress. Teachers met weekly to decide what topics they would cover in the coming week, keeping the upcoming benchmark exam in mind. Mrs. Major would base her lessons on those topics and was required to upload her lesson plans onto a TaskStream™ site.

There were also notable differences in the opportunities these teachers had for collaboration and interaction with other teachers. Mrs. Major mentioned two ways in which she collaborated with the other teachers at her school. The first was the weekly meetings the teacher had to decide on the topics from the curriculum guide they would focus their instruction on during the coming week. The second collaborative opportunity she mentioned was the exchange and compilation of teaching resources. She stated "we'll buy different books and we exchange and we got together this year and we put together all of our resources in this little red booklet" (PI1, L649). Mrs. Major's discussions of these two collaborative opportunities demonstrated a relatively low-level agenda. They appeared to focus on deciding which topics to cover and what activities to have students do, but not on how these methods would be used or why. In addition, Mrs. Major never mentioned collaborative opportunities with teachers outside of her school.

During our first discussion, Mrs. Lewis briefly mentioned that she shared the block right before lunch with all of the other science teachers and they met at least twice a week to "coordinate things." In addition to this comment, Mrs. Lewis brought up the other teachers at her school in relation to their use of technology and the subjects they taught, but we never had a major discussion of any other interactions they had. Much like Mrs. Major's, Mrs. Lewis' discussions with teachers at her school did not appear to involve how or why she was teaching, but focused more on what she was using to teach. When asked what some of the most valuable aspects of the ITS Center's PDE had been for her, Mrs. Lewis mentioned meeting the other teachers and seeing some of "their approaches to teaching science" (EI, L9).

Mrs. Patton brought up collaborating and interacting with other teachers at her school more than either Mrs. Major or Mrs. Lewis. The obvious place she discussed collaboration with other teachers was when asked about her planning. She stated:

> We have a mandatory once a week period with department heads or departments so we sit together and plan with the department, that's Monday that was today. Then there's another physics teacher and I and thankfully this year we have the same conference period so we spend that conference period really planning because this is his first year here so we really coordinate a lot and plan. We're part of another thing called AP strategies trying to increase AP enrollment and part of it is being able to be pulled out twice a year actually more than that, several times during the school year for vertical team meetings from secondary on, $6^{th}$ grade on, so we do a lot that kind of planning as well. (POI1, L169)

This quote demonstrated that Mrs. Patton had multiple opportunities to collaborate and work with other teachers, both in her school and her district. It also appeared from this quote that their interactions were, in part, focused on how things could be done, like increasing AP enrollment and aligning science learning across multiple grades. In addition to this quote, Mrs. Patton discussed other teachers' ideas and practices in comparison to her own and how she had viewed their practice differently as she matured as a teacher. She also maintained a high level of involvement in extracurricular activities through her involvement with the AP board and graduate school. Finally, in her exit interview, Mrs. Patton said that "networking" and talking with other physics teachers had been one of the most valuable aspects of the ITS Center's PDE.

Classroom Observations

Stepping into each teacher's classroom was a unique experience. The interviews illuminated and explained my observations of teaching practices. M-SCOPS Profiles were utilized to illuminate and facilitate a discussion of the differences and similarities among the three teachers. These observations will be further explained (triangulated) through some of the interview and performance data that I collected. A visual representation of the characteristics compared in this section can be found in Table 7.3.

TABLE 7.3
Comparison of Classroom Observations

| *Teacher* | *Levels of instructional scaffolding* | *Levels of representational scaffolding* | *Lesson complexity, segmentation &flow* |
|---|---|---|---|
| Mrs. Major | Mostly teacher-directed – IS levels ranged from 5/1 to 3/3 | Focus on lower-level skills – RS levels ranged from 1-3 | Low level of complexity – focus on lecture and practice. |
| Mrs. Lewis | Completely teacher-directed – IS levels were all 5/1 | Focus on lower-level skills – RS levels ranged from 1-3 | Low level of complexity – lecture-recitation style classes |
| Mrs. Patton | Mostly student-directed - majority of time spent at a IS level of 2/4 | Focus on higher-level skills – majority of time spent at levels of 4-6 | Highly complex – periods of higher order thinking broken with short segments of teacher direction |

An M-SCOPS Profile depicts four dimensions of what occurs in a classroom: instructional scaffolding, representational scaffolding, segmentation, and flow. When these four elements are combined in the pictorial representation of a science or mathematics lesson, the researcher goes beyond mere description to a more holistic analysis of the lessons. Through this holistic analysis, overall patterns within and between the lessons of different teachers can be seen and interpreted.

It may be helpful to refer back to Tables 3.1 and 3.2, which detail the levels of instructional scaffolding and representational scaffolding, and Figures 4.1, 4.2, 5.1, 5.2, 6.2 and 6.3, which contain the M-SCOPS Profiles of the observed classes, as you read this section. Being able to refer back to the listed figures and tables at a glance will greatly facilitate understanding the discussion that follows.

*Instructional Scaffolding*

The first of the four dimensions an M-SCOPS Profile depicts is that of instructional scaffolding (IS), represented by the central red band. IS refers to the level of teacher or students directedness of the lesson (Table 3.1). When the red band is more to the left of the central line it indicates a more teacher-directed approach to instruction. When the band is more to the right of the line it indicates that the students are given the opportunity to take more initiative for their own learning. There were distinct differences among the three teachers in respect to the levels and complexity of IS observed in their classes.

Mrs. Lewis (Figures 4.1 and 4.2) maintained her class at an IS level of "5/1" throughout both observed lessons. Students listened to lecture or completed assigned problems from the book. The structure of both lessons aligned with what I learned about Mrs. Lewis' ideas behind her teaching. She felt as though the purpose of her teaching was to prepare students for college and structured her class in a teacher-directed lecture and recitation style, similar to what you might find in a typical college chemistry course.

While a teacher-directed approach to instruction could also be seen in Mrs. Major's classroom, (Figures 5.1 and 5.2) the majority of class time was spent with students working in groups at IS levels of "4/2" and "3/3" to complete teacher determined tasks. Students worked in groups to complete worksheets, a DNA laboratory, and the PowerPoint presentations for Mrs. Major's IF. Much like Mrs. Lewis, Mrs. Major believed in structuring her class around a lecture-practice format. She believed that students needed to be taught one little chunk of information per day followed by a period of practice applying that information. The tasks she provided her students offered little choice and students took little initiative for their own learning.

The levels and complexity of shifting between the IS levels in Mrs. Patton's class (Figures 6.2 and 6.3) were quite different from those of the other two teachers. Mrs. Patton's students did not spend any extended period of time at an IS level of "5/1." Even when Mrs. Patton was completing problems at the front of the room, all students' were engaged and her instruction looked more like a teacher led discussion, rather than a teacher-directed lecture. A significant amount of time (more than 45% of each observed class) was spent at a level of "2/4" where students took the majority of initiative for their own learning. During these segments students were working on teacher-determined tasks but, unlike the other two teacher's classrooms, they had some level of choice in the selection and shaping of the activity they were working on.

*Representational Scaffolding*

The levels of representational scaffolding (RS) that can be seen in the six Profiles provide the most striking difference among the three teacher's classrooms (Table 3.2). At a quick glance, nothing is more apparent than the "filled" appearance of Mrs. Patton's Profiles in comparison to the Profiles of the other two teachers. This "fill" effect is created from the differences in the levels and types of RS employed during each teacher's observed lessons. This dimension provided a great deal of insight into the differences among the three teachers' instruction.

During both of Mrs. Lewis' observed lessons, instruction shifted between RS levels of "1" (attend) and "3" (rearrange). The concentration of instruction on these lower-order skills was in line with the teacher-directedness "5/1" IS level of the lessons. The focus on lower-order skills during these class periods did not engage students as well as a more complex assignment, that utilized their basic understanding of class material in higher-order skills, would have. This may have, in part, explained why students were often disengaged with the lecture content and why Mrs. Lewis' AP students could "multitask." Mrs. Lewis did not use manipulatives or pictures in her lectures, but focused student learning solely on words and symbols.

Although the level of IS shifted more in Mrs. Major's class than in Mrs. Lewis', the levels of RS that her instruction utilized were quite similar. Much like Mrs. Lewis', Mrs. Major's instruction stayed at or below a RS level of "3" (rearrange) during both of the classes I observed. Even though Mrs. Major's instructional methods gave students a bit more initiative for their learning during group work and laboratory activities, the activities they worked on only utilized lower-level thinking skills that focused them on factual recall and procedural knowledge. Unlike Mrs. Lewis, Mrs. Major gave students opportunities to work with pictures and objects, although student learning was consistently focused on lower-order skills.

While the more student-directed levels of IS provided some evidence of difference when Mrs. Patton's instruction was compared to that of the other two teachers, obvious differences could be seen by the levels of RS that were employed. In contrast to the other two teachers' classes, Mrs. Patton's class spent the majority of class time focused on information at levels of "4" (transform), "5" (connect), and "6" (generate). Engaging in these higher-order skills gave students opportunities to apply and use their factual and procedural knowledge in more complex tasks. Mrs. Patton expected students to focus on learning lower-order skills outside of class as they completed homework assignments. During class, the higher-order skills students were engaged in encouraged them to apply the knowledge they learned outside of class to tasks that required them to use and understand their knowledge. During both observations of Mrs. Patton's class, student learning was focused on a variety of RS including manipulatives and pictures as well as words and symbols.

*Segmentation and Flow*

Much like the other dimensions depicted by the M-SCOPS Profiles, the level and complexity of segmentation and flow offered some insight into the three teacher's instruction. Segmentation refers to the changes in activity. Each segment is noted by a different number and often a shift in the levels of IS and/or RS. Flow refers to the ways in which the segments change and the patterns that can be seen among them. In this section, I refer to portions of the class as well as segments in order to highlight how each lesson flowed. I use the term portion to refer to a planned shift in student activity. Some portions of the observed classes consisted of a single segment while others consisted of multiple segments as the activity of some or all of the students changed. I found it necessary to make this distinction between segments and portions as I analyzed the Profiles along with the teachers' interviews. I found that students' activities often shifted during the portions of lesson pre-planned by the teacher. This distinction between portions and segments helped to clarify the connections between what the teachers told me about how they planned their lessons and the patterns seen within the M-SCOPS Profiles.

Through my analysis I noted that both of Mrs. Lewis and Mrs. Major's observed classes had very similar patterns of flow. The similarities between the two teachers instruction made sense since both of them had mentioned during their interviews that they planned a period of lecture in which new information was presented, followed by a period of recitation in which new information was practiced. The Profiles of both teachers also contained blank segments in which all students were off-task. Mrs. Patton's class demonstrated a more complex pattern of segmentation. Both of her observed classes shifted between segments of different levels of higher-order skill interspersed with short periods of teacher direction. Class began and ended on time and students were on-task during all portions of the class. All three teachers indicated the portions and segmentation patterns I had observed were typical of their teaching practice.

Both of Mrs. Lewis' observed classes had two main portions. The first of these portions (segment 2 in both observations) was focused on a lecture and the second portion (observation 1: segments 3-6; observation 2: segment 3) was focused on content application practice either through book problems or test corrections.

Mrs. Lewis had, during her first interview, indicated that she typically structured classes in this manner, starting with a lecture and then giving students time to work on their homework and ask questions. She stated: "We'll do a PowerPoint and then we'll practice. We'll do that. It's kind of, I don't know, that's my lesson cycle kind of" (POI1, L484). The blank space in the beginning of both observations, as well as the ending of the first observation, indicated that all students were off-task during these segments.

A similar pattern of lecture followed by practice could be seen in the M-SCOPS Profiles of Mrs. Major's classes. The Profile of the first of Mrs. Major's observed classes demonstrated this pattern in two main portions. The first of these portions (segment 3) involved a lecture. The shorter segments before and after the lecture focused on organizational activities. In the second portion of this class (segment 5) students were working to complete a worksheet in groups. The short closure indicated by segment 6 occurred when Mrs. Major asked students to put their desks back in rows. The blank segments at the beginning and end of the Profile indicated that class did not begin, nor did it end, on time.

The Profile of the second of Mrs. Major's observed classes was separated into three main portions. The first portion (segments 3-5) introduced students to the activity they worked on during the third portion of class. The shorter segments included in this portion demonstrated a shift in student activity as their activity changed from listening to Mrs. Major, to taking a pre-test, and back to listening again. The second portion of class (segments 6-7) was focused on a DNA verification lab. Mrs. Major introduced this lab in segment 5 as she went over the procedures step by step. Students performed the procedures on their own during segment 6. Students worked on the PowerPoint project, introduced at the beginning of class, during the portion represented by segment 8. Segments 2 and 9 indicated the opening and closing of Mrs. Major's class. The activities that comprised these segments were more focused on organizational issues rather than reflecting on or synthesizing what they learned. The blank first segment of the Profile indicates that this class had not begun on time.

Mr. Major told me that the laboratory I had observed during this second visit to her classroom was atypical of her classroom practice. When I asked if the lesson I observed was typical of her teaching she stated: "Oh no, normally I'm lecturing on how to read a pedigree or what are the different types of chromosomal mutations" (POI2, L216). This statement indicated that while the teacher-directed nature of her instruction was common, the use of technology and manipulatives was not a common occurrence in her classroom.

Mrs. Major discussed the ways in which she organized her class during her interviews. She stated: "With 90 minutes you kind of have to plan those lessons that go 30-30-30. 30 minutes of lecture, 30 minutes of application, 30 minutes of something else, or sometimes 45-45" (POI2, L317). This statement was mirrored in the M-SCOPS Profiles of Mrs. Major's observed classes. The first class I observed consisted of 30 minutes of lecture followed by 60 minutes of application. The second class I observed consisted of 30 minutes of project introduction, 30 minutes of a DNA verification laboratory, and 30 minutes of project work.

The segmentation pattern observed in Mrs. Patton's class differed significantly from those seen in the other two classes. Distinct breaks between activities refocused and redirected student learning. The first of Mrs. Patton's classes I observed had three main portions of instruction. The first of these portions (segment 2) covered past material, the next (segment 3) covered new material, and the third (segment 5) offered students an open ended activity where they could apply their understanding of the concepts presented. As the class progressed, the activities of the students increased in complexity, moving from a level of “4” (transform), to “6” (generate). The Profile of the class indicated clear opening and closing segments. During both of these segments, Mrs. Patton briefly focused her students on organizational issues as well as how their learning connected from previous, and to future, classes. These brief segments were not the only times when connections were made to prior and future classes. Mrs. Patton had alerted her students to connections throughout her classes and had scaffolded student learning to build on these connections.

Much like my first observation, the M-SCOPS Profile from my second visit to Mrs. Patton’s classroom indicated a similar class structure. During the first portion of this second class, (segments 2-4) Mrs. Patton involved students in solving a problem that reinforced the previously learned concept of two-dimensional projectile motion. The focus of the class quickly shifted as the students generated ideas about how to calculate where a ball bearing would hit the floor using their knowledge of the forces involved in projectile motion. Much like the first class I had observed, this class had clear opening and closing segments.

*Complexity*

When one takes a holistic look at the M-SCOPS Profiles of the three teachers’ classes, and compares them to one another, interesting observations can be made. Mrs. Lewis’ classes were the least complex overall. Students were generally focused on low levels of information and were passive, receiving information in the form of words and symbols and taking little initiative for their own learning. Mrs. Major’s classes utilized slightly more complex patterns of IS but her students were focused on low-levels of information reception and manipulation. Mrs. Major’s students were largely passive, receiving information, completing problems, and following procedures outlined by the teacher. Mrs. Patton’s classes, on the other hand, utilized both student-centered levels of

IS as well as higher levels of RS, demonstrating a focus on higher-order skills. Her lessons were geared toward engaging students in hands-on and minds-on activities. These activities encouraged students to utilize their content knowledge and think about their understanding of it.

## Classroom Learning Environment Survey Results

Each teacher was asked to hand out the Classroom Learning Environment Survey (CLES) (McRobbie & Tobin, 1997) (Appendix D) to all of their students at the end of the fall 2006 semester. This data, which was the only form of student report data, illuminated and validated the differences among the three teachers' practices that I had observed and analyzed using the M-SCOPS Profiles. The similarities between my observations and student responses to the CLES triangulated and strengthened my analysis of the teachers' observations.

The 25 questions on the CLES gauged student perceptions of five constructs: disruptions to learning, relevance, commitment to learning, participation, and autonomy. These constructs were reported on two scales: students' perceptions of their actual class, and what their ideal class would look like (see Chapter 3 for details). These scales are referred to as the actual and desired scale to save space. Frequency distributions comparing the responses of each teacher's students to each construct and scale are presented in one table and two figures. The tables present the students' response percentages and cumulative percentages. The first figure after each table visually represents the frequency distribution of student responses to each of the five Likert scale ratings. The second figure after each table visually represents the combined percentages of each teacher's students' responses from the two lowest rankings (almost never and seldom) and the two highest rankings (often and very often). These representations are presented and discussed in relation to my own observations and analysis of the M-SCOPS Profiles from each teacher's class.

### *Disruptions to Learning Construct*

Although the frequency distribution of student responses to the "disruptions to learning" construct did not show drastic differences among the three teachers, they generally supported what I had observed during my visits to each teacher's classroom. Responses from the students of all three teachers were very similar on the desired scale and only differed by 3-4% on each level (Table 7.4). Student responses on the actual scale differed slightly more among the three teachers and mirrored the levels of off-task behavior I observed in the classrooms (Table 7.5). Mrs. Major's students were distributed slightly more toward the "very often" side of the scale. Responses from Mrs. Patton's students were distributed slightly more toward the "almost never" side of the scale. Responses from Mrs. Lewis' students were in between those from the other two teachers (Figures 7.1, 7.2, 7.3 and 7.4)

CLES responses from Mrs. Major's students indicated that they perceived the highest level of disruption to learning. More of her students responded to the "often" and "very often" levels (24% cumulatively) and fewer to "almost never" and "seldom levels" (60% cumulatively) than either of the other two teachers. Mrs. Lewis and Mrs. Patton's classes responded slightly less frequently at levels of "often" and "very often" (10% cumulative and 6% cumulative, respectively) and slightly less often at levels of "almost never" and "seldom" (74% cumulative and 77% cumulative, respectively).

The amounts of off-task behavior I had observed in the three teachers' classes mirrored the patterns of student responses to the actual CLES scale. In Mrs. Patton's class, all students were on-task throughout class and there were no blank segments in either of the M-SCOPS Profiles. In Mrs. Lewis' class, all students had focused on the lectures while she was giving them, even though many off-topic comments had been made. When Mrs. Lewis stopped delivering her instruction and gave students time to work on homework problems, the amounts of off task behavior had increased. The portions of time most students were off-task are represented by the blank segments in the M-SCOPS Profile and encompassed 20% of the first class and 3% of the second. In Mrs. Major's class, students were frequently off-task during all portions of the class. Off-task class time, represented by the blank segments in the M-SCOPS Profiles, encompassed 19% of the first class and 5% of the second.

TABLE 7.4
Frequency Distribution of Student Responses to the Desired Scale of the Distractions to Learning Construct

| Response | *Mrs. Lewis* | | *Mrs. Major* | | *Mrs. Patton* | |
|---|---|---|---|---|---|---|
| | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* |
| Almost Never | 71 | 71 | 67 | 67 | 73 | 73 |
| Seldom | 13 | 84 | 14 | 81 | 15 | 88 |
| Sometimes | 7 | 91 | 7 | 88 | 8 | 96 |
| Often | 6 | 97 | 5 | 93 | 1 | 98 |
| Very Often | 3 | 100 | 7 | 100 | 2 | 100 |
| Total | 100 | | 100 | | 100 | |

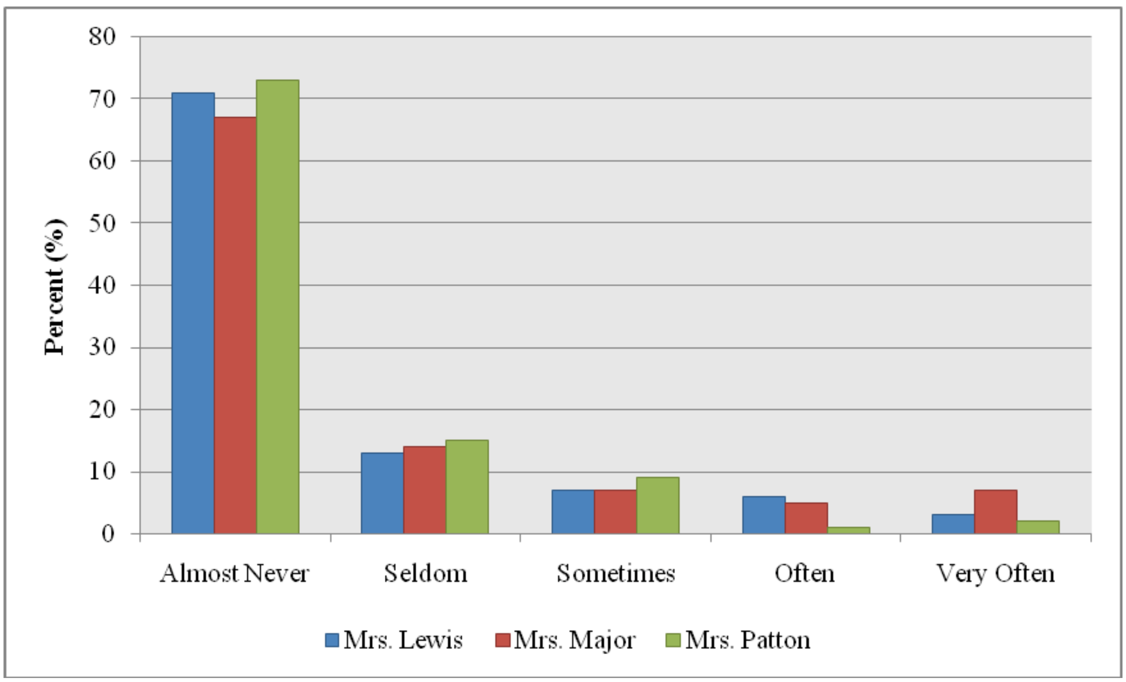


FIGURE 7.1 Frequency distribution of student responses to the desired scale of the disruptions to learning construct.

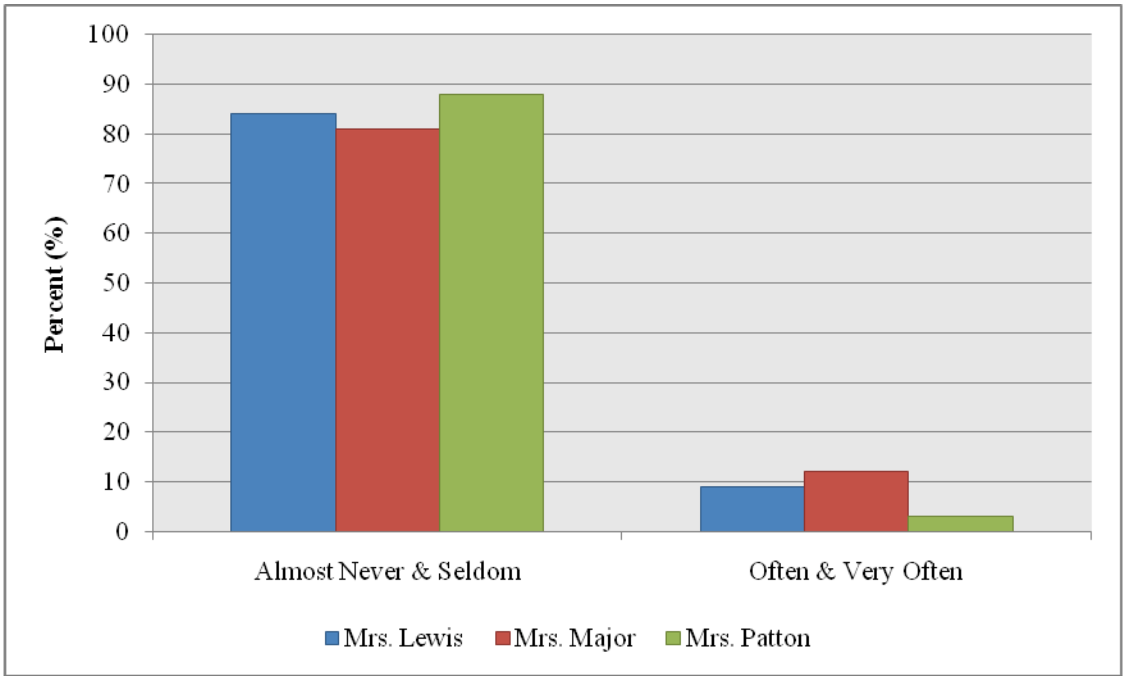


FIGURE 7.2 Frequency distribution for desired scale disruptions to learning construct, low and high responses combined.

TABLE 7.5
Frequency Distribution of Student Responses to the Actual Scale of the Disruptions to Learning Construct

| Response | *Mrs. Lewis* Percent (%) | *Mrs. Lewis* Cumulative Percent (%) | *Mrs. Major* Percent (%) | *Mrs. Major* Cumulative Percent (%) | *Mrs. Patton* Percent (%) | *Mrs. Patton* Cumulative Percent (%) |
|---|---|---|---|---|---|---|
| Almost Never | 50 | 50 | 42 | 42 | 46 | 46 |
| Seldom | 24 | 74 | 18 | 60 | 31 | 77 |
| Sometimes | 16 | 90 | 16 | 76 | 16 | 93 |
| Often | 5 | 95 | 9 | 85 | 5 | 99 |
| Very Often | 5 | 100 | 15 | 100 | 1 | 100 |
| Total | 100 | | 100 | | 100 | |

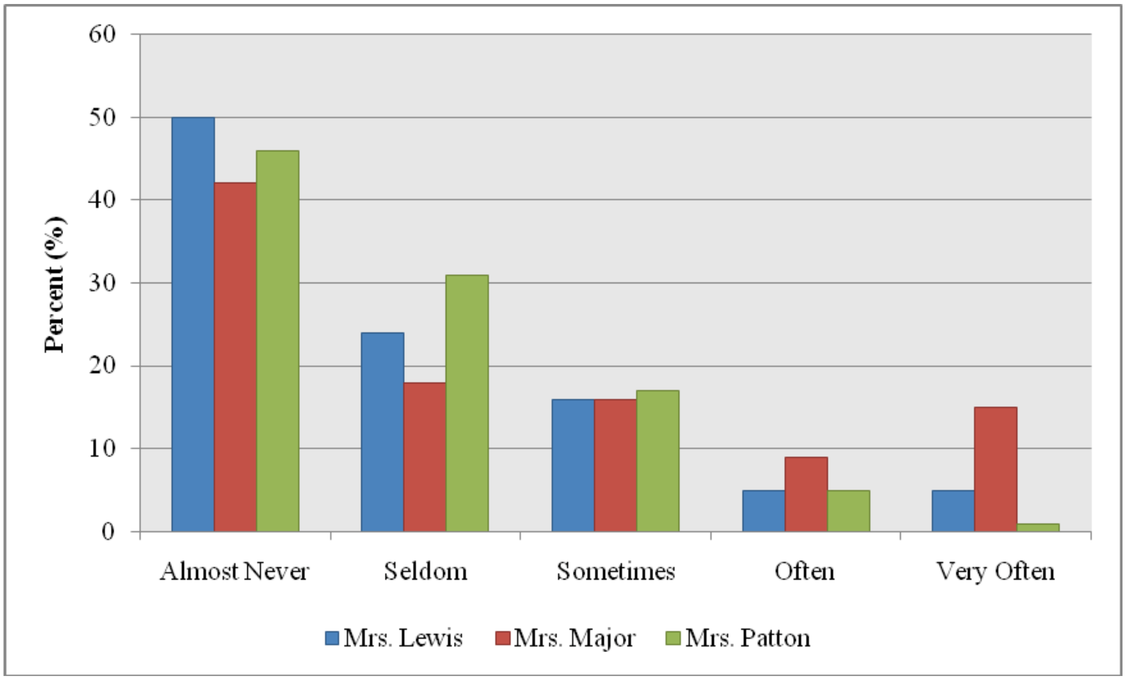


FIGURE 7.3 Frequency distribution for actual scale of disruptions to learning construct.

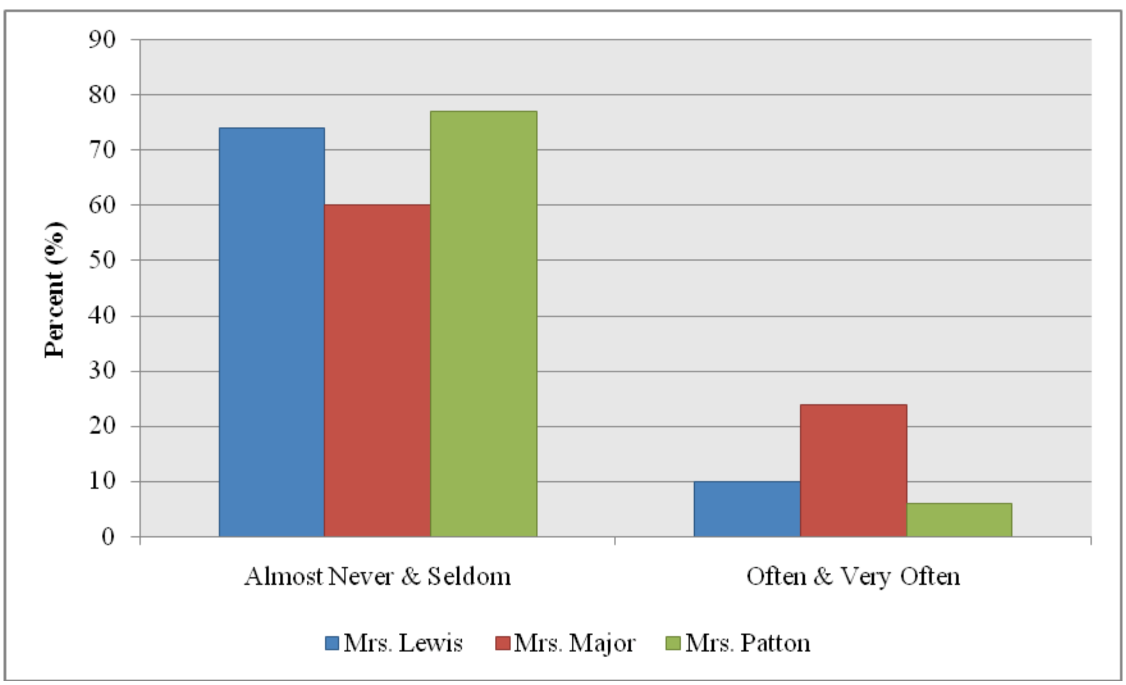


FIGURE 7.4 Frequency distribution for actual scale disruptions to learning construct low and high responses combined.

*Relevance*

The frequency distribution of student responses to the relevance construct also supported my observations of the teachers' classrooms (Tables 7.6 and 7.7). On the lower end of the actual Likert scale of the relevance construct, represented by responses of "almost never" and "seldom," Mrs. Major's students responded most frequently (30% cumulatively), Mrs. Lewis' students responded less frequently (18% cumulatively), and Mrs. Patton's students responded the least frequently (9% cumulatively). At the higher end of the Likert scale, represented by responses of "often" and "very often," Mrs. Major's students responded the least frequently (41% cumulatively), Mrs. Lewis' students responded slightly more frequently (53%cumulatively), and Mrs. Patton's students responded the most frequently ( 57% cumulatively) (Figures 7.7 and 7.8). Student responses to the desired scale were similarly distributed (Figures 7.5 and 7.6). I attributed these differences to the fact that Mrs. Major's classes were composed entirely of freshman level students while the other two teachers' classes were composed of junior and senior level students. Students in the higher grade levels would be able to make a more direct connection between the content they were learning and their future lives. Another possible reason responses from Mrs. Patton's students were distributed more on the "very often" side was the activities she utilized in her class. Her students had been engaged in collaborative activities that employed higher order skills more often than the other two teachers. These activities could help students to see more relevance to their future careers by offering them opportunities to apply their content knowledge to laboratory activities situated in the real world.

TABLE 7.6
Frequency Distribution of Student Responses to the Desired Scale of the Relevance Construct

| Response | *Mrs. Lewis* | | *Mrs. Major* | | *Mrs. Patton* | |
|---|---|---|---|---|---|---|
| | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* |
| Almost Never | 3 | 3 | 9 | 9 | 1 | 1 |
| Seldom | 7 | 10 | 10 | 18 | 4 | 6 |
| Sometimes | 17 | 26 | 21 | 39 | 19 | 25 |
| Often | 30 | 57 | 25 | 64 | 32 | 57 |
| Very Often | 43 | 100 | 36 | 100 | 43 | 100 |
| Total | 100 | | 100 | | 100 | |

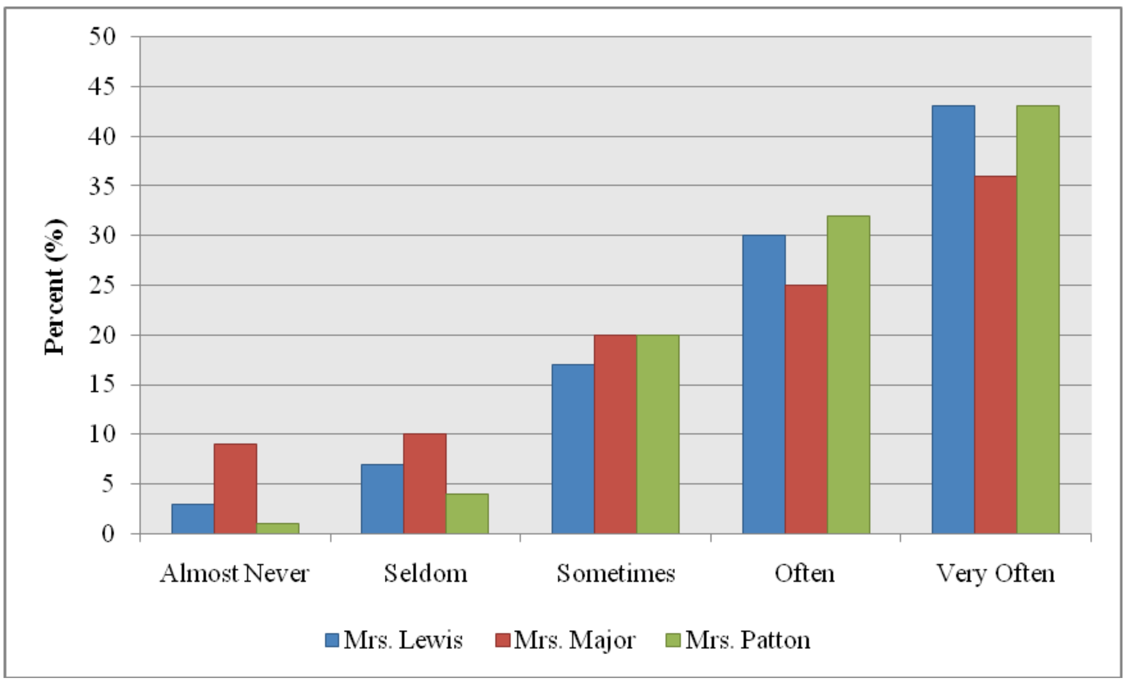


FIGURE 7.5 Frequency distribution for desired scale of relevance construct.

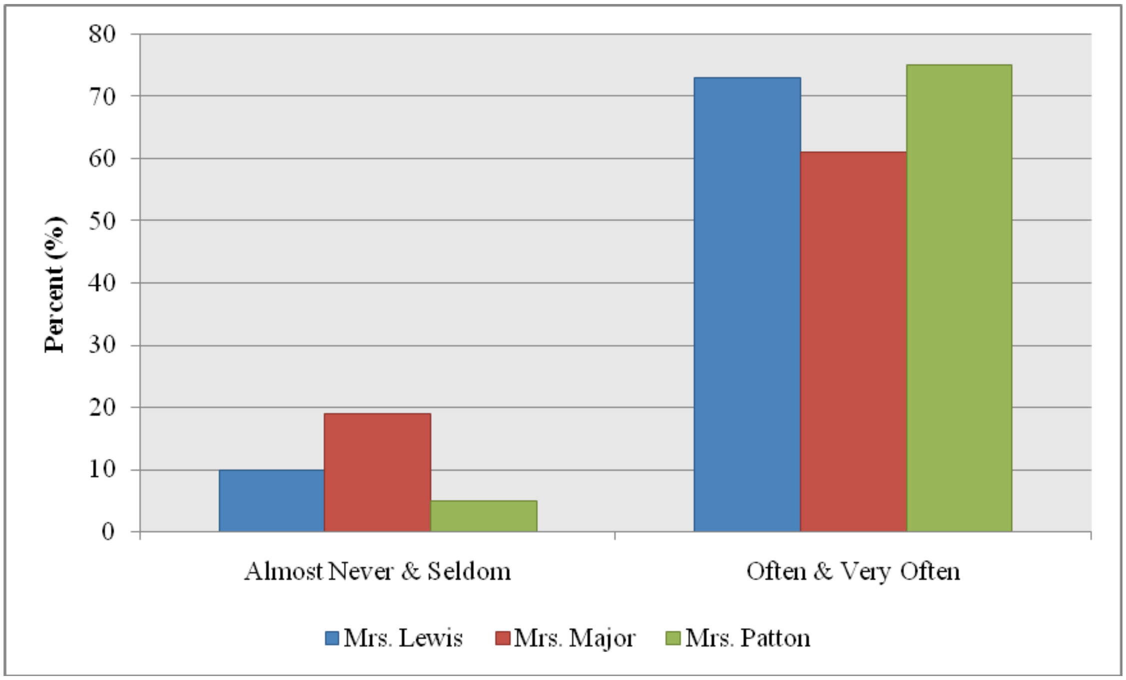


FIGURE 7.6 Frequency distribution for desired scale relevance construct, low and high responses combined.

TABLE 7.7
Frequency Distribution of Student Responses to the Actual Scale of the Relevance Construct

| Response | *Mrs. Lewis* | | *Mrs. Major* | | *Mrs. Patton* | |
|---|---|---|---|---|---|---|
| | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* |
| Almost Never | 5 | 5 | 12 | 12 | 1 | 1 |
| Seldom | 13 | 18 | 18 | 30 | 8 | 9 |
| Sometimes | 29 | 47 | 29 | 59 | 34 | 43 |
| Often | 30 | 77 | 24 | 83 | 33 | 76 |
| Very Often | 23 | 100 | 17 | 100 | 24 | 100 |
| Total | 100 | | 100 | | 100 | |

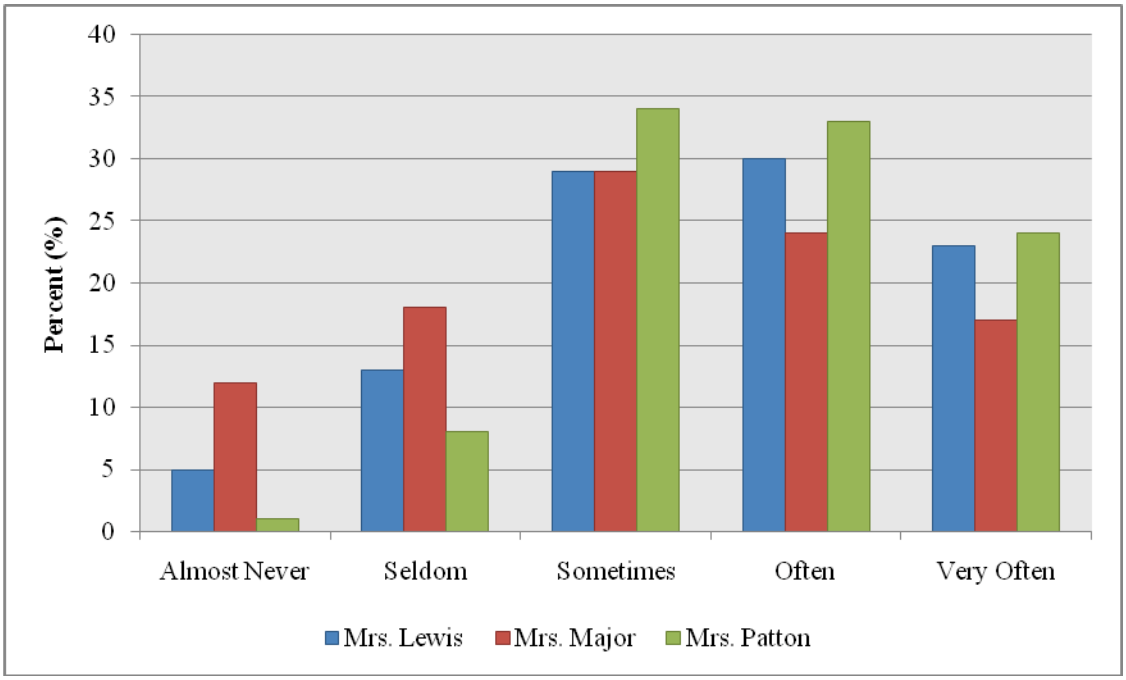


FIGURE 7.7 Frequency distribution for actual scale of relevance construct.

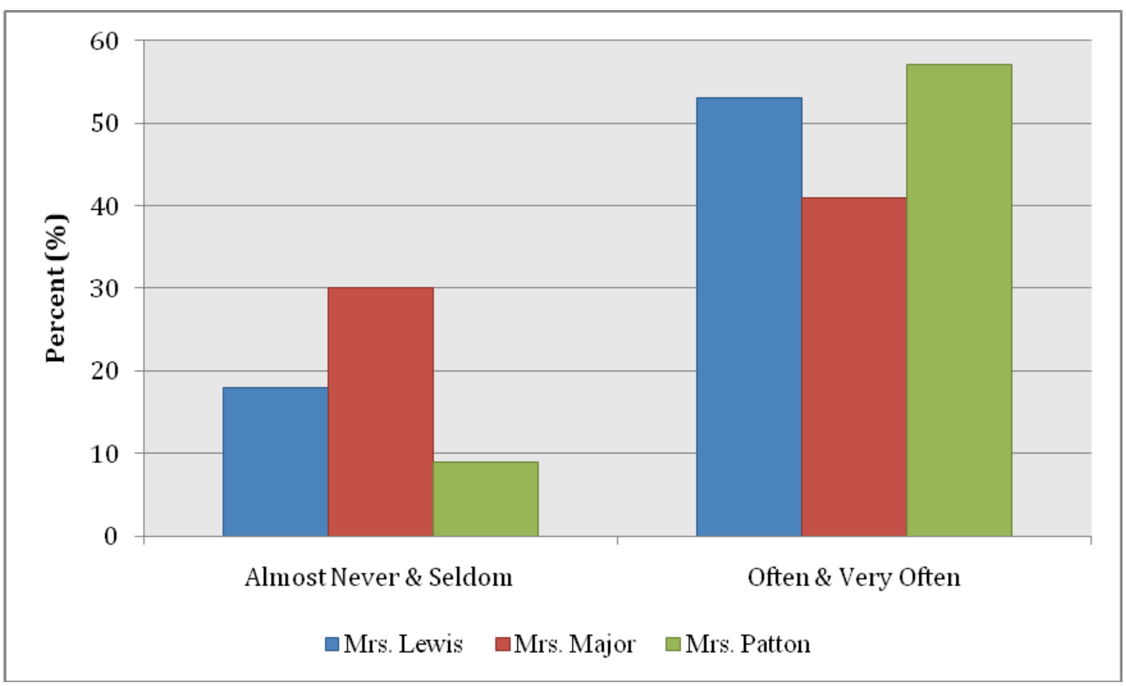


FIGURE 7.8 Frequency distribution for actual scale relevance construct, low and high responses combined.

*Commitment to Learning Construct*

The frequency distribution of student responses to the commitment to learning construct continued to support my classroom observations (Tables 7.8 and 7.9). The differences that could be seen aligned with the levels of engagement I had observed. Student responses from all three teachers were very similar on the desired scale (Figures 7.9 and 7.10), with Mrs. Patton's students responding more toward the "very often" side of the scale. Student responses on the actual scale (Figures 7.11 and 7.12) differed slightly more among the three teachers and mirrored the levels student engagement and higher-order skills I had observed in the classrooms. Mrs. Major's students showed the highest frequency of response to the lower two choices of the scale (19% cumulatively). Responses from Mrs. Patton's students were more toward the "very often" side of the scale. Responses from Mrs. Lewis' students were in between those of the other two teachers.

At the lower end of the Likert scale, represented by responses of "almost never" and "seldom," Mrs. Major's students responded most frequently (19% cumulatively), Mrs. Lewis' students responded slightly less frequently (15% cumulatively), and Mrs. Patton's students responded the least frequently (6% cumulatively). At the higher end of the Likert scale, represented by responses of "often" and "very often," Mrs. Major's students responded the least frequently (54% cumulatively), Mrs. Lewis' students responded slightly more frequently (63%cumulatively), and Mrs. Patton's students responded the most frequently (70% cumulatively).

I attribute the differences seen in the "commitment to learning" construct to two features. First of all, all of Mrs. Major's classes were composed entirely of freshman level students while the other two teachers' classes were composed of mostly junior and senior level students. One would expect students further along in their high school career, especially those enrolled in AP courses, to be more committed to subjects they saw as relevant to their future lives and careers. Secondly, during both visits I made to Mrs. Patton's class, students were involved in applying their content knowledge to laboratory activities that utilized the concepts they were learning about in the real world.

These activities would make their learning more relevant and would increase their commitment to learning, since they saw their learning as applicable to their lives.

TABLE 7.8
Frequency Distribution of Student Responses to the Desired Scale of the Commitment to Learning Construct

| | *Mrs. Lewis* | | *Mrs. Major* | | *Mrs. Patton* | |
|---|---|---|---|---|---|---|
| Response | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* |
| Almost Never | 4 | 4 | 5 | 5 | 0 | 0 |
| Seldom | 4 | 8 | 5 | 10 | 1 | 1 |
| Sometimes | 12 | 20 | 13 | 23 | 8 | 10 |
| Often | 23 | 42 | 21 | 45 | 26 | 35 |
| Very Often | 58 | 100 | 55 | 100 | 65 | 100 |
| Total | 100 | | 100 | | 100 | |

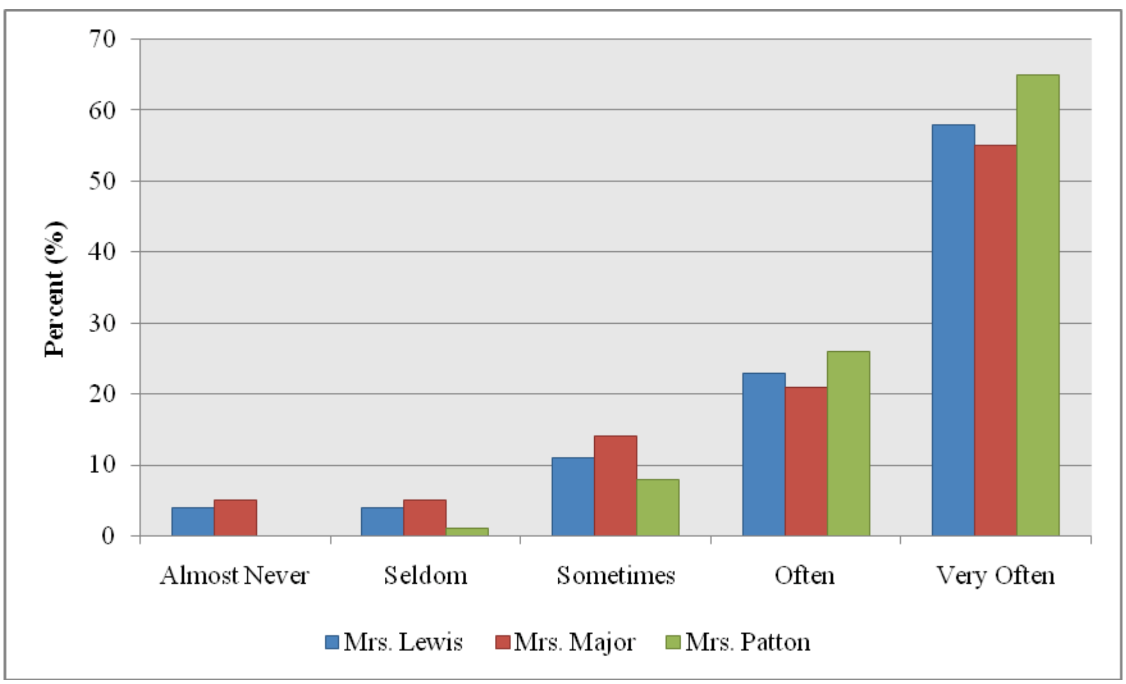


FIGURE 7.9 Frequency distribution for desired scale of commitment to learning construct.

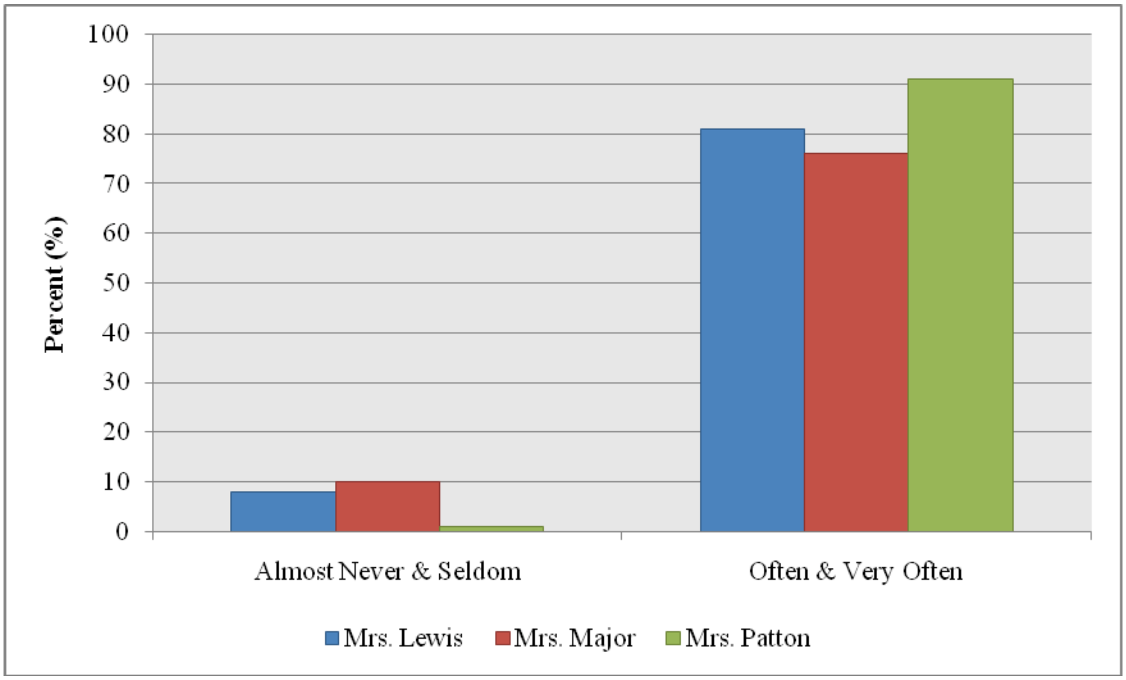


FIGURE 7.10 Frequency distribution for desired scale commitment to learning construct, low and high responses combined.

TABLE 7.9
Frequency Distribution of Student Responses to the Actual Scale of the Commitment to Learning Construct

| Response | *Mrs. Lewis* | | *Mrs. Major* | | *Mrs. Patton* | |
|---|---|---|---|---|---|---|
| | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* |
| Almost Never | 7 | 7 | 10 | 10 | 1 | 1 |
| Seldom | 8 | 15 | 9 | 19 | 5 | 5 |
| Sometimes | 22 | 38 | 26 | 44 | 25 | 30 |
| Often | 35 | 72 | 26 | 71 | 41 | 71 |
| Very Often | 28 | 100 | 29 | 100 | 29 | 100 |
| Total | 100 | | 100 | | 100 | |

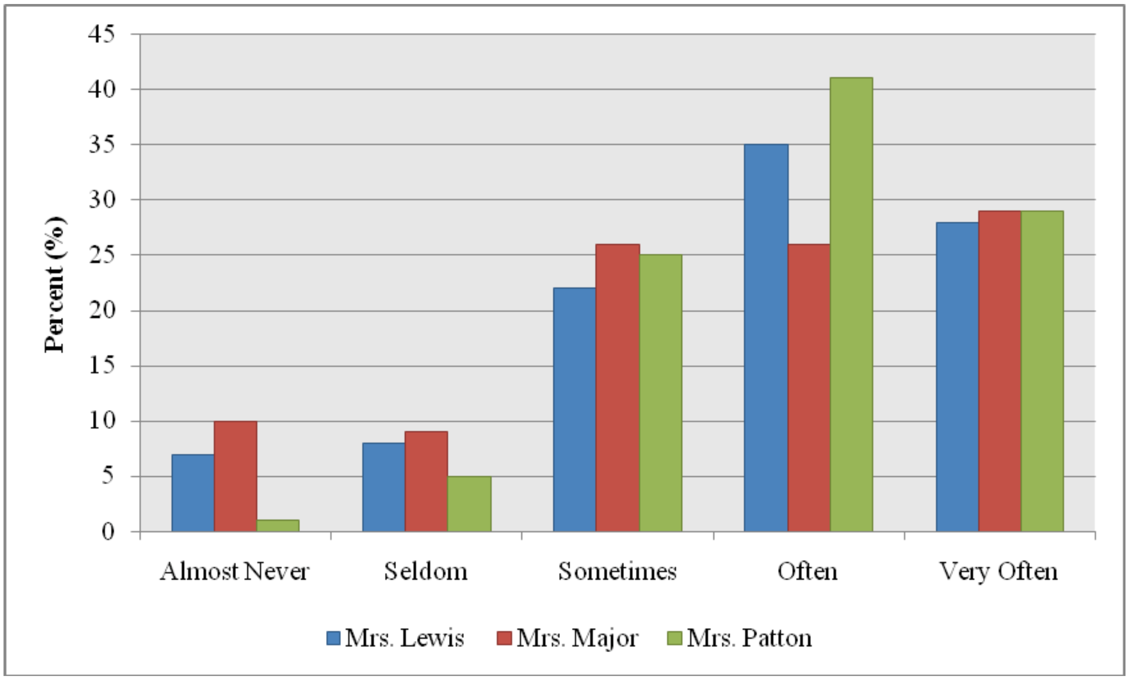


FIGURE 7.11 Frequency distribution for actual scale of commitment to learning construct.

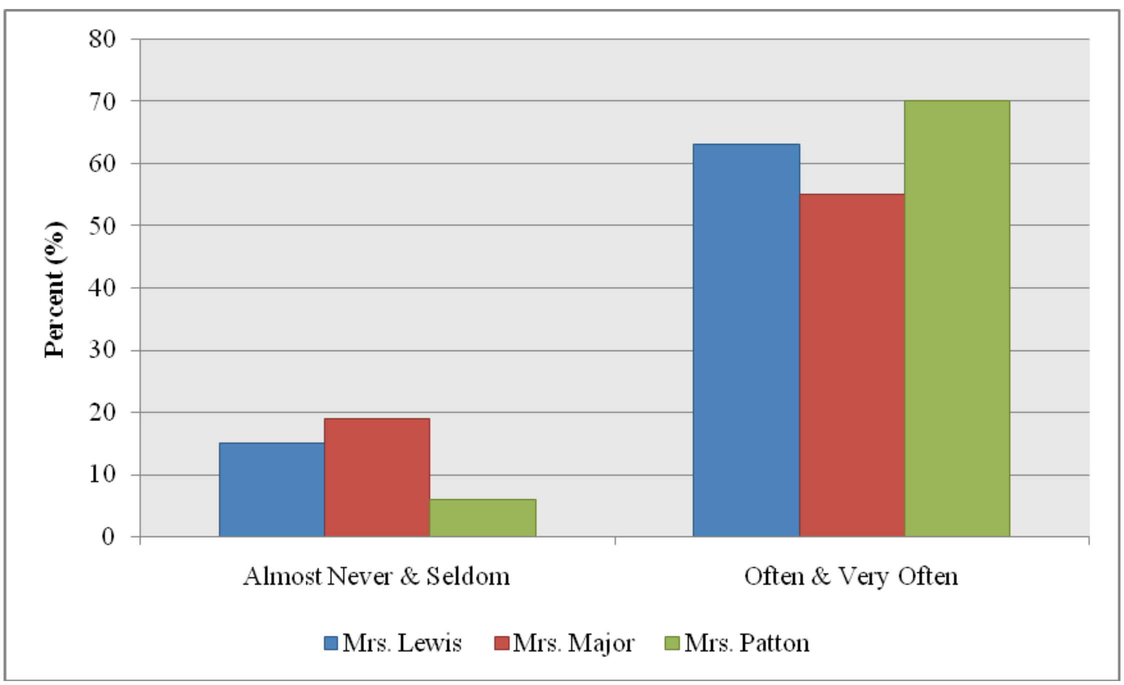


FIGURE 7.12 Frequency distribution for actual scale commitment to learning construct, low and high responses combined.

*Participation*

The frequency distributions of student responses to the questions involved in the participation construct demonstrated the same patterns I had seen in their responses to the other constructs' questions (Tables 7.10 and 7.11). Surprisingly, students responded with the greatest amount of variation to questions on the desired scale (Figures 7.13 and 7.14). At the lower end of the scale, represented by responses of "almost never" and "seldom," Mrs. Major's students responded most frequently (25% cumulatively), Mrs. Lewis' students responded slightly less frequently (16% cumulatively), and Mrs. Patton's students responded the least frequently (8% cumulatively). At the higher end of the Likert scale, represented by responses of "often" and "very often," Mrs. Major's students responded the least frequently (44% cumulatively), Mrs. Lewis' students responded slightly more frequently (56%cumulatively), and Mrs. Patton's students responded the most frequently (65% cumulatively).

Students' responses to the questions on the actual scale, although less varied, demonstrated the same general distribution (Figures 7.15 and 7.16). At the lower end of the scale, represented by responses of "almost never" and "seldom," Mrs. Major's students responded most frequently (35% cumulatively), Mrs. Lewis' students responded slightly less frequently (19% cumulatively), and Mrs. Patton's students responded the least frequently (12% cumulatively). At the higher end of the Likert scale, represented by responses of "often" and "very often," Mrs. Major's students responded the least frequently (31% cumulatively), Mrs. Lewis' students responded slightly more frequently (42% cumulatively), and Mrs. Patton's students responded the most frequently ( 54% cumulatively).

I attributed the difference in the distribution of students' responses in the "desired participation" construct to the levels of relevance they saw in the material they were learning as well as the thinking skills they were engaged in during instruction. Much like I described in my analysis of the commitment to learning construct, AP students would see more relevance in what they were learning as it applied to the college courses they anticipated taking in the future. In Mrs. Patton's classes, students were engaged in laboratory activities that connected their learning to the real world more directly than the activities I observed in the other two teacher's classrooms. The levels of thinking skills students were engaged in during the teachers' classes could have had an impact on their desire to participate. If students saw science learning as focused on facts and procedures they may have viewed their participation in learning simply as a demonstration of their knowledge and skills. Students in Mrs. Patton's class, on the other hand, engaged in collaborative activities on a regular basis and might see an increase in participation as more desirable.

Students' responses to the actual scale could be more directly attributed to the levels and frequency of participation I had observed in each teacher's instruction. Mrs. Patton's students had been engaged in higher-order skills through collaborative work during the majority of each class period (more than 45% of each observed class). During this time they shared their own ideas and listened to the ideas of other students. The responses of students in the other two classes were lower than those in Mrs. Patton's classes. Both Mrs. Major and Mrs. Lewis' classes were more teacher-directed and students spent much less time actively engaging in sharing or discussing their ideas. In Mrs. Major's class, although students were given time to do group work, the activities that focused their learning during these times required the application of rote knowledge and not a great deal of idea sharing. I attributed the greater frequency of students' responses at high levels of "often" and "very often" to the level of discussion allowed and the time given for problem solving. Even though the assignments in Mrs. Lewis' class focused on the same application level of rote knowledge, student CLES responses demonstrated a higher level of "commitment to learning" and "relevance" on the other constructs. I believe these students were more motivated to work together and ask each other for help in solving problems during class.

TABLE 7.10
Frequency Distribution of Student Responses to the Desired Scale of the Participation Construct

| Response | *Mrs. Lewis* | | *Mrs. Major* | | *Mrs. Patton* | |
|---|---|---|---|---|---|---|
| | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* |
| Almost Never | 5 | 5 | 14 | 14 | 1 | 1 |
| Seldom | 11 | 16 | 11 | 25 | 7 | 8 |
| Sometimes | 28 | 43 | 31 | 56 | 27 | 35 |
| Often | 26 | 70 | 21 | 77 | 33 | 68 |
| Very Often | 30 | 100 | 23 | 100 | 32 | 100 |
| Total | 100 | | 100 | | 100 | |

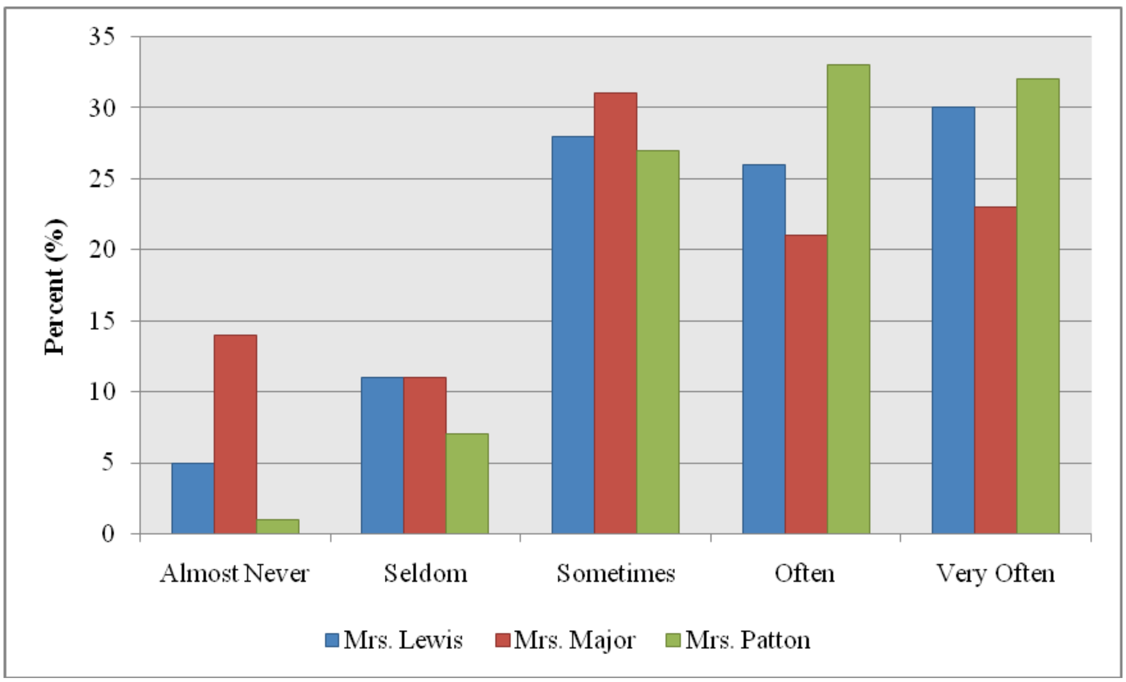


FIGURE 7.13 Frequency distribution for desired scale of participation construct.

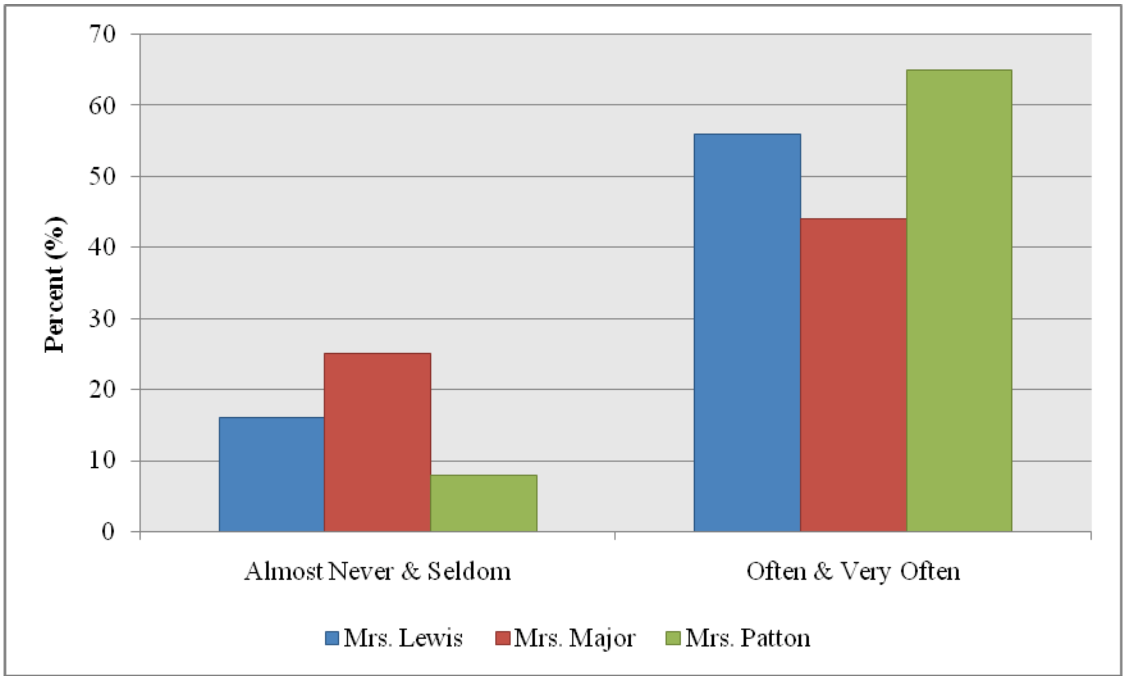


FIGURE 7.14 Frequency distribution for desired scale participation construct low and high responses combined.

TABLE 7.11
Frequency Distribution of Student Responses to the Actual Scale of the Participation Construct

| Response | *Mrs. Lewis* | | *Mrs. Major* | | *Mrs. Patton* | |
|---|---|---|---|---|---|---|
| | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* |
| Almost Never | 6 | 6 | 20 | 20 | 2 | 2 |
| Seldom | 13 | 19 | 15 | 35 | 10 | 12 |
| Sometimes | 38 | 57 | 35 | 69 | 34 | 46 |
| Often | 25 | 83 | 21 | 90 | 36 | 82 |
| Very Often | 17 | 100 | 10 | 100 | 18 | 100 |
| Total | 100 | | 100 | | 100 | |

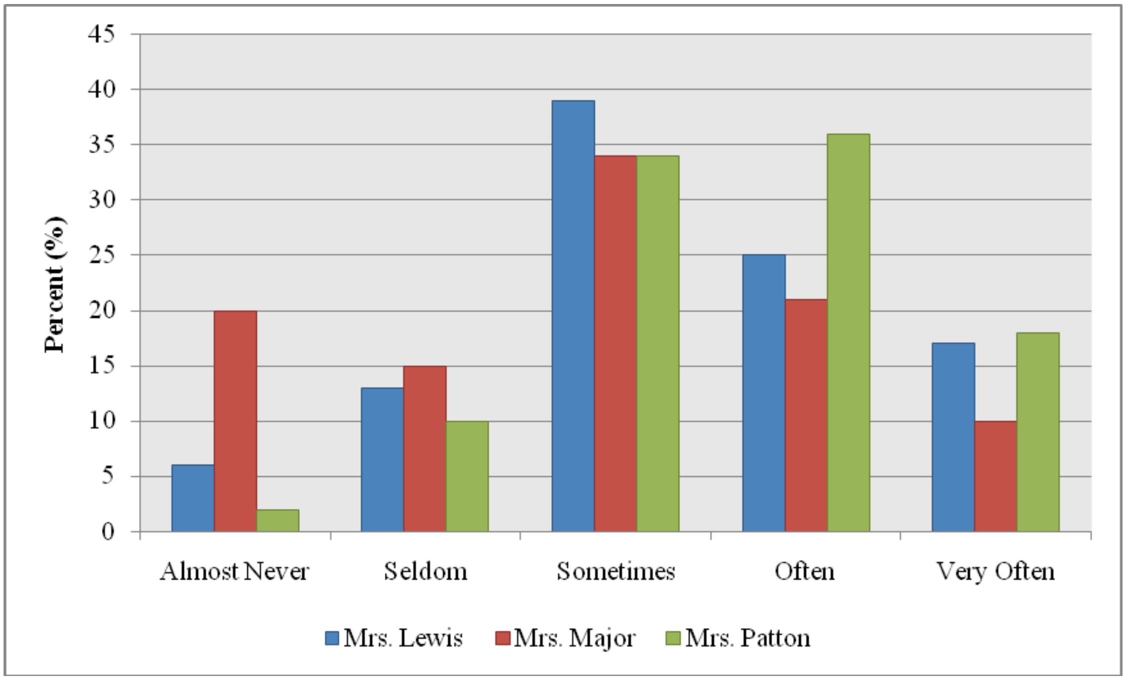


FIGURE 7.15 Frequency distribution for actual scale of participation construct.

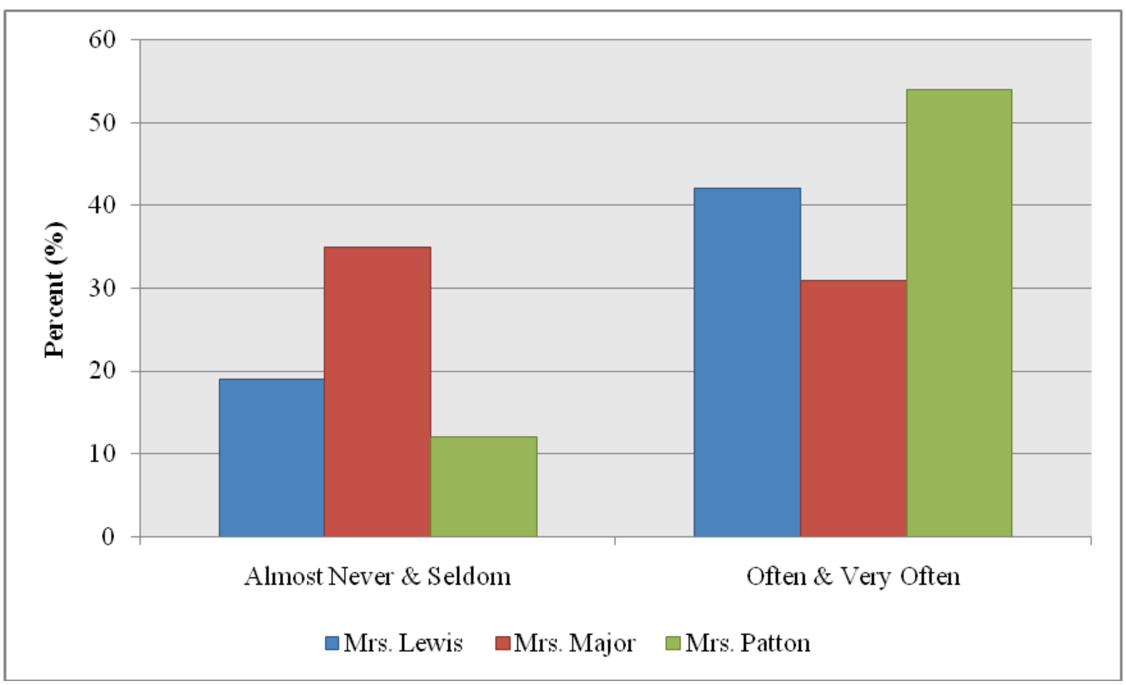


FIGURE 7.16 Frequency distribution for actual scale participation construct low and high responses combined.

*Autonomy*

The frequency distributions of student responses to the questions involved in the autonomy construct demonstrated the only patterns that differed from those I saw in their responses to the other constructs' questions (Tables 7.12 and 7.13). The frequency count percentages of Mrs. Lewis' students' responses were in between those of the other teachers for all other constructs. Their responses for the autonomy construct were clearly skewed toward the lower "almost never" side on both the desired and actual scales. The students' responses from both of the other teachers were clearly skewed toward the higher "very often" side of the scale.

At the lower end of the desired scale, represented by responses of "almost never" and "seldom," Mrs. Lewis' students responded most frequently (33% cumulatively), Mrs. Major's students responded slightly less frequently (18% cumulatively). Mrs. Patton's students responded the least frequently (11% cumulatively). At the higher end of the Likert scale, represented by responses of "often" and "very often," Mrs. Lewis' students responded the least frequently (40% cumulatively), Mrs. Major's students responded slightly more frequently (61%cumulatively), and Mrs. Patton's students responded the most frequently (70% cumulatively) (Figures 7.17 and 7.18).

At the lower end of the actual scale represented by responses of "almost never" and "seldom" Mrs. Lewis' students responded most frequently (50% cumulatively), Mrs. Major's students responded slightly less frequently (24% cumulatively), and Mrs. Patton's students responded the least frequently (18% cumulatively). At the higher end of the Likert scale, represented by responses of "often" and "very often," Mrs. Lewis' students responded the least frequently (30% cumulatively), Mrs. Major's students responded slightly more frequently (54% cumulatively), and Mrs. Patton's students responded the most frequently (58% cumulatively) (Figures 7.19 and 7.20).

The construct of autonomy focuses on the amount of choice students feel they have in deciding the direction of their learning. Autonomy is similar to the construct of initiative measured by the instructional scaffolding levels depicted by the M-SCOPS Profiles. Based on this connection, student responses made sense. Mrs. Lewis' M-

SCOPS Profiles revealed the highest level of teacher-direction and the lowest level of student choice. Much like the student CLES responses indicate, Mrs. Patton's class had the highest level of student initiative and the lowest level of teacher-direction. Levels of both student initiative and teacher direction in Mrs. Major's classes were in-between those of the other teachers. The patterns seen in both instruments reinforced one another, cemented the validity of the survey data, and illuminated my understanding of it.

TABLE 7.12
Frequency Distribution of Student Responses to the Desired Scale of the Autonomy Construct

| | *Mrs. Lewis* | | *Mrs. Major* | | *Mrs. Patton* | |
|---|---|---|---|---|---|---|
| Response | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* | *Percent (%)* | *Cumulative Percent (%)* |
| Almost Never | 29 | 29 | 10 | 10 | 3 | 3 |
| Seldom | 14 | 43 | 8 | 18 | 8 | 11 |
| Sometimes | 17 | 60 | 21 | 39 | 20 | 31 |
| Often | 18 | 78 | 21 | 60 | 25 | 55 |
| Very Often | 22 | 100 | 40 | 100 | 45 | 100 |
| Total | 100 | | 100 | | 100 | |

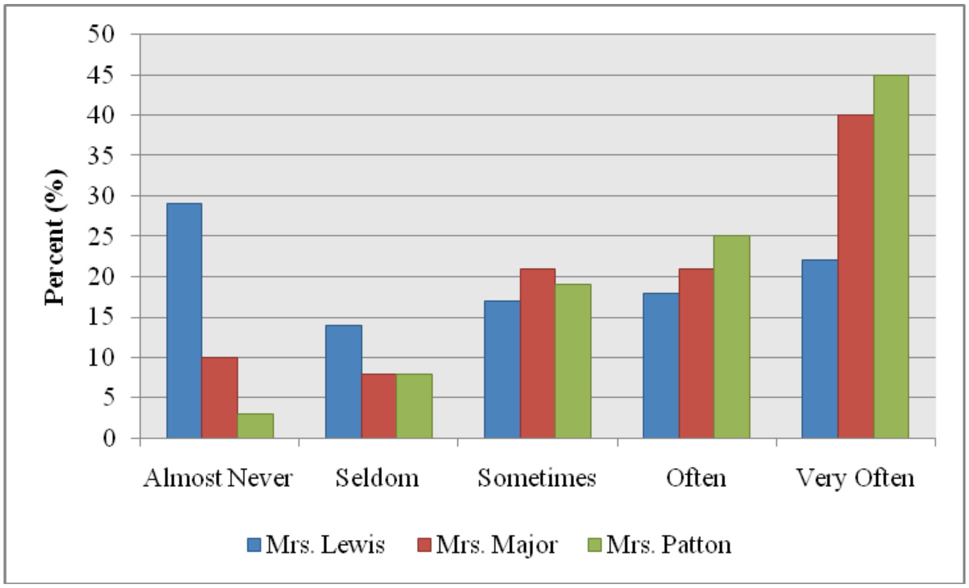


FIGURE 7.17 Frequency distribution for desired scale autonomy construct low and high responses combined.

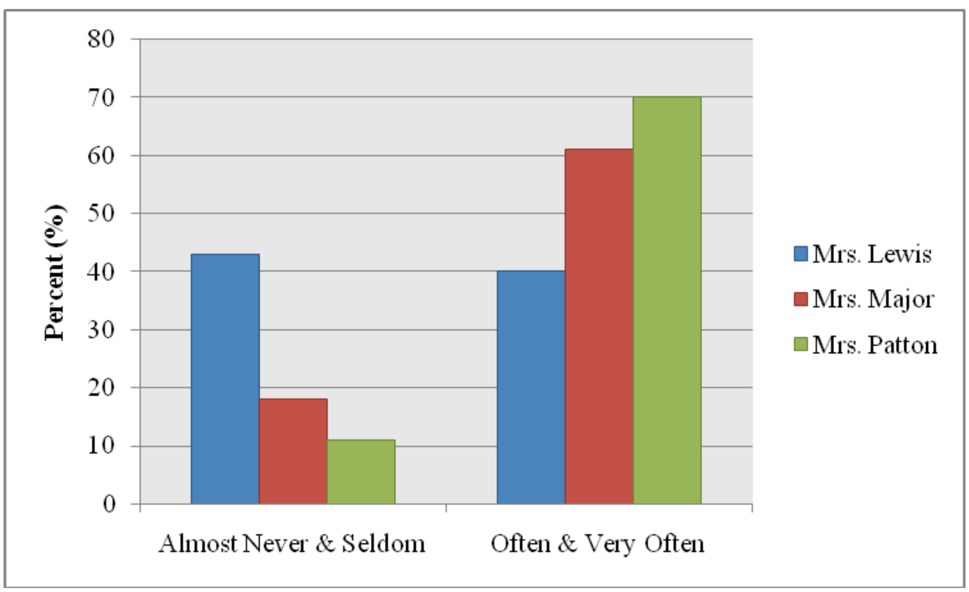


FIGURE 7.18 Frequency distribution for desired scale of autonomy construct.

TABLE 7.13
Frequency Distribution of Student Responses to the Actual Scale of the Autonomy Construct

| Response | *Mrs. Lewis* Percent (%) | *Mrs. Lewis* Cumulative Percent (%) | *Mrs. Major* Percent (%) | *Mrs. Major* Cumulative Percent (%) | *Mrs. Patton* Percent (%) | *Mrs. Patton* Cumulative Percent (%) |
|---|---|---|---|---|---|---|
| Almost Never | 29 | 29 | 13 | 13 | 6 | 6 |
| Seldom | 21 | 50 | 11 | 24 | 12 | 18 |
| Sometimes | 20 | 70 | 22 | 46 | 24 | 42 |
| Often | 19 | 89 | 21 | 67 | 26 | 68 |
| Very Often | 11 | 100 | 33 | 100 | 32 | 100 |
| Total | 100 | | 100 | | 100 | |

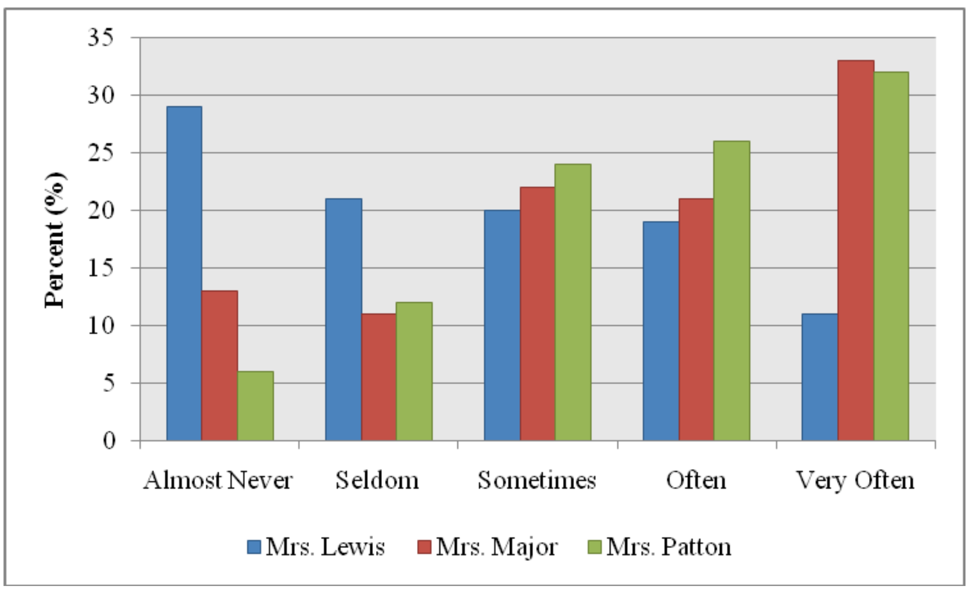


FIGURE 7.19 Frequency distribution for actual scale of autonomy construct.

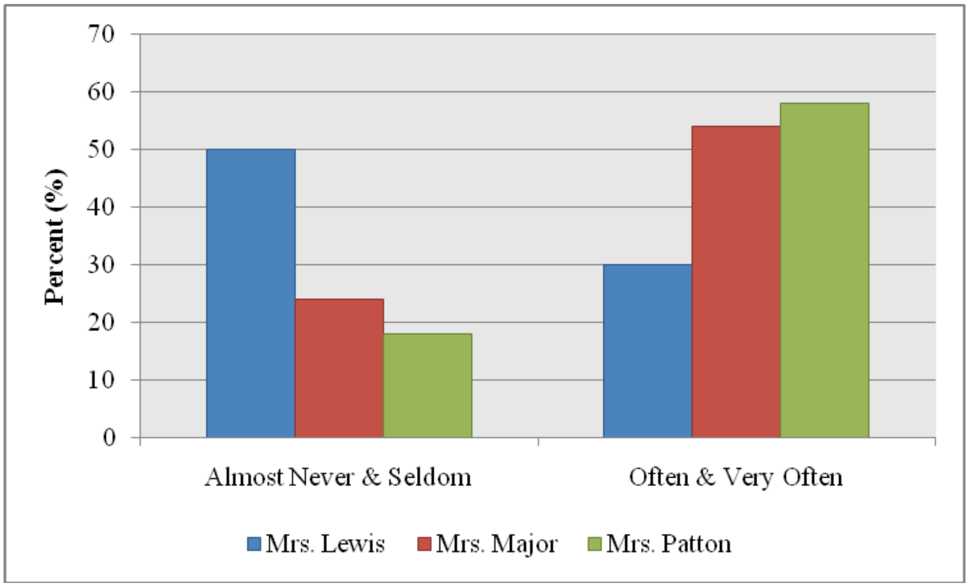


FIGURE 7.20 Frequency distribution for actual scale autonomy construct, low and high responses combined.

## Personal Practice Theories

The previous sections demonstrated the differences and similarities that were seen in the observations of the three teachers' classroom practices, and backed up these comparisons with data from student responses to the CLES. The post-observation discussions I had with each teacher provided a valuable window into their reasoning and the beliefs that drove the classroom structure and practices I observed. This portion of the cross-case analysis describes and compares five major themes related to the practices of the three teachers and the personal practice theories that guided them. An overview of these themes can be found in Table 7.14.

TABLE 7.14
Comparison of Personal Practice Theory Themes

| *Teacher* | *Focus of thinking/reflection* | *Technology Use* | *Lesson Planning* | *Assessment Practices* | *Group Work* |
|---|---|---|---|---|---|
| Mrs. Major | On providing information and experience | Limited use | By topic and what worked in past | Quizzes, tests, homework, practice activities (Teacher assessment) | Frequently used, focused on concept reinforcement through low level tasks |
| Mrs. Lewis | On students ability and willingness | Instructional Use | By chapter | Homework and exams (Student accountability and teacher assessment) | Seldom use, focused on concept reinforcement through low level tasks |
| Mrs. Patton | On students understanding and thinking processes | Heavy use, both instructional and IT | By student understanding | Homework, quizzes, tests, lab write-ups, questions and observations (Planning instruction, teacher assessment, students' metacognitive development) | Frequent use, focused on higher order tasks encouraging students to apply their knowledge in new ways |

*Technology Use*

The technology use I observed and discussed with each of the three teachers differed. Mrs. Major and Mrs. Lewis' use of technology was limited while Mrs. Patton's technology use was complex and highly integrated into her instructional practices. The use of technology in each teacher's class mirrored what I learned about their teaching and planning through my analysis of their classroom observations, including their M-SCOPS Profiles and students' responses to the CLES.

**Mrs. Lewis**

Mrs. Lewis' main use of technology was for the delivery of instruction. In this manner she used PowerPoint Presentations to deliver lectures and she invested in an InterWrite™ School Pad, which allowed her to advance and write on the presentations from anywhere in the room. The ability to write on the presentations through the InterWrite™ School Pad allowed Mrs. Lewis to work problems on the screen, so she utilized it in the same way she previously used the overhead projector. Mrs. Lewis also integrated technology into her instruction in the form of CBL2 probes and Excel spreadsheets during the laboratories that comprised the immersion experience of her IF. She also encouraged her students to use both the Internet and PowerPoint to research and present the projects that were part of her IF and focused on exploring real world examples of solubility.

While these examples of technology use enhanced Mrs. Lewis' instruction, they did little to alter the complexity of her students' thinking about chemistry content. When listening to lectures driven by PowerPoint and completing confirmatory labs using CBL2 probes and Excel, students were still largely focused on lower-order skills of attend, replicate, and rearrange (see Table 3.1 for descriptions). Technology also enhanced, but was not an integral part of, the completion of the students' research projects. Mrs. Lewis stated that most of her students conducted their research in the library, at home, or out in the community. These uses of technology did not mirror the way scientists use technology in their research. Even though her students were encouraged to think about concepts in different ways, the aspects on which they were focused did not mirror the core conceptions of scientific inquiry that were the basis of the IT focus during the ITS Center's PDE.

**Mrs. Major**

Of the three teachers, Mrs. Major had discussed the use of technology the least and what little use I had observed demonstrated a negligible departure from her regular methods of teaching. The only technology I had observed Mrs. Major use during my observations was during the implementation of her IF from the ITS Center's PDE. She did not mention using technology outside of this activity. The types of technology Mrs. Major integrated into her IF included the "sun safety video" and use of the laptop computers so her students could access the Internet to gather information. The students also used the laptops to create a PowerPoint presentation utilizing the information they found. Much like Mrs. Lewis' use of technology, these uses encouraged her students to think in lower-level patterns of attend, replicate, and rearrange. These were not examples of IT since they did not encourage engagement in the core conceptions of scientific inquiry. Unlike Mrs. Lewis, who gave her students more opportunity for discussion and freedom in the choice of topics for their research projects, Mrs. Major's students remained focused on highly structured, teacher-directed activities throughout. It seemed as though Mrs. Major utilized technology as a novelty to motivate her student to work on their assignments, but did not change her methods of teaching as she incorporated it.

**Mrs. Patton**

In contrast to the other two teachers, technology was highly integrated in Mrs. Patton's instruction, her IF, and, where appropriate, was well aligned with the ITS Center's definition of IT. Her use of technology had enabled her to do things that would not have been possible without it and had enhanced her students' learning experiences significantly. During my visits to her classroom, I observed her students using computers, force probes, and velocity gates. In addition to the technology used by her students, I saw Mrs. Patton use instructional technology to work problems with her students (see Figure 6.1). As I analyzed Mrs. Patton's interviews and performance artifacts I noted additional uses of technology including internet homework and the digital microscopes which formed the basis of her IF.

The examples of technology used in Mrs. Patton's classroom differed from the examples I had seen the other teachers use. Instead of presenting information in a different way or motivating students, Mrs. Patton used technology in ways that enabled her students to engage with course content in more complex ways and regulate their own learning. Mrs. Patton used force and velocity probes to help her students apply their knowledge of physics to more abstract problems. The instructional technology she utilized allowed her to demonstrate things to her students in multiple ways. These demonstrations would have been difficult without these technologies (see Figure 6.1). The internet homework, as discussed in Chapter 6, offered her students opportunities for immediate feedback and helped them collaborate while focusing on broad concepts, rather than procedures. The microscopes used in her IF helped students engage in many of the core conceptions of scientific inquiry used by scientists.

**Summary**

Although all three teachers used technology, the extent and manner in which they integrated it into their classroom practice was very different. Mrs. Major used technology to add novelty and motivate her students. She did not deviate significantly from her everyday classroom practice when she introduced the technologies. Mrs. Lewis used technology to enhance her lecture delivery, to provide her students with hands on experiences that reinforced concepts, and to research real world examples of solubility. These uses of technology departed from Mrs. Lewis' every day teaching practices in many ways. The research project allowed her students a great deal more initiative and freedom than was commonplace in her instruction. Mrs. Patton's technology use deviated from that of the other two teachers as it was highly integrated and significantly enhanced her instructional practice. It offered her students opportunities to collaborate, develop a deeper conceptual understanding of course materials, and monitor their own learning.

I found it interesting to note that, for the most part, the teachers' use of technology mirrored the levels of instructional scaffolding used in their classroom practice. Mrs. Lewis and Mrs. Major's instruction had focused more on the memorization and application of information and procedures (i.e., lower-level skills). The use of technology mirrored this focus in the surface level way in which it was applied. Mrs. Patton's instruction focused her students on higher order skills of transforming, connecting, and generating and her use of technology mirrored this focus and enhanced her instruction.

*Lesson Planning*

Each of the teachers was asked how they planned their curriculum. Mrs. Lewis and Mrs. Major both stated that they planned their curriculum around topics or chapters while Mrs. Patton discussed planning her curriculum around her students' understanding of concepts and inquiry units that focused on broad concepts. These methods demonstrated an alignment with the other aspects of each teacher's personal theories and practices.

**Mrs. Lewis**

Discussions with Mrs. Lewis revealed that she planned her curriculum according to the chapters in the book. She stated:

> I have them for 18 weeks. I taught 1 through 5 in my book and then I skipped to chapter 13. I'm sorry because it just went better in the order sequence. I thought it was better to go to electrons and atoms and all the SPDF and electron configuration after studying the atoms. So I go from 5 to 13 and teach 13, 14, 15, and 16 and then I drop back to 6 and pick that up, so, just made more sense in the order of things so, I hit about a chapter a week. (POI1, L367)

As was discussed in the school context section, Mrs. Lewis had complete control over her curriculum; no one told her what she had to teach or when. Her decision to teach in direct alignment with the book indicated that she viewed her subject in much the same way as the book presented it. Her discussion of the switch she made from overhead projector to PowerPoint delivery of lectures indicated that Mrs. Lewis had rigidly followed this curriculum for a number of years. One statement she made that revealed this was:

> I think since I've gotten this (pointing to the InterWrite™ school pad) and the projector and have access to doing PowerPoints now, more goes into it right now. I think once everything's kind of, because it gets set. I think that whole process of getting more technology integrated into my curriculum is more time consuming. (POI1, L577)

Her statement that "more goes into it right now" indicated that she did not have to do as much planning while using filed overheads. Her comment that it would be less time consuming once "it gets set" indicated that she planned to save and reuse the same lectures in the future.

**Mrs. Major**

Mrs. Major's school controlled her curriculum much more than the schools of the other two teachers. Curriculum guides and benchmark exams had been instated to help monitor and control the pace of students' learning. Mrs. Major discussed the impact these curriculum guides had on her lesson planning during her first interview:

> They brought these curriculum guides and we were covering the items already but now they want us in a specific place at a specific time and it's just hard to say 'okay I'm going to teach this in 6 weeks and make sure the kids understand it'. How do you know if we have to do some re-teaching or something? So they don't account for allowing re-teaching time in there. So it can get kind of hectic making sure you're on someone else's schedule and coming in and saying 'we're going to test you on this day' if you haven't covered it all yet. (POI1, L312)

Mrs. Major's statement that she was "covering the items already" that were included in the curriculum guides made it appear that she planned her curriculum around concepts similar to those in the guides. Later in her interview, when asked about planning, Mrs. Major stated:

> I do my planning, we do our planning on what we call TaskStream™ and we'll look in our curriculum guide and it tells us what they want covered, in a specific amount of time or this particular six weeks and I break it. I sort of scan through and see what those topics include and I break it apart and just plan it out like that. (POI1, L464)

This statement revealed that, even though the curriculum guides dictated what Mrs. Major had to cover each six weeks, she could decided how she would "break the information down for students" and the manner in which it was conveyed. The above statement, along with others, revealed that Mrs. Major was required to post her lesson plans along with the topics they covered to a website called TaskStream.

During her second interview, Mrs. Major discussed how she planned for specific lessons. One of the main ways she talked about planning was in the division of her 90-minute block periods. She stated: "With 90 minutes you kind of have to plan those lessons that go 30-30-30, 30 minutes of lecture 30 minutes of application 30 minutes of something else, or sometimes 45-45" (POI2, L316). I found her use of the terms "lecture," "application" and "something else" interesting. These terms reinforced the lecture-practice cycle that I had observed during my first visit to her classroom and reinforced the other planning methods she discussed.

In addition to the manner in which she partitioned her classes, Mrs. Major also discussed how she chose what to do during the different portions. She stated:

> I take a look at what I've done previously and what's worked and what hasn't and I try and notice which things get the kids stuck so I sort of change up things to make up for problems that I notice. I always show them okay this is what kids will normally do that I've noticed before and some of them will still make those mistakes but I try and stop it you know with some of the others so yeah just sort of what's worked before and what hasn't worked I sort of toss that out and find new things. (POI1, L639)

This statement revealed that the main focus of Mrs. Major's planning efforts was on the "chunks" of information she covered and the activities she offered her students to reinforce the "chunks." Mrs. Major chose both the "chunks" and the activities she used in her lessons in a "what worked best" manner. The above statement indicated that she would think about how her students had responded to a specific activity and modify it or switch to a new activity to "make up for problems." Furthermore, Mrs. Major appeared to do her best to stop students from making mistakes by telling them the mistakes prior students had made. This practice was in line with the highly structured and teacher-directed manner in which she taught her class.

**Mrs. Patton**

Unlike the other two teachers, Mrs. Patton used student understanding, in addition to her understanding of her subject matter, to guide her progression through her curriculum. These two aspects of understanding were complex and intertwined in not just her planning but in the entire way she conducted her class. Her thorough understanding of her subject matter and the repertoire of pedagogical approaches she utilized to help her students develop a conceptual understanding of the content, allowed her to plan a rough progression of lessons based around "big ideas" in physics. This rough progression allowed Mrs. Patton to adapt her day-to-day instruction on the spot based on her students' understanding. She would "test" their understanding through traditional assessments and also through more ill-structured inquiry laboratories that gauged students' application and transfer of knowledge in a different way.

When asked about how she planned her lessons, Mrs. Patton responded:

> Ohhhh, my husband just laughs at me because, of course, I spend so much time at home planning. He doesn't understand why I don't have it all figured out yet. (laughing) Why do I have to spend so much time planning didn't I do the same thing last year? (laughing) My pre-AP is such that I can do it without thinking. I can get up there and make up problems and blah, blah, blah. When I first started it was the script. This is what I'm going to do, I circled the problems I was going to work from the book and blah, blah, blah. I've taught it enough years now that I can do it on my feet and I never understood that when I started because Ms. Alexander who's been here, she's taught AP chemistry for 20 years and she doesn't play games. She just goes the way the kids can do it but I could never understand that. I was like how in the world? But the more years I teach the more you know which way to go with this. (POI1, L503)

Mrs. Patton's use of phrases such as "I can do it on my feet" and "goes the way the kids can do it" indicated that she was assessing and reflecting on student understanding, as well as making instructional decisions, in action. Mrs. Patton also demonstrated that she understood that this expertise took years to form and that it enabled her to teach in the way she did by reflecting on her students' understanding in action.

Mrs. Patton's focus on student understanding to plan her day-to-day lesson progression could also be seen in the quote used in to discuss responsibility for learning. She stated:

> This class, as I said before, I'm taking 9 hours and not thinking real clearly, I threw a problem in that was way up here and the difficulty level was the first thing they saw and I had to spend the two days fixing it because I didn't start off with the easy problem. (POI1, L471)

Mrs. Patton spending "two days fixing it" showed that she used her students' understanding to plan her lessons. It also indicated that, unlike the other two teachers who planned for all of their classes at once, Mrs. Patton was comfortable with her classes being at different places in their curriculum on the same day.

**Summary**

Comparing the three teachers' methods of lesson planning furthered my understanding of their personal theories and practices in multiple ways. I came to understand that Mrs. Lewis and Mrs. Major focused their instruction on lower-levels concepts and skills that involved attending to, replicating, and rearranging rote knowledge and procedures. Even though the focus of their instruction was similar, their planning practices differed. Mrs. Lewis' discussions demonstrated that she followed a fairly set curriculum; while Mrs. Major stated that she changed, or thought about changing, the activities she used while the topics she covered remained relatively unchanged.

Unlike the other two teachers, Mrs. Patton embraced the challenges of teaching for conceptual understanding. She offered her students a variety of teacher and student directed activities that scaffolded and engaged students learning in appropriate but challenging ways. Her methods of constantly assessing student understanding and her adaptive methods of planning based on the understanding she saw, were necessary for the successful implementation of the complex thinking skills, assessment methods, and instructional procedures that formed the basis of her teaching practice.

*Assessment Practices*

Much like I found in my analysis of the other themes, each teacher's discussions of the types of assessment they utilized, and the role those assessments played in their classrooms, illuminated connections among their ideas and provided insight into their teaching practices. Mrs. Lewis discussed two modes of assessment: homework and exams. Homework was completed daily and chapter tests were given at the end of each week. Mrs. Major discussed homework and tests in a similar way, but she also discussed using quizzes in a slightly more formative role to gauge her students understanding on a more regular basis. Mrs. Patton's discussion of assessment mirrored the constant assessment of student understanding I had observed. She mentioned a variety of assessment methods, all well integrated in her teaching practice, which helped her gauge her students' understanding. These assessments also helped her students learn to assess their own understanding. Each teacher's assessment methods are discussed in more depth below.

**Mrs. Lewis**

The types of assessments Mrs. Lewis used and the role they played in her teaching practice were closely tied to her method of lesson delivery and planning. Mrs. Lewis followed her book, "hitting about a chapter a week" and her assessments reflected this focus. As I had seen during my classroom observations, Mrs. Lewis assigned homework each class and provided her students with in-class time to work on it and ask questions. Exams were cumulative, often at the end of a chapter or unit and focused on students' recall and application of knowledge.

During my second visit to her classroom, I had observed students taking papers out of an organizer against a wall and working on them. When I asked what they were working on, Mrs. Lewis told me they were working on test corrections and stated:

> They get back half credit or something like that. I don't do that with all of my classes but I do that with the AP bunch because they really wanted to know what they did wrong, that bunch and they're really kind of duking it out for the top 10 slots in this class. They're com- they will actually try to learn from, they are more self-motivated. They learn from their mistakes, and they learn "I won't do that again." So, I don't do that with every

> class, but I do let them do it because they, did you see them feverishly doing corrections? (POI2, L173)

This quote revealed that Mrs. Lewis did not normally view the exams she administered to the students as learning experiences. They were only a way to assess their knowledge, hold them accountable for learning, and give them a grade. She only allowed her AP students to correct their tests because they "wanted to know what they did wrong" and would "learn from their mistakes." Her statement indicated that she did not believe this was the case with her other students.

**Mrs. Major**

Mrs. Major's use of assessment mirrored Mrs. Lewis' in many ways. Since she planned her lessons around concepts in a "lecture-application-something else" pattern, the focus of her assessments followed this pattern as well. She stated: "The way I have it set up, I teach them a concept one day and then quiz them on it the next day to make sure they understand and then we pull them all together before we test." This statement revealed that Mrs. Major assessed her students learning more often than Mrs. Lewis, but that she also administered cumulative tests focused on student recall and application of information. Unlike Mrs. Lewis, Mrs. Major tried to schedule what little time she could for "re-teaching" when students' grades indicated they did not adequately understand the information she presented the first time. Mrs. Major also assessed her students understanding through the practice activities she offered them each class. Discussions about missing assignments and grades indicated that she collected and graded many of these to hold her students accountable for practicing.

Both Mrs. Lewis and Mrs. Major used assessments to motivate students, provide practice, and inform them of their students' understanding. While homework and practice activities were intended to encourage students to engage with the material, other forms of assessment, such as quizzes and tests, were not crafted to be learning experiences. Aside from the time students spent practicing and applying information, assessments did not appear to extend students' understanding.

**Mrs. Patton**

Much like the discussions of observations and the other themes demonstrated, Mrs. Patton's use of assessment was complex and highly integrated into every facet of her teaching. Throughout our discussions she demonstrated that that she was assessing what her students understood through various assignments; including homework, quizzes, tests, and lab write ups. She also discussed using less traditional methods of assessment, such as questions asked by her students and the looks of understanding she saw in their eyes. She was constantly thinking, testing, and reflecting on what her students understood and what they were able to do. She used the knowledge she gained through all of these methods to shape her instruction.

The various forms of assessment Mrs. Patton described made her students thinking visible to her, but also to the students themselves. Her constant reflection on understanding and adaptation of her teaching helped her students develop an awareness of their own thinking, or metacognition. In addition to the processes of reflection and adaptation Mrs. Patton used, she also embedded explicit opportunities for students to explore their own understanding in her assessment methods. One of the most obvious methods of explicit self-assessment brings us back to the example of the internet homework. The multiple chances students were given to submit a correct answer gave them the opportunity to assess their work as they completed it.

**Summary**

The assessment practices of Mrs. Lewis and Mrs. Major were quite similar, while those of Mrs. Patton differed dramatically. Mrs. Patton used her assessment to shape her instruction and help her students learn to plan and regulate their own learning. Mrs. Lewis and Mrs. Major used assessment to evaluate student learning. The assessment practices of all three teachers mirrored the focus of their instruction and the goals for their teaching. Mrs. Lewis and Mrs. Major taught in teacher-directed ways and focused their instruction and assessment on lower-level skill. Mrs. Patton utilized multiple varied and integrated methods of assessment that made thinking and understanding visible to herself and her students. Her use of assessment mirrored the higher-level skill focus and more student directed nature of her classroom.

*Task Structure*

The level of structure and variety of the activities each teacher incorporated into their classroom practice differed. Mrs. Lewis and Mrs. Major gave their students well-defined tasks such as listening to lectures, completing homework problems from the book, and completing teacher-designed worksheets. These activities focused on lower-level skills and students' work was focused on arriving at a single correct answer. These activities offered little explicit opportunity for students to plan or begin to regulate their own learning.

The degree of structure involved in the activities Mrs. Patton offered her students varied. She provided her students with opportunities to practice lower-level skills where they applied their knowledge to problems that had a single correct answer, but also provided them with opportunities to wrestle with, and collaborate on solving, more ill-structured problems. The majority of her class time was dedicated to these more abstract problems and lower-level skill mastery was a precursor to these activities. This format and range maximized the ways in which students' knowledge was applied to the subject matter. By providing students with a range of learning opportunities, she could assess their knowledge from multiple angles, focusing on conceptual understanding and thereby gaining a more thorough picture of her students understanding. In addition, the well-structured tasks Mrs. Patton offered her students gave them multiple opportunities to assess and reflect on their own understanding, helping them learn more than course content alone.

*Group Use*

The three teachers in this study also appeared to place different value on group work. They utilized group work in their teaching practice in different ways and at different frequencies. Discussions with Mrs. Lewis indicated that she placed little value on providing opportunities for students to work in groups and did not include many labs or other opportunities for group work. Discussions with Mrs. Major indicated she placed more value on group work and provided many opportunities for students to work together both on labs and seat-work activities. Even though they valued and used group work in different ways and with different levels of frequency, the opportunities for group work Mrs. Lewis and Mrs. Major discussed were similar and mirrored the low-level skill focus and high level of structure of their overall teaching practices. Mrs. Patton, on the other hand, provided students with multiple different opportunities to work in groups. She seemed to understand the value of sharing ideas and the necessity for collaborative tasks to be complex enough for students to contribute and share ideas in order to find an acceptable solution. I provide specific examples from both Mrs. Major and Mrs. Patton's practice to illustrate the differences between the two teachers.

**Mrs. Major**

Mrs. Major's students worked in groups during both of my visits to her classroom. During my first visit, she used what she called "cooperative learning." She described how she structured these groups in the following passage:

> I incorporated the cooperative learning. I've done cooperative learning before when I taught all Biology which was easier for Biology but I didn't do a lot of it before because it just makes for, sometimes it just, it doesn't work correctly. They use it as a way to copy and I don't want them to copy. I want them to help each other out and learn the information. So, I designed it this time where the team leader was someone who was very strong in science already. I scored them a couple of tests before I chose the team leaders and I um gave the support group. I didn't want to stick them with really, really low level, low level kids. I let them choose who they wanted to work with and it ended up perfectly because I told them they had to have heterogeneous groups and have both male and female there and they sort of, they picked people who even normally they wouldn't work with I think and they've been working out well. I told them I don't want you to let them cheat I want you to teach them. I said it's your responsibility that they know how to do this on tests and they're like "man really?" so they've been helping them out quite a bit. (POI1, L869)

Mrs. Major's discussion of her use of cooperative learning portrayed the structure of the groups as smaller versions of her teaching style. She appointed one student as the "team leader" and this student was responsible for leading and teaching the other students in the group.

During my second observation of Mrs. Major's class I observed students working in groups as they completed the procedures of the DNA lab. Prior to allowing students to begin working on the DNA lab, Mrs. Major demonstrated the correct laboratory procedure at the front of the room. Students did not need to think about the procedures they were following, they just needed to complete them. Each group I watched closely seemed to have a "leader." The leaders completed most of the technical laboratory procedures and ordered the other students in the group to measure things and bring the various necessary solutions to the workbench.

**Mrs. Patton**

Mrs. Patton's students worked in groups during both of my visits to her classroom, but her use of groups was much different from Mrs. Major's. Group work in Mrs. Patton's class was centered on more abstract, ill-structured tasks that required students to share their diverse viewpoints and collaborate to come to an acceptable solution.

During my first visit to Mrs. Patton's class, students worked in groups to design a laboratory in which they calculated the 2D forces acting on a block of wood on an incline plane. Students were provided with the materials they could use to design their lab and the overall goal of the lab. Together, they came up with a design that would allow them to determine and calculate all of the forces. During the time they were given to work on this problem at their lab benches, students shared and critiqued each other's ideas. Coming up with an acceptable design appeared to be a challenging and complex task that required a high level of collaboration to complete.

The laboratory I observed during my second visit to Mrs. Patton's classroom was much like the first. Students were challenged to calculate where on the floor a ball bearing would hit after being rolled down an incline plane. They were given this goal and the materials they could use to make their calculations. Much like the lab I observed during my first visit, finding a workable way to use the equipment and determine where the ball bearing would land required a high degree of discussion and collaboration among group members.

The method by which Mrs. Patton chose the leaders for groups in her class contrasted with the method Mrs. Major employed in her class. Mrs. Patton randomly chose group leaders and members from a pile of index cards with students' names on them. The students chosen as leaders then randomly chose 3 or 4 cards for group members. The roles of the leaders were not as definitive as they were in Mrs. Major's class. The leaders in Mrs. Patton's class were contributing group members, with the same goals and responsibilities as the other students, once the groups were set.

In addition to the group work opportunities I observed during the laboratories in Mrs. Patton's classes, she also integrated an opportunity for discussion during the more teacher-directed portion of her class. As students were working along with Mrs. Patton to solve a problem, she asked a question that seemed difficult for them to answer. Instead of offering the answer directly, Mrs. Patton directed students to discuss their thoughts and work on the problems' solutions with their neighbors. This small but important use of group work enhanced their learning experience by providing them the chance to probe, test, and justify their understanding with a peer.

**Summary**

Much like the other themes I have discussed, the use of groups in the three teachers' classes reflected the focus and methods of their instruction. Mrs. Lewis' lack of group use belied the college-lecture style of her instruction. Mrs. Major's instruction was highly teacher-directed and focused on lower-level skills of attending, replicating, and rearranging. The manner in which she constructed the groups mirrored her methods of instruction as she assigned "strong" students to be group leaders so they could teach the other students what they needed to know. During the DNA lab, students automatically adopted roles of "leader" and "follower" as their attention was focused on low-level procedures and getting the job done. Mrs. Patton's instruction was more student-directed and the tasks she offered her students were complex, focusing them on the use of higher-level skills. The amount of choice and initiative students had, paired with the high-level of thinking involved, gave her students opportunities to share ideas and work collaboratively.

*Focus of Thinking/Reflection*

One of the less obvious themes that emerged from my discussions with the three teachers was the focal point of the comments they made when thinking about or reflecting on their classroom practice. I make a differentiation between thinking about and reflection here since Mrs. Lewis and Mrs. Major did not appear to have critically reflected on their thoughts about teaching. Mrs. Patton, on the other hand, appeared to critically reflect on many ideas during our interviews as she demonstrated the complexity of thought that went into her instructional decisions. She tested and grappled with new ideas before accepting them into her teaching repertoire.

**Mrs. Lewis**

My discussions with Mrs. Lewis indicated that she did not critically reflect on how she taught, but rather focused the majority of her thoughts on the ability and willingness of her students to learn the material presented. She indicated that she planned her curriculum around the chapters of the book in cycles of lecture and problem solving sessions. Her reuse of overheads and desire to reuse PowerPoint presentations in future semesters indicated that she felt the pace and sequence of topics was set. She indicated she felt that the time constraints on her curriculum forced her to pace herself and cover "about a chapter a week" (POI1, L375) regardless of students understanding, further reinforcing her lack of critical reflection.

The majority of Mrs. Lewis' comments about her curriculum focused on the ability and willingness of her students to learn the material she presented. This was demonstrated by her comments about student ability and apathy, indicating that she felt it was the students' responsibility to listen, learn, practice, understand, and keep up with the pace she was forced by curricular time constraints to keep. One comment she made that illustrated this point was:

> Pre AP and AP is a little bit different [than regular chemistry] because it's a different type of student because they're a little bit more motivated and a little bit more, you know, they're trying to have this really high GPA

> and the whole thing where some of the regular are just trying to get through. So we have this four chapter, I call it epic adventure through chemistry, where you know if you didn't learn how to name compounds in chapter 6 or it escaped you or you don't know the chemical quantities then we start on this, so they're starting on this. This is a struggle. (POI1, L346)

Her statement: "Pre-AP and AP is a little bit different because it's a different type of student because they're a little bit more motivated." indicated that she felt external motivation was key for students to spend their time paying attention, learning, and practicing the information she presented. Those students with little aspiration to attend college did not seem to care as much about grades, and frequently lacked the motivation to put in the time needed to understand many of the more basic chemistry concepts. This led to more complex concepts being "a struggle" for them, as they did not adequately learn the basics.

**Mrs. Major**

My discussions with Mrs. Major indicated that she focused the majority of her thoughts about her teaching on the ways in which she "broke down the information" (POI1, L466), on the activities she used, and on assessing student factual recall. Many of the comments she made indicated that she was focused on students "gain in information," rather than understanding of concepts. The modifications she made to her practice were to reinforce concepts in different ways or streamline the learning process so students were alerted to, or avoided, the mistakes that could be made. Her discussion of planning demonstrated these ideas to me. She stated:

> I take a look at what I've done previously and what's worked and what hasn't and I try and notice which things get the kids stuck so I sort of change up things to make up for problems that I notice. I always show them, okay this is what kids will normally do that I've noticed before and some of them will still make those mistakes but I try and stop it you know with some of the others so yeah just sort of what's worked before and what hasn't worked I sort of toss that out and find new things. (POI1, L639)

Mrs. Major's comment that she showed her students common mistakes and tried to stop them from making them indicated her focus on streamlining and mistake-proofing her curriculum. Another comment she made about student understanding further demonstrated Mrs. Major's focus:

> With some of them I could spend two weeks on some of the stuff and some of them still wouldn't get it or wouldn't know it after we taught it, tested it, and re-taught it again they still, you know, wouldn't score any higher but, I just think some days they need a little bit more time on some topics. (POI1, L569)

Her comment that even after a topic was "taught, tested, and re-taught" indicated that Mrs. Major was not focusing on deep understanding but on low-level factual recall. Her use of the word re-teaching indicated that she was not drastically altering her practices, or probing students' understanding in different ways, but simply going over the information a second time to enhance student retention.

**Mrs. Patton**

Unlike the other two teachers, Mrs. Patton appeared to assess and critically reflect on her students' learning and understanding constantly. She demonstrated that she saw a direct correlation between the way in which she presented and explained concepts to her students, the level of difficulty of the activities she offered them, and opportunities for them to think and learn about their learning. The questions she asked, the problems she focused on, and the activities she employed were used to probe her students understanding and her methods were constantly modified to address the developments she observed. The following statement is one example of how these ideas were revealed in our discussions:

> This class, as I said before, I'm taking 9 hours and not thinking real clearly, I threw a problem in that was way up here and the difficulty level was the first thing they saw and I had to spend the two days fixing it because I didn't start off with the easy problem. It was the eyes, they shut down they quit thinking on me and I was just like oh boy did I screw up. Well my other period on the next day, I did it the right order and they got it and of course the test averages indicated that as well. (POI1, L471)

The comments that she "had to spend two days fixing it" after she saw in her students eyes that they "shut down" indicated to me that Mrs. Lewis was assessing her students understanding using multiple feedback mechanisms and modifying her instruction moment-to-moment and day-by-day in response to what she observed.

**Summary**

Comparing the way each teacher thought and/or reflected helped me to better understand their personal theories and practices. Mrs. Lewis focused the majority of her thoughts on the ability and willingness of her students, which was well in line with the teacher-directed manner in which she taught. Mrs. Major focused her thoughts on ways in which opportunities for students to make mistakes or get lost could be reduced or eliminated. This focus aligned well with her teacher-directed practice and discussions of trying to plan around one small concept per day. Mrs. Patton was the only one of the three teachers who critically reflected on her practice and the focus of her reflection was on student understanding.

Performance Artifacts

Each of the teachers constructed a series of three performance artifacts during the ITS Center's PDE: IFs, SYI Summary Papers, and ARPs. Teachers were asked to follow a set of guidelines for each paper. These guidelines asked them to incorporate ideas from the educational research they had been asked to read over the course of the ITS Center's PDE. This requirement offered a lens into each teacher's understanding of the concepts discussed in the readings. The ways in which each teacher applied their ideas to these papers demonstrated strong connections to their personal theories and practices.

The purpose of this section is to compare the three teachers' interpretations and applications of ideas from the educational research to the projects they were required to complete for the ITS Center's PDE. Specifically, I compared three aspects of their IFs: overall design, interpretation of the Etheredge and Rudnitsky (2003) inquiry frame, and technology integration. I focused on two aspects of their SYI Summary Papers: preparation of students for the IF experience and reflection, and their ARPs on the basis of how practical and meaningful their plans appeared. A summary of these aspects can be found in Table 7.15. I begin this section with a brief description of what the guidelines asked teachers to focus on and then continue by describing the aspects of each assignment mentioned above.

*Instructional Frameworks*

The main focus of the ITS Center's PDE and the IF assignment was to encourage teachers to incorporate current scientific research, inquiry-based teaching techniques, and information technology (IT) into their science classrooms. Teachers were asked to develop an inquiry cycle (Etheredge & Rudnitsky, 2003) that they would implement in their classrooms the following school year (School Year I). The afternoon sessions of the first summer experience were dedicated to helping teachers understand the educational research, apply their understanding of the research they learned about through their work with the scientists, and crafting their inquiry cycles based on these ideas.

Teachers were asked to follow guidelines (Appendix E) that were designed to focus their writing on specific features of the educational research and the scientists' work they had been exposed to. The guidelines helped to focus the teachers' IF design on inquiry cycles and the incorporation of IT. The structure of these guidelines offered the opportunity to compare the three teachers' interpretation and application of these ideas. Therefore, in my discussion of the IF, I focus on the teachers' overall IF design, their interpretation and use of the inquiry cycle, and their interpretation of IT.

The descriptions of the participants performance artifacts included in this section are intended to be brief. They focus on comparing the three teachers work. More in-depth descriptions can be found in the within-case analysis chapters.

TABLE 7.15
Comparison of Performance Artifact Characteristics

| *Teacher* | *Overall Instructional Framework Design* | *Inquiry Cycle Alignment* | *Technology Integration* | *SYI Summary Discussion of Preparation for the Instructional Framework* | *Refection in SYI Summary* | *Action Research Plan* |
|---|---|---|---|---|---|---|
| Mrs. Lewis | Focused on concept reinforcement | Removed | Approaching IT | Taught necessary concepts | Little reflection | Practical but not meaningful |
| Mrs. Major | Focused on concept reinforcement | Far removed | Not IT | Taught necessary concepts | Little reflection | Neither meaningful nor practical |
| Mrs. Patton | Focused on inquiry processes and application of conceptual understanding | Well aligned | IT | Immersed students in a discussion of nanotechnology and system observation | Reflection | Meaningful and practical |

**Overall Design**

Each teacher in this study crafted an IF that was unique. Allowing for these unique designs was intended as a way for the teachers to create a lesson that meshed with the affordances and constraints of their classrooms. While their IFs did indeed do this, they also appeared to mesh well with the personal theories and practices that defined their instruction. Mrs. Lewis and Mrs. Major constructed IFs that focused on reinforcing concepts, aligning with the focus on concept reinforcement through practice that I had observed in both of their classrooms. Mrs. Patton designed an IF which focused on extending and applying students' understanding to authentic research activities, a pattern which reflected what I had learned about her personal theories and practice as well. In order to demonstrate these similarities and differences, I briefly describe the overall design of each teacher's IF and then delve into how their interpretations of the inquiry cycle and IT compared.

The immersion experience that Mrs. Lewis described in her IF consisted of three steps. The first of these steps was a brief discussion based on pictures of thermal fish kills. The second step consisted of students completing a series of two hands-on verification laboratories. Students would use CBL2 probes to measure water temperature and concentration of dissolved oxygen. This data would be combined with other data to produce graphs of two solubility curves with reverse relationships. Students would then complete a formal lab write-up and present and discuss their results, in poster format, with the class.

Once the immersion experience was complete, students would be asked to connect their ideas about solubility to a real-world example. The inquiry cycle steps of research question generation, student research, and consequential task were subsumed under the umbrella of an independent library research project. Groups of students would choose a real world example of solubility factors affecting their environment and create a presentation based on what they learned about their chosen example.

The immersion experience Mrs. Major described in her IF consisted of a pretest followed by a video on sun safety. Mrs. Major would then provided her students with a list of questions and give them time to begin working on a PowerPoint that answered those questions. Once they were complete, students would present their PowerPoint presentations to the class.

Mrs. Patton's immersion experience involved her students watching a video of the colloidal particles found in a coffee stain, discussing the various macro- and nano-scale forces that acted on the particles, and participating in a benchmark lesson on colloids, van der Waal forces, and Brownian motion. The students would utilize digital QX5 microscopes to watch the forces they had learned about in the benchmark lesson. Students would be given time to develop questions about the colloidal particles that they were interested in researching. Once these questions were developed, students would use the digital microscopes to record video of the particles and test their hypotheses and then apply their new knowledge to a consequential task. For this task, students would be given data that mirrored the data they had collected during their research and would be asked to explain this new data set using their understanding of nanoforces.

**Interpretation of the Etheredge and Rudnitsky Inquiry Cycle**

The Inquiry cycle described by Etheredge and Rudnitsky (E&R) (2003) details four steps: immersion, researchable question, student research, and consequential task (Figure 7.21). A particular emphasis is placed on the system of variables that the entire cycle is based on. E&R discuss that the system of variables should "create a micro-world in which students can explore relationships among these variables" (p. 35). This system is then used to sustain students in "purposeful, systematic inquiry, where the class is collaborating in establishing knowledge claims—things they agree they know and understand about the system" (p. 39). It is in this system of variables that students are immersed and, through the understandings gained through this immersion, they develop researchable questions and conduct their research. The final step in the Inquiry cycle gives students the opportunity to use what they learned about the system of variables on what they call a "consequential task." E&R describe the ideal consequential task as one that "requires the application of considerable knowledge to solve a problem."

Each teacher was asked to base their IF on this description of an inquiry cycle, and each interpreted the cycle in a unique way. In this section, I compare how the three teachers' IFs aligned with this cycle and their personal theories and practices.

Mrs. Lewis' IF presented more of a series of activities, rather than an inquiry cycle like the one E&R (2003) describe. Mrs. Lewis used the inquiry cycle framework of immersion, researchable questions, student research, and consequential task, but based the activities on the concept of solubility and not a system of variables on which her students could engage in "purposeful, systematic inquiry" (2003, p. 39). This design demonstrated that Mrs. Lewis focused on the surface level procedures of the steps of the learning cycle rather than the deeper ideas about teaching and learning on which the inquiry cycle was based.

Mrs. Major was the only one of the three teachers who did not design an IF that followed the four steps of the E&R inquiry cycle. She used the term "immersion" to refer to the first portion of her IF activity but little connection to the inquiry cycle was evident. Her "immersion" consisted of students watching a video and being given their assignment, which was to create a PowerPoint that answered a list of eight teacher-generated questions. This activity failed to capture most of the elements of the inquiry cycle described by E&R and, instead, was more of a structured information gathering session.

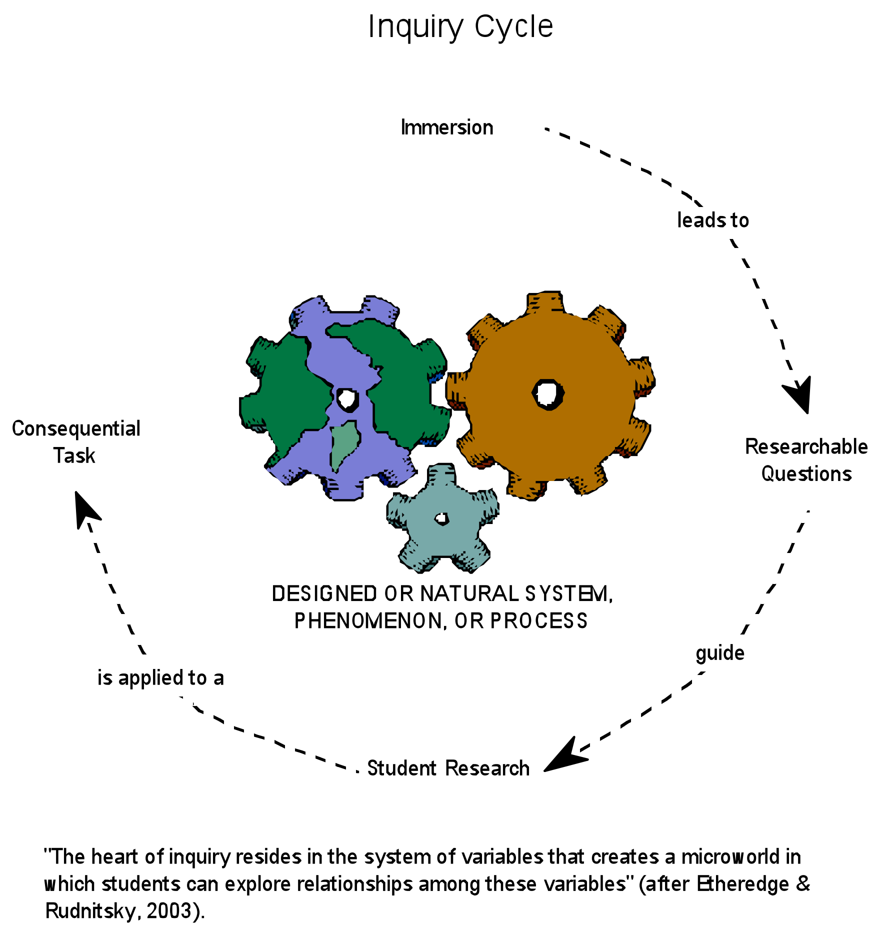


FIGURE 7.21 The inquiry model for the design of the Instructional Framework (from Stuessy, 2005 based on terminology from Etheredge & Rudnitsky, 2003).

Mrs. Patton's IF design was much more complex than those of the other two teachers and appeared to be well aligned with the E&R inquiry cycle. Like Mrs. Major, Mrs. Patton began her IF with her students watching a video on nanoforces. Unlike Mrs. Major, Mrs. Paton used this video to start a discussion of student ideas about forces at the nanoscale that led into a benchmark lesson on Brownian motion and van der Wall forces. After the lesson, students were given the opportunity to observe particulate motion using digital microscopes. These exploratory and collaborative activities engaged students in making observations and agreeing upon knowledge claims with the system of variable that would be the focus of their research, much like E&R describe.

After this immersion experience, groups of students worked together and used their assertions and observations to craft researchable questions. These questions used the knowledge claims they established during the immersion, and their understanding of forces, to design an experiment they could conduct using the digital microscopes and other materials that were made available to them. Development of questions and research plans in this manner also mirrored the intention of E&R as students used their observations to determine research methods that would be feasible to implement with the tools available to them.

Mrs. Patton's students conducted their research and, after they worked through the research question, they were asked to complete a consequential task. The consequential task required students to use the knowledge they gained to evaluate video data that was collected with the digital microscopes.

**Integration of Technology**

Encouraging teachers to integrate inquiry and IT into their classrooms in ways that mirrored the authentic work of scientists was a central goal of the ITS Center's PDE. We adopted the view points of Chinn & Malhotra (2002) and Edelson, (1999) which state that school inquiry tasks that mirrored the authentic work of scientists, captured the core components of scientific thinking and reasoning and rely on information technology (IT). These tasks allow users to visualize, communicate, manipulate, or otherwise work with complex data sets in ways they would be unable to without them. What makes a technology IT is in the manner in which it is utilized and not the technology itself. The same technology used similarly in two different situations (e.g. graphing in Excel) may capture scientific reasoning in one and not in the other.

Teachers were encouraged to integrate IT into the design of their IF. Time was taken out of the afternoon sessions to help the participants reflect on what they had learned about the scientists' work and use of technology and connect their ideas and observations to their individual classroom settings. All three teachers integrated technology into their IF, but only Mrs. Patton's IF integrated a use of technology that reflected core components of scientific reasoning and could be considered IT.

Mrs. Lewis integrated three forms of technology into the design of her IF: CBL2 probes, Excel and PowerPoint. The CBL2 probes and Excel were used in a series of two confirmatory labs that formed a part of her IF's immersion. Her students used PowerPoint to organize their independent research project presentations. Mrs. Lewis' IF described the use of Excel and CBL2 probes in ways that focused on data collection and the illumination of patterns within the data. These technologies were not used as parts of an inquiry cycle and their use did not help students to reason deeply about the "how's" and "why's" Mrs. Lewis' use of technology approached, but did not achieve, the ITS Center's use of the term IT.

Mrs. Major's students watched a video on sun safety, used the Internet to research teacher-generated questions, and created a PowerPoint presentation that detailed their responses to the questions. Much like I saw during my observations of Mrs. Major's classes, the activities she detailed in her IF were highly structured. Students were focused on gathering and presenting information rather than critically thinking and reasoning about data or information. This focus and level of structure did not provide opportunities for students to engage in the core components of scientific reasoning. For these reasons, I found Mrs. Major's use of technology to be far removed from the idea of IT expressed during the ITS Center's PDE.

Mrs. Patton's IF was focused on a use of technology that mirrored the scientists' work she had observed. Her students used digital microscopes to collect short videos of colloidal particles that they analyzed. This engaged students in thought and reasoning patterns similar to those of the scientists. This similarity effectively captured the essence of the definition of IT promoted by the ITS Center's PDE.

*School Year I Summary Papers*

In order to return for the second summer of the ITS Center's PDE, participants were required to implement their IFs, fill out a series of surveys about their implementation, and write a short paper describing and reflecting on their implementation. This paper was referred to as the School Year I Summary Paper (SYI Summary). Guidelines (Appendix F) asked teachers to describe and analyze their implementation of their IF. Specifically they were asked to reflect on the difficulties they encountered, what they did to overcome those difficulties, and what they would do to improve their implementation the following school year.

**Reflection**

Each teacher's writing demonstrated differences in the amount and depth of reflection in their SYI Summary Papers. The majority of Mrs. Lewis and Mrs. Major's paper focused on describing their IF implementation and how they related to the interpretations of the educational research discussed during the first summer of the ITS Center's PDE. There was very little discussion in either of their papers about the why things went the way they did, how they differed from their usual classes, or how they might change the structure of their IF for implementation the following year. The only example of reflection was the mention of the procedural details they would like to change in the following year. Mrs. Patton described her IF implementation and related her description to educational research, but she also reflected on each portion of her description. During these reflective segments, she discussed how the attitudes, motivations, and engagement of the students compared to her normal teaching practice. The observations she discussed included more grade-oriented students being less excited about the project, and the high level of engagement exhibited by other her students.

**Preparation of Students for the Immersion**

Interesting comparisons were found in the way each teacher discussed their own preparation and implementation of the IF. Mrs. Lewis and Mrs. Major discussed preparing their students by teaching them necessary concepts while Mrs. Patton discussed guiding her students in a discussion of nanotechnology research with a multimedia PowerPoint presentation.

In her SYI Summary, Mrs. Lewis discussed the topics she taught that "laid the ground work" for her students' engagement in the ARP. She wrote that: "three traditional tests and four laboratory investigations determined that the students were well aware of the variables associated with the system regarding solubility" before they began the independent research project associated with her IF.

Similarly, Mrs. Major stated that her "students were pre-taught the basics of chemical reactions" before beginning her IF experience. She also administered a pretest that helped her to "diagnose what [her students] already knew about ozone and what they may have read or heard." Through this pretest she determined that "most of the students had heard of ozone before and knew that it was a protective layer in our atmosphere. That was the main extent of their knowledge. A few students knew how to draw the ozone molecule, because we had built it during our molecular models lab" (SYI Summary, page 2)

Mrs. Patton did not discuss any specific preparatory steps she took with her students before beginning her IF, but discussed her immersion in depth. She wrote:

> The immersion experience was a PowerPoint describing nanotechnology and the research that is occurring with nanotechnology. This PowerPoint included video clips, applets, and questions. The first part of the PowerPoint described nanotechnology and included the *Powers of Ten* applet. The students were very interested in the *Powers of Ten* applet; they wanted to see this applet over and over again. The next part of the PowerPoint discussed matter at the nanoscale. A discussion occurred over their macroscopic knowledge of matter and how that is applied to the nanoscale. The discussion was very lively and *everyone* participated. The notes over the discussion are available in PowerPoint form. The next part of the lecture described the practical applications of nanotechnology. Students were able to see true life applications of nanotechnology that will change the world in which they live. The students continued to be very involved in this discussion. When the ethics of nanotechnology was brought up, the discussion became even more interesting. The last part of the lecture was the introduction of Dr. Bevan's research and the basis of their inquiry task. (SYI, Pg. 3-4)

Mrs. Patton's description of this process was much different than the process the other two teachers described. She had engaged her students in thinking about and discussing what nanotechnology was and connecting those understandings to real world applications.

*Action Research Plans*

The ARPs were the final product of the Summer II experience. Teachers developed questions they wanted to investigate about their students' involvement in the

IF experiences they had crafted and implemented. Each teacher developed researchable questions they were interested in, designed methods through which they could collect data to answer their questions, and consulted educational research to support their decisions. Teachers were offered a set of loosely constructed guidelines to follow in their thinking about their ARPs (Appendix G). Each teacher had unique questions and interpreted ideas from the educational research in different ways to support their ideas. Because of this, their specific interpretations were difficult to analyze. I analyzed each teacher's ARP on two broad levels: whether the methods they described would lend themselves to answering the questions they discussed in their ARPs (practicality) and how meaningful their research would be to the educational research community at large. I focused on how their use and interpretation of the educational research aligned with the constructs they invoked.

**Meaningfulness**

Each participant invoked ideas from educational research to support and situate their research questions in educational research. As can be expected, each teacher interpreted the research they consulted differently. Mrs. Lewis and Mrs. Major's interpretations were not well aligned with the philosophy of the literature they discussed, but Mrs. Patton's interpretations were relatively well aligned with the literature she discussed.

Mrs. Lewis focused her ARP literature review on the literature describing the impacts authentic scientific inquiry can have on students' conceptual understanding and transfer of concepts. At the root of the problem was the design of her IF, which did not align well with the concept of authentic scientific inquiry in the literature she cited. Her use of this literature and the potential benefits it described did not apply to her intervention. Her interpretations of the other two constructs were also not well aligned with the philosophy on which the literature she cited was based. It appeared from her writing that she interpreted the construct of conceptual understanding as concept mastery and the construct of transfer as retention (see Chapter IV for a more in depth description of these interpretations). The ways in which she interpreted these concepts affected the way in which her research was aligned with current ideas about educational research and made it less meaningful to the research community.

Mrs. Major's ARP did not demonstrate a logical flow of thought. Her use of literature was not well connected to her research questions or the methodology she described. Her literature review focused on the difficulties that faced African American and Hispanic male students. Her purpose statement and research question focused on evaluating the impacts of authentic inquiry experiences on the depth of students' conceptual understanding. The assessments included in her methods focused on evaluating the amount of information students gained, the feelings of students as the project progressed, and the efficiency of their group work. Since Mrs. Major's IF did not demonstrate an alignment with the literature on authentic inquiry, or appear to foster conceptual understanding of the material, her rationale and methods did not support her project. The lack of alignment between these elements of her ARP made the research less than meaningful from the standpoints of both her own professional development and the research community at large.

Mrs. Patton's ARP focused on how students' motivation and epistemological beliefs changed after participation in an authentic inquiry project. Her rational was solid, drawing on current literature related to both of the constructs she was assessing and the impacts of authentic inquiry. Her rationale also provided a logical argument for her research methodology. These characteristics, paired with the authentic inquiry experience described in her IF, made her project appear meaningful to both her own professional development and the broader research community.

**Practicality**

The practicality of each teachers ARP, or the way in which their methods addressed their research questions, also differed. Mrs. Lewis presented a plan that supported her interpretation of transfer as retention that could be completed in her classroom with relative ease. As was discussed, the methods described in Mrs. Major's plan were disconnected from her research questions and rationale, described a very muddy data collection and analysis plan and presented a problematic research plan that was difficult to complete. Mrs. Patton's plan was well designed. She described methods that would allow her to investigate the phenomena she focused on and fit well into her classroom teaching.

In her ARP Mrs. Lewis interpreted the constructs of conceptual understanding, transfer, and inquiry differently than they way they were described in the literature she cited. She focused her research questions on conceptual understanding and transfer, terms she appeared to use interchangeably with "mastery" and "long term retention." While these definitions did not align with the literature she cited, she used them consistently, and the methods she described addressed her interpretations. Her methods could be carried out within her classroom with relative ease, which led to my assertion that her ARP was practical.

The data sources Mrs. Major described in her ARP were not well aligned with her research questions and some of them would be very difficult to gather. She also misinterpreted the construct of conceptual understanding, but her interpretation was not as consistent as Mrs. Lewis'. Mrs. Major assessed her students' understanding through a five-question quiz that focused on short answer recall questions that did not adequately assess understanding or concept mastery. Mrs. Major also stated that she would assess "student participation levels, actual time on-task, and the amount of work accomplished each day" all of which would be difficult to assess and use to support her research.

Mrs. Patton's ARP utilized two validated instruments to answer her research questions. Both the instruments and the research questions focused on change in students' epistemological beliefs and motivation. She added that she planned to have her students keep reflective journals throughout their research experiences to support what she may find with the surveys. These methods outlined a plan that could provide adequate answers to her research questions and would be relatively easy to carry out in her classroom.

## Perceptions of the ITS Center's PDE Impact

Much like the other elements of this analysis, each teacher's perceptions of the impacts the ITS Center's PDE had on their thoughts and teaching practices differed.

Mrs. Lewis and Mrs. Major discussed finding specific activities or techniques that enhanced lessons or topics they already utilized and increased motivation to change aspects of their practices. They also both discussed not placing much value on the educational research they were introduced to. Mrs. Patton's perceptions differed. She discussed finding new ideas or concepts that helped her look at her teaching practice in a new light as being most valuable to her. Many of the ideas she discussed came directly from the educational research and, when directly asked, she discussed finding the educational research a valuable portion of the experience as well. A visual representation comparing the teachers' perceptions can be found in Table 7.16.

TABLE 7.16
Comparison of Perceptions ITS Center's PDE Impact

| *Teacher* | *Perceptions of Value and Impact* | *Perceptions of Educational Research* |
|---|---|---|
| Mrs. Lewis | Technology and ways to model concepts she already taught; connected understanding to other areas of science and allowed her to furnish her students with more information | Too removed to be of much use |
| Mrs. Major | New activities and ways to modify existing activities used to reinforce existing concepts | Not written for her; did not like it |
| Mrs. Patton | New ideas to expand thinking about teaching; new technology and ideas to enhance her classroom practice | Interesting, helped her to think about her teaching in new ways |

*Perceptions of Value and Impact*

All three teachers valued the ITS Center's PDE and indicated that it had some impact on their teaching practice, but they placed their perceptions of value an impact in different places. Mrs. Lewis placed the most value in the push the experience had given her to incorporate technology into her instruction. She had also discussed the value of learning new methods to model some of the concepts her students had difficulty understanding, broadening her ideas, and enhancing her ability to see new connections among chemistry and other subjects. Her perceptions of value indicated that she had enhanced her classroom practice but that her personal practice theories had not changed a great deal. Her perceptions further indicated that she had valued her time with the scientists over the time she had spent with the educators.

Mrs. Major discussed placing the most value on the push the ITS Center's PDE had given her to "accelerate the modification" (EI, L60) of her curriculum by incorporating new activities and techniques into her practice. In particular, she discussed decreasing the structure of her laboratory activities by not providing students with as many guidelines and providing more opportunities for cooperative learning. Even though the impacts Mrs. Major discussed indicated the potential for positive impacts to her teaching practice, they also indicated that she had not internalized reform-based ideas about teaching and learning during the ITS Center's PDE.

Mrs. Patton's perceptions of value and impact were more abstract than those of the other two teachers. She discussed perceiving the most value in the ideas the ITS Center's PDE had made her aware of. She felt that these ideas had justified many of the things she was already doing in her classroom or changed the way she thought about them. Some of the ideas she discussed were inquiry and the idea of the consequential task, reasons why incorporating technology was important, awareness of new technologies she could use, transfer, and action research. Her discussion of these ideas indicated that she had thought about many of the ideas she had encountered and that the ideas had influenced her thinking about her classroom practice in ways that mirrored the recommendations of reform.

*Perceptions of Educational Research*

Each of the three teachers also indicated that they perceived and valued the ideas they encountered in the educational research differently. Mrs. Lewis discussed feeling as though the ideas and methods discussed in the educational research were a bit farfetched, and carried little relevance to the reality of her classroom. Mrs. Major discussed feeling as though the educational research was not “written for her” (EI, L86) and that the authors needed to write in a more practical manner before she could understand or incorporate it into her ideas about teaching. Unlike the other two teachers, Mrs. Patton discussed having enjoyed reading the educational research. She demonstrated throughout her interviews that she now incorporated many of the research ideas, such as scaffolding, transfer, and consequential tasks into her thinking about her classroom practice. She also stated that she still wrestled with some of the details of the ideas and how they might best fit with her thinking to impact her students learning.

## Cross-case Summary and Implications

The preceding descriptions indicated that each teacher’s practice, personal theories, performance artifacts, and perceptions of the ITS Center’s PDE were related to their orientation toward reform. Data from the cases of Mrs. Lewis and Mrs. Major, representatives of the group of teachers who appeared to have difficulties understanding the ideas presented in the ITS Center’s conceptual frame, demonstrated their practice and personal theories were far removed from the vision promoted by reform. Data from the case of Mrs. Patton, a teacher who appeared to have understood and integrated many ideas from the ITS Center’s PDE into her teaching practice, demonstrated that her practice and personal theories were well aligned with the vision promoted by reform. Table 7.17 provides a brief comparative overview of how the teachers ideas aligned, or failed to align, with the reform-oriented ideas presented in the ITS Center’s conceptual frame. This overview is focused on four main themes: the teachers’ personal theories and teaching practice, their Instructional Frameworks, their perceptions of the ITS Center’s PDE, and their thoughts about educational research.

TABLE 7.17
Comparison of the Three Teachers' Alignment with Reform

| *Theme* | *Does not incorporate reform-oriented ideas.* | *Incorporation of reform-oriented ideas appeared surface level or differed significantly from original philosophy.* | *Incorporation of reform-oriented ideas appeared to be well-aligned original philosophy.* |
|---|---|---|---|
| Teaching Practice & Personal Theories | Mrs. Lewis – Completely teacher-directed instruction; planed by book; assessed for accountability and teacher knowledge; used well designed tasks; saw little value in group work; focused thinking on student ability, willingness and efficiency. | Mrs. Major – Predominantly teacher-directed instruction; planned by curriculum guide; assessed for accountability and teacher knowledge; used well-designed tasks; valued group work and used it in ways that mirrored her instruction; focused thinking on eliminating opportunities for student mistakes. | Mrs. Patton – Varying degrees of teacher/student directed instruction; planned by relationship of student understanding to learning goals; assessed for student as well as teacher understanding; used varying levels of task structure; valued group work and used it to address less structured tasks; critically reflected on students' understanding |
| Instructional Framework | Mrs. Major – Not aligned with the inquiry cycle; use of technology did not reflect an understanding of IT or inquiry processes. | Mrs. Lewis – Followed steps of inquiry cycle; design but was more like a series of activities than an extended inquiry investigation; use of technology approached IT. | Mrs. Patton – Directly aligned with inquiry cycle; use of technology embodied the definition of IT. |
| Perceptions of ITS Center's PDE | Mrs. Lewis – Valued learning about new technologies, new ways to model concepts she already taught, and connections among areas of science.<br>Mrs. Major – Valued learning about new activities and ideas for modifying existing activities. | | Mrs. Patton – Valued collaboration with other teachers, learning about new ideas that made her think differently about her practice and learning about new technologies she could apply to her classroom practice. |
| Views of Educational Research | Mrs. Lewis – Felt it was not practical and disconnected from the reality of the classroom.<br>Mrs. Major – Did not like it; felt it was "not written to her, not written for her." | | Mrs. Patton – Felt it was interesting and helped her think about her teaching in new ways. |

As the data summarized in the above table demonstrate, elements of the teaching and learning of all three teachers were aligned with their orientation toward reform. Mrs. Lewis was a teacher who strove to efficiently cover content, focused on preparing her students for college, and held a transmittal and mastery view of chemistry. The IF she created described a series of activities and was not aligned with E&R's inquiry cycle. Also in line with her personal theories and practices was her discussion of finding new ideas for transmitting and reinforcing concepts most valuable and her thoughts that the educational research was not relevant to her classroom. Mrs. Major was a teacher whose thinking appeared to focus on minimizing opportunities for student mistakes through teacher-directed instruction and well-structured tasks. She created an IF in line with this orientation in which students were asked to gather information from the Internet and compile it in a PowerPoint that answered a series of teacher designed questions. Her discussions of valuing learning about new activities and ways to modify existing activities and feeling that the educational research was not written for her were also in line with her practice and personal theories.  Mrs. Patton's personal theories and practices indicated an orientation toward reform and she created an IF that indicated a deep understanding of How Students Learn (Donovan & Bransford, 2005), E&R's inquiry cycle (Etheredge & Rudnitsky, 2003) and incorporated IT. Her discussion of valuing learning about ideas that encouraged her to think about her practice in different ways and feeling that the educational research offered her many of these ideas also paralleled these views.

This cross-case analysis revealed the differences and similarities among many of the complex characteristics that drove the teaching practices of Mrs. Lewis, Mrs. Major, and Mrs. Patton. It also revealed that their learning was aligned with their teaching practices and mirrored the similarities and differences observed. In order to inform the design of the ITS Center's PDE and speak to the growing body of research on teacher professional development, an understanding of how similarities and differences among teachers' practices and personal theories and learning from the ITS Center's PDE relate to the research literature discussed in Chapter II is needed. The chapter that follows addresses this need.

# CHAPTER VIII

# DISCUSSION AND INTERPRETATION

Prior knowledge has a profound effect on an individual's ability and willingness to accommodate new learning (Vosniadou & Brewer, 1992; Vosniadou & Ioannides, 1998). Teachers are no exception. A teacher's practice is based on a complex system of beliefs that influence the ways she understands teaching (Magnusson, Krajcik, & Borko, 1999) and incorporates new knowledge into her classroom practice (Kang & Wallace, 2005; Smith & Southerland, 2007; Yerrick et al., 1997). These belief systems include teachers' knowledge, attitudes, and beliefs about their students, subject matter, and curriculum (Jones & Carter, 2007) and are largely based on past experiences in teaching and learning contexts (Ball & Cohen, 1999; Brownlee, Boulton-Lewis, & Purdie, 2002). Smith and Southerland (2007) identify the belief systems of teachers as the "missing link" to understanding how internal and external factors influence teachers' interpretation and implementation of reform.

The purpose of this dissertation was to explore the influence of such internal and external factors on three teachers' implementations and interpretations of reform, as reform was presented in the ITS Center's PDE. I explored the relationships of school contexts, personal practice theories, and classroom practices and their influences on the teachers' perceptions and interpretations of the ITS Center's PDE. The overarching goals of this exploration were to inform the designers of the ITS Center's PDE about the impact of their work and to add to the growing body of research on teacher learning.

## Turning to Theory

The predominantly qualitative nature of this study afforded me the luxury of turning to theory to aid in explaining my findings about the relationships among three teachers' thoughts and actions. The ITS Center attempted to provide an exemplary PDE for all 60 of its participants over the course of two summers and two school-year implementations. The three teachers in this study were chosen to reflect the range of participants, on the basis of how well the ideas they expressed in their Instructional Frameworks, Action Research Plans, and exit interviews aligned with the ITS Center's visions of reform. In reflection, while I expected to find some difference among the three participants, I did not expect the magnitude of within-case congruence and cross-case variation I found. Within-case analyses revealed that the individual teacher's classroom practices, personal practice theories, school contexts, and, ultimately, their perceptions and interpretations of the ITS Center's PDE were highly interrelated. The cases as a whole, however, differed significantly from one another. As I looked across the cases of the three teachers and attempted to make sense of the patterns, I came to see that they reflected an orientation toward science teaching and reform. I turned to current theory to help me make sense of my findings and to determine how, and if, they might inform theory in some way.

In my search through the literature and discussions with my advisor, I selected Bandura's (1999) socio-cognitive model of triadic reciprocal causation (Figure 8.1) as a frame for interpreting the patterns of within-case congruence and cross-case variation described in Chapters IV through VII. This model explains the functioning of individuals in social organizations in light of three mutually influencing factors (personal, behavioral and environmental), which affect the overall productive outcomes of social practice. There is no fixed pattern in which these three factors interact; rather, their interactions depend on many complex factors, including "activities, situational circumstances, and socio-structural constraints and opportunities" (Bandura, 1999, p. 6).

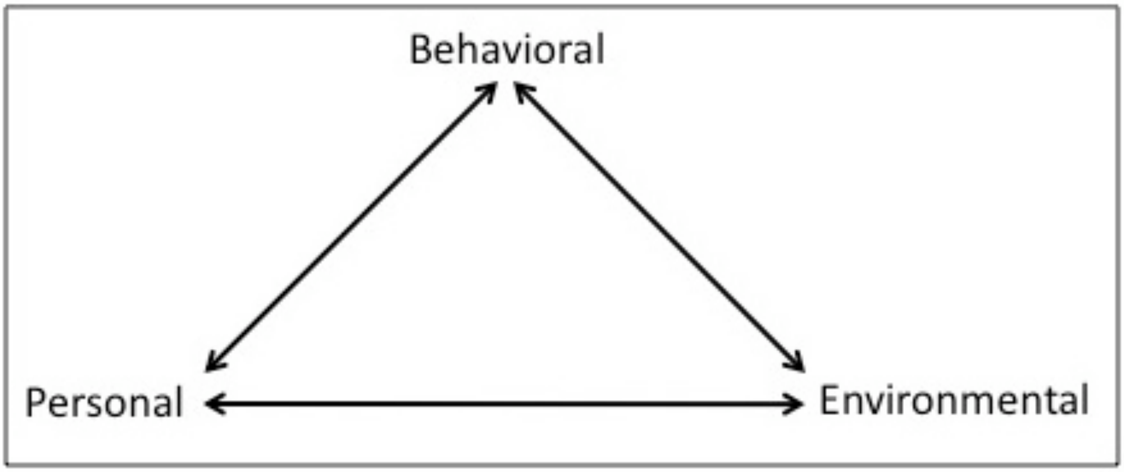


FIGURE 8.1 Model of triadic reciprocal causation (adapted from Bandura, 1999).

This study focused on the relationship among characteristics of each teacher's practice (i.e., school context, classroom context, teaching practice, and personal practice theories) and their perceptions and interpretations of the ITS Center's PDE. Regarding the triadic reciprocal causation model, Bandura discussed how personal and behavioral factors influenced the parts of an environment an individual experiences and how they are experienced. He stated:

> There is a major difference between the potential environment and the environment people actually experience. For the most part, the environment is only a potentiality whose rewarding and punishing aspects do not come into being until the environment is selectively activated by appropriate courses of action. Which part of the potential environment becomes the actual experienced environment thus depends on how people behave. (p. 6)

Following the logic in the above statement, each of the teachers in this study focused on different parts of the ITS Center's PDE, which made the actual environments they experienced different. My analyses of the teachers perceptions and interpretations (i.e. outcomes of social practice) revealed which aspects of the "potential" of the ITS Center's PDE they focused on and illuminated the influence of personal and behavioral factors. To further enhance my understanding of the relationships among the elements of each teacher's practice and the perceptions and interpretations that resulted from their experiences during the ITS Center's PDE, I applied the factors described in Bandura's model to my understanding of each teacher's practices (Figure 8.2).

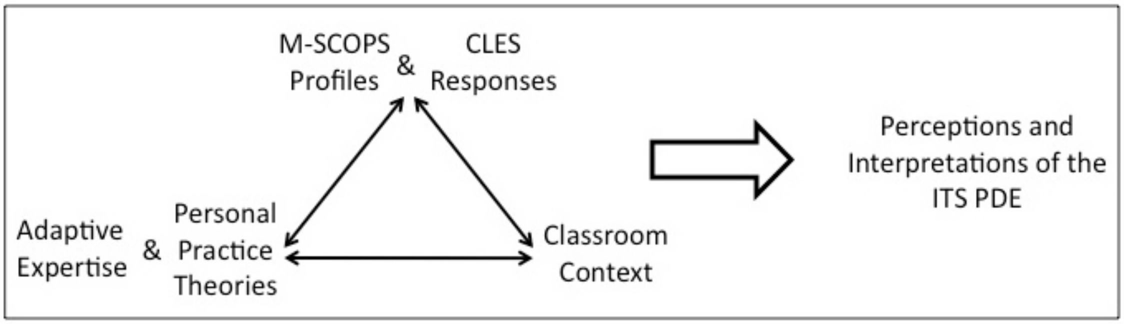


FIGURE 8.2 Application of the model of triadic reciprocal causation to present study.

Bandura's model provides a broad perspective with which to think about the relationships among the teachers' classroom contexts, teaching practices, personal practice theories, and perceptions and interpretations of the ITS Center's PDE. In order to interpret what I learned about each teacher, I selected five indicators from the literature: percentages of class time as quantified by the *Mathematics and Science Classroom Observation Profile System* (M-SCOPS) (Stuessy, 2002), mean scores from the *Classroom Learning Environment Survey* (CLES) (McRobbie & Tobin, 1997), alignment of teaching practices to the "changing emphases for science teaching" outlined in the *National Science Education Standards* (National Research Council, 1996), evidence of characteristics of adaptive expertise (Crawford et al., 2005), and orientation toward science education reform (Luft & Roehrig, 2007). Table 8.1 provides a visual representation of how these indicators aligned with the factors included in Bandura's model.

TABLE 8.1
Alignment of Indicators with the Triadic Reciprocal Causation Model Factors

| | | *Triadic Reciprocal Causation Model Factor* | | |
|---|---|---|---|---|
| *Factor* | *Indicator* | Personal | Behavioral | Environmental |
| Classroom Context | M-SCOPS Percentages | | | X |
| | CLES Means | | | X |
| Teaching Practices | NSES Changing Emphases | | X | |
| Adaptive Expertise | Crawford et al. (2005) | X | | |
| Personal Practice Theories | Teacher Beliefs Interview | X | | |

I used these constructs as a "short-hand" method of framing my interpretation so that my thoughts and explanations would speak to theories that would be most relevant to designers of PDEs and to the growing body of research on teacher learning. To clarify my thought processes, each of these elements is discussed separately and then all are brought together and related to the teachers' perceptions and interpretations of the ITS Center's PDE (i.e., outcomes of social practice). Finally, I evaluate Bandura's theory in terms of its explanatory power.

*Classroom Context*

I used both M-SCOPS Profiles (Stuessy, 2002) and students' responses to the CLES (McRobbie & Tobin, 1997) to quantitatively compare the classroom contexts of the three teachers (Table 8.2). Percentages of time from the two classroom observations of each teacher were averaged for five characteristics revealed using the M-SCOPS Profiles (Table 8.2). These characteristics were: (1) time spent in teacher-directed instruction (representation scaffolding level of 5/1; see Table 3.1 for explanation), (2) time students spent engaged in lower-order skills (instructional scaffolding levels of 1 & 2; see table 3.2 for explanation), (3) time students spent engaged with 2D representations, (4) time students spent engaged with 3D representations, and (5) time students spent off task.

The characteristics mentioned above were chosen based on the insight they provide to how each teacher's classroom aligned with the ITS Center's vision of reform-based practices. In a classroom that aligned with this vision, one would expect to see students taking more initiative for their own learning, focusing on higher-order skills, and engaging with multiple representations of ideas. All of these processes should increase students' motivation and focus, thereby decreasing off-task behavior.

TABLE 8.2
M-SCOPS Profile Comparison

| *Teacher* | *Teacher-directed instruction* | *Lower-order Skills* | *2D Representations* | *3D Representations* | *Off-task* |
|---|---|---|---|---|---|
| Mrs. Lewis | 89 | 49 | 0 | 0 | 12 |
| Mrs. Major | 25 | 52 | 20 | 20 | 16 |
| Mrs. Patton | 45 | 13 | 78 | 48 | 0 |

*Note.* All values are percentages of total class time averaged from the two observations of each teacher's classroom.

Frequency distributions were provided in Chapter VII regarding students' responses to the five constructs in the *Classroom Learning Environment Survey* (CLES) (McRobbie & Tobin, 1997). For purposes of interpretation, each of the response categories for the actual scale of the five constructs targeted by in the CLES were assigned a numerical value from 1-5, (1=strongly disagree; 5=strongly agree). These numerical values were then summed and averaged for each teacher to indicate differences between and among student responses to the constructs (Table 8.3). The

CLES was also chosen because of its alignment with the ITS Center's vision of reform-based practice. Responses from students in classes more aligned with this vision would be expected to indicate high levels of perceived autonomy, relevance, participation, and commitment to learning as well as low levels of disruption to learning.

TABLE 8.3
Comparison of Mean Student Responses to the CLES

| | *CLES Subscale* | | | | |
|---|---|---|---|---|---|
| *Teacher* | *Disruption to learning* | *Relevance* | *Commitment to learning* | *Participation* | *Autonomy* |
| Mrs. Lewis | 1.91 | 2.53 | 3.69 | 3.34 | 2.62 |
| Mrs. Major | 2.37 | 3.16 | 3.55 | 2.86 | 3.50 |
| Mrs. Patton | 1.84 | 3.71 | 3.95 | 3.58 | 3.66 |

Comparing researcher observation with student perception using the values reported in the above tables is a means of triangulation intended to confirm and enhance insight into the classroom contexts of the three teachers. My analysis of Mrs. Lewis' classroom context indicated that her practice was far removed from the vision of science education reform on which the ITS Center's PDE was based. M-SCOPS Profiles described a practice that was highly teacher-directed, focused on lower-level skills, predominantly based on words and symbols, and characterized by considerable portions of off-task student time. These observations were supported by student perceptions of autonomy and relevance as being the lowest of the three teachers, indicating that Mrs. Lewis' students perceived low control over what they learned and viewed their learning as unrelated to their lives outside of school. A similar analysis of Mrs. Major's class revealed that her students spent much less time in teacher-directed instruction and were offered opportunities to engage with 2D and 3D representations; however, their learning was also focused on lower-order skills. Mrs. Major's students spent a slightly higher portion of class time off-task. CLES results supported these observations. Student responses indicated the highest perceived level of disruptions to learning and lowest perceived levels of commitment to learning and participation. These characteristics indicated that the classroom practice of both teachers was far removed ITS Center's PDE vision of reform. Mrs. Patton's class data, on the other hand, revealed that her practice was highly aligned with the ITS Center's PDE vision of reform. M-SCOPS Profiles demonstrated practices that engaged students in higher-order skills, used a great deal of 2D and 3D representations, and kept students on-task the entire time. These observations were supported by student responses to the CLES, which indicated the highest perceived levels of autonomy, relevance, participation, and commitment to learning and lowest levels of disruption.

*Classroom Practice*

The *National Science Education Standards* outlines characteristics of "changing emphases for teaching" (Table 2.1). The characteristics listed under the "more emphasis" column formed the basis of the vision of reform-based practice promoted by the ITS Center's PDE. In order to compare the practices of each teacher to those outlined in this table, I constructed a checklist of changing emphases to demonstrate how each teacher's practice and personal practice theories aligned with the characteristics listed in Table 8.4.

TABLE 8.4
Comparison of Teaching Practice to the NSES Recommendations for "Changing Emphases"

| *Less Emphasis/More Emphasis* | *Mrs. Lewis* | *Mrs. Major* | *Mrs. Patton* |
|---|---|---|---|
| Treating all students alike and responding to the group as a whole/Understanding and responding to individual student's interests, strengths, experiences, and needs | ● | ● | ◉ |
| Rigidly following curricula/ Selecting and adapting curricula | ● | ● | ◉ |
| Focusing on student acquisition of information/ Focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes | ● | ◒ | ◉ |
| Presenting scientific knowledge through lecture, text, and demonstration/ Guiding students in active and extended scientific inquiry | ● | ● | ◉ |
| Asking for recitation of acquired knowledge/ Providing opportunities for scientific discussion and debate among students | ● | ● | ◉ |
| Testing students for factual information at the end of a unit or chapter/ Continuously assessing student understanding | ● | ◒ | ◉ |
| Maintaining responsibility and authority/ Sharing responsibility for learning with students | ● | ● | ◉ |
| Supporting competition/ Supporting a classroom community with cooperation, shared responsibility, and respect | ● | ◒ | ◉ |
| Working alone/ Working with other teachers to enhance the science program. | ◒ | ◒ | ◉ |
| **Overall** | ● | ● | ◉ |

Symbols indicate alignment and can be interpreted as the following: ◉=highly aligned with "more emphasis" characteristics, ◓=aligned with "more emphasis" characteristics, ○=neutral ◒=aligned with "less emphasis" characteristics, ●= highly aligned with "less emphasis" characteristics.

Mrs. Patton's classroom practice was highly aligned with the classroom characteristics advocated by the NSES. Her discussions of the ways she constantly worked to make students' thinking visible, adapted assignments and activities to conform to her students understanding, and engaged in working to enhance the science program with other teachers provided evidence of this alignment. The shifts between more teacher-directed and more student-centered activities and focus on higher-order skills revealed, and the M-SCOPS Profiles concurred, that she was sharing the responsibility for learning with her students.

The classroom practices of the other two teachers were far removed from those of Mrs. Patton and were more aligned with the characteristics the NSES emphasize moving away from. Mrs. Lewis' practice was the furthest removed from all of the ideal characteristics the NSES describe. Her practice was focused on transmitting information to students through lecture, the assessment methods she discussed asked for students to recite information and procedures, and the M-SCOPS Profiles revealed the high level of authority she maintained. While Mrs. Major quizzed her students understanding more often, included more opportunities for students to engage in hands-on activities, and employed group work more frequently than Mrs. Lewis, I felt her practice was also far removed from the NSES vision of reform-based practice. Her quizzes assessed students' knowledge acquisition; her presentation of hands-on activities focused students on procedures; and her cooperative learning techniques mirrored her teacher-directed methods of instruction. These characteristics led to my view that the practices of Mrs. Lewis and Mrs. Major were far removed from the vision of reform as described in the NSES and promoted by the ITS Center's PDE overall.

*Adaptive Expertise*

Enacting the vision of reform described in the NSES requires that teachers have efficient access to large amounts of knowledge and deep conceptual understandings. It also necessitates the ability to creatively and adaptively apply knowledge and understandings to teaching practices. In short, teachers need to be adaptive experts (Hatano & Inagaki, 1986; Schwartz et al., 2005). The characteristics outlined in Table 2.2 from Crawford et al. (2005) provide a useful framework for comparing the thought processes of the three teachers and discussing how they aligned with the vision of science teacher adaptive expertise. Table 8.5 presents a checklist based on my interpretation of the ways in which each teacher's thoughts and actions aligned with ideas about the characteristics of adaptive expertise in science teaching (Crawford et al., 2005).

TABLE 8.5
Checklist of Characteristics of Adaptive Expertise

| *Characteristic* | *Mrs. Lewis* | *Mrs. Major* | *Mrs. Patton* |
|---|---|---|---|
| Epistemic and Disproportional Aspects of Adaptiveness | | | |
| • Maintain an epistemic distance between prior knowledge and model of a case or problem at hand | ◒ | ● | ◉ |
| • An epistemic stance that views the world as complex, messy, irregular, dynamic, etc. | ● | ◒ | ◉ |
| • Comfort or willingness to reveal and work at the limits of one's knowledge and skill | ● | ◒ | ◉ |
| • An inclination toward learning rather than merely applying knowledge | ● | ◒ | ◉ |
| Adaptive Cognitive and Metacognitive Processes | | | |
| • Data-oriented forward reasoning (hypothesis-based reasoning) | ● | ● | ◉ |
| • Causal reasoning | ◒ | ◒ | ◉ |
| • Seeking and analyzing feedback about problem-solving processes and outcomes | ● | ● | ◉ |
| • Monitoring results and performance | ● | ● | ◉ |
| • Monitoring own learning | ● | ● | ◉ |
| • Assessing own knowledge states | ● | ● | ◉ |
| • Assessing adequacy of current knowledge for solving case at hand | ● | ● | ◉ |
| Overall | ● | ● | ◉ |

Symbols indicate the following: ◉=very evident, ◓=evident more often than not, ○=neutral ◒=occasionally evident, ●= not evident.

I drew my interpretations of teachers' adaptive expertise mainly from the teachers' descriptions of, and reflections on, their teaching and planning practices, as well as their perceptions and interpretations of new knowledge from the ITS Center's PDE. For example, Mrs. Lewis' practice of repeating a sequence of lectures indicated that she was more focused on “merely applying” her knowledge to her classroom practice than she was inclined to learn from it. During our discussions she did not appear to reflect on her teaching practice and focused on her students’ motivation and ability (or lack thereof) to successfully learn the material she presented. The interpretations of constructs evident in her performance artifacts from the ITS Center’s PDE indicated that she did not think deeply about how the ideas presented to her differed from her own. In other words, she had not “maintained an epistemic distance between prior knowledge and model of a case or problem at hand” nor did she seek and/or analyze feedback. This led to my overall determination that characteristics of adaptive expertise were not evident in the case of Mrs. Lewis.

Mrs. Major’s discussions of her teaching practice and performance artifacts indicated a similar lack of alignment with the characteristics of adaptive expertise Crawford et al. describe. While Mrs. Major did seem to view the world as messy, irregular, and dynamic, she was more inclined to work at the limits of her knowledge and skills. She did try to learn from her practice, but many of her comments, interpretations, and practices were at odds with the ideas and constructs she invoked. For example, her discussion and implementation of cooperative learning demonstrated that she did not understand it in the same way it was described in the literature. Her discussion of the effects the literature had on her classroom indicated that she did not judge the adequacy of her current understanding, but assumed it to be correct. The level of conviction with which Mrs. Major stated her, largely misconceived, ideas about reform-based teaching demonstrated that most of the adaptive expert cognitive and metacognitive processes were not evident in Mrs. Major’s thought processes. This observation formed the basis of my claim that, overall, characteristics of adaptive expertise were not evident in the case of Mrs. Major.

Mrs. Patton, on the other hand, had a very different approach to teaching and learning. Observations of and discussions about her classroom practice demonstrated all of the “epistemic and disproportional aspects of adaptiveness.” For example, the numerous ways she integrated technology into her practice demonstrated that she had an inclination toward learning. Her use of technology and the design of her Instructional Framework indicated that that she was comfortable working at the limits of her knowledge and abilities. The level of reflection evident in her practice, discussion, and performance artifacts, combined with the high level of alignment that could be seen between many of her ideas and the original authors', indicated that her thought processes were highly aligned with the cognitive and metacognitive characteristics of adaptive expertise Crawford et al. describe. All of these characteristics led to my claim that overall, the traits of adaptive expertise were very evident in the case of Mrs. Patton.

*Orientation to Science Teaching*

Orientations toward science teaching have been discussed as playing a pivotal role in shaping teachers' beliefs and knowledge of teaching and learning (Magnusson et al., 1999). Luft and Roehrig (2007) describe a framework for classifying teachers' beliefs about reform-based teaching methods (Table 8.6).

The categories in this framework were based on teachers' responses to a seven-item semi-structured interview protocol Luft and Roehrig call the Teacher Beliefs Interview (TBI). The TBI includes the following questions:

1. How do you maximize student learning in your classroom?
2. How do you describe your role as a teacher?
3. How do you know when your students understand?
4. In the school setting, how do you decide what to teach and what not to teach?
5. How do you decide when to move onto a new topic in your class?
6. How do your students best learn science?
7. How do you know when learning is occurring in your classroom?

TABLE 8.6
Teacher Beliefs Interview Category Description

| *Category* | *Example* | *View of Science* |
|---|---|---|
| Traditional: Focus on information, transmission, structure or sources. | I am an all-knowing sage.<br><br>My role is to deliver information. | |
| Instructive: Focus on providing experience, teacher-focus, or teacher decision. | I want to maintain a student focus to minimize disruptions.<br><br>I want to provide students with experiences in laboratory science (no elaboration). | Science as rule or fact. |
| Transitional: Focus on teacher/student relationships, subjective decisions or affective response. | I want a good rapport with my students, so I do what they like in science.<br><br>I am responsible to guide students in their development of understanding and process skills. | Science as consistent, connected and objective. |
| Responsive: Focus on collaboration, feedback or knowledge development. | I want to set up my classroom so that students can take charge of their own learning. | |
| Reform-based: Focus on mediating student knowledge or interactions. | My role is to provide students with experiences in science which allow me to understand their knowledge and how they are making sense of science. My instruction needs to be modified accordingly so that students understand key concepts in science. | Science as a dynamic structure in a social and cultural context |

*Note.* Adapted from Luft and Roehrig (2007)

Luft and Roehrig provide detailed examples of responses from teachers with belief orientations from each of the five categories they describe (pp. 57-63). While this current investigation did not specifically employ the TBI, I found the framework and concept maps useful. The questions I asked and comments the teachers made during my discussions with them aligned with the TBI framework. Table 8.7 presents my interpretation of the alignment of the three teachers' responses with the framework and concept maps detailed by Luft and Roehrig.

TABLE 8.7
Orientations Toward Science Education Reform

| *Teacher* | *Q1* | *Q2* | *Q3* | *Q4* | *Q5* | *Q6* | *Q7* | *Overall* |
|---|---|---|---|---|---|---|---|---|
| Mrs. Lewis | ● | ● | ● | ● | ● | ● | ● | Traditional |
| Mrs. Major | ● | ◒ | ◒ | ● | ◒ | ◒ | ◒ | Instructive/ Traditional |
| Mrs. Patton | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | Reform-based |

*Note.* Symbols indicate alignment with orientations in Table 8.7 as follows: ⊙=reform-based, ◓=responsive, ○=transitional, ◒=instructive, ●= traditional.

Much like the NSES recommendations for emphasis, Luft & Roehrig's framework describes beliefs and practices as they move from more teacher-directed to more student-directed methods. Much like with the four measures prior to this, I used a combination of data from observations, interviews, and performance artifacts to determine the classifications of each teacher included in Table 8.7. Data from Mrs. Lewis indicated that she focused on information transmission (i.e., traditional orientation). Data from Mrs. Major indicated that she focused on both transmitting information and providing students with teacher-directed experiences (i.e., in between the categories of instructive and traditional). Data from Mrs. Patton indicated that she focused on creating experiences and seeking feedback that allowed her to understand how her students were making sense of ideas and tailor her instruction to maximize their understanding of key concepts (i.e., reform-based).

*Perceptions and Interpretations of the ITS Center's PDE*

The previous sections of this chapter demonstrated that each teacher's alignment with the ITS Center's vision of reform was relatively consistent across the five identifiers discussed. According to Bandura's model, these patterns should have a large influence on the teachers' perceptions and interpretations of the ITS Center's PDE (i.e., outcomes of social practice). Each teacher's perceptions and interpretations were highly congruent with the patterns of reform alignment revealed by the indicators. This alignment indicates the high level of influence personal, behavioral, and environmental factors had on the teachers' learning from the ITS Center's PDE. The following tables summarize the teachers' perceptions and interpretations and their alignment with the ITS Center's vision of reform. Lists of perceptions and interpretations were taken directly from the within-case analysis headings. Symbols in all tables indicate alignment with the ITS Center's vision of reform as follows: ◉=well aligned, ◓=aligned, ○=neutral, ◒=removed, ●=far removed.

TABLE 8.8
Alignment of Mrs. Lewis' Perceptions and Interpretations

| | |
|---|---|
| *Perceived Impact* | |
| • Technology integration | ● |
| • Concept modeling | ◒ |
| • Broadened ideas | ● |
| • Educational research | ● |
| *Interpretation* | |
| • Inquiry cycle | ◒ |
| • Information technology | ◒ |
| • Conceptual understanding as concept mastery | ● |
| • Transfer as retention | ● |
| Overall | ● |

Table 8.8 summarizes Mrs. Lewis' perceptions and interpretations and their alignment with the ITS Center's vision of reform. The impacts Mrs. Lewis perceived the ITS Center's PDE had on her teaching included the integration of instructional technologies, new ways to model concepts, and broadened ideas with which she could "furnish [her students] with a little more information" (POI1, L799). I viewed these impacts, coupled with her perception of the educational research as not being relevant to her practice, as far removed from the ITS Center's vision of reform. For example, Mrs. Lewis discussed that she felt the ITS Center's PDE impacted her teaching by broadening her ideas so that she could "furnish" her students with more information. This view demonstrated that the teacher-directed methods that permeated Mrs. Lewis' classroom context, teaching practices, and personal theories influenced the way she perceived this impact. Her discussion of learning new ways she could "model certain aspects of chemistry" (POI1, L691) reinforced this connection.

Mrs. Lewis' interpretations were also removed from the ITS Center's vision of reform and reflected her traditional practices and theories. Her interpretation of the inquiry cycle included a series of verification laboratories that were more aligned with her concept mastery view of chemistry than Etheredge and Rudnitsky's (2003) description of variable systems. Mrs. Lewis had, however, included activities that were uncommon to her day-to-day practice and more aligned with reform. These included hands-on activities, student use of technology, and independent research. Mrs. Lewis' interpretation of constructs in her ARP further reinforced the influence personal, behavioral, and environmental factors had on her learning. She discussed conceptual understanding as concept mastery and transfer as retention, interpretations that were more aligned with her traditional teaching orientation and far removed from the original philosophies on which they were based. All of these factors contributed to my overall classification of Mrs. Lewis' perceptions and interpretations as being far removed from the ITS Center's conceptual frame.

TABLE 8.9
Alignment of Mrs. Major's Perceptions and Interpretations

| | |
|---|---|
| *Perceived Impact* | |
| • Accelerated curriculum modification | ● |
| • Decreased lab activity structure | ● |
| • Incorporation of cooperative learning | ● |
| • Educational research | ● |
| *Interpretation* | |
| • Inquiry cycle | ● |
| • Information technology | ● |
| • Conceptual understanding as information gain | ● |
| • Cooperative learning as peer-directed instruction | ● |
| Overall | ● |

Table 8.9 summarizes Mrs. Major's perceptions and interpretations and their alignment with the ITS Center's vision of reform. The impacts Mrs. Major discussed the ITS Center's PDE had on her teaching included accelerated curriculum modification, decreased lab activity structure, and incorporation of cooperative learning. These impacts indicated a higher level of alignment with her classroom context, teaching practices, and personal practice theories than with the ITS Center's conceptual frame. For example, group work in Mrs. Major's classroom was more like peer-directed instruction than the cooperative learning described in the literature she invoked. Her discussion of choosing the students who were doing well in her classes as group leaders reinforced this observation and my claim that her ideas were far removed from the ITS Center's conceptual frame.

The interpretations reflected in Mrs. Major's performance artifacts were also far removed from the ITS Center's conceptual frame. The inquiry cycle described in her IF included no system of variables, but rather asked students to gather information from the Internet. The technology involved in this activity included the Internet and PowerPoint. Neither this activity, nor the technology included in it, engaged students in scientist-like patterns of reasoning. Therefore, I viewed these interpretations and Mrs. Major's overall learning, as far removed from the ITS conceptual frame.

TABLE 8.10
Alignment of Mrs. Patton's Perceptions and Interpretations

| | |
|---|---|
| *Perceived Impact* | |
| • Awareness & justification | ● |
| • Inquiry & the consequential task | ● |
| • Technology | ● |
| • Transfer | ● |
| • Action research | ● |
| • Educational research | ● |
| *Interpretation* | |
| • Inquiry cycle | ● |
| • Information technology | ● |
| • Scaffolding | ● |
| • Transfer | ● |
| Overall | ● |

Table 8.10 summarizes Mrs. Patton's perceptions and interpretations and their alignment with the ITS Center's vision of reform. Mrs. Patton's perceptions and interpretations of the ITS Center's PDE appeared to be well aligned with the vision of reform promoted by the ITS Center's PDE. The impacts she identified were based on ideas that helped her think about her teaching differently. These included new and different ideas about inquiry, the consequential task, technology, transfer, and action

research. Her discussion of these ideas demonstrated that she had a solid understanding of what they meant and also that she had not finished thinking about how they applied to her classroom practice.

The interpretations that emerged from my analysis of Mrs. Patton's performance artifacts were also well aligned with the intentions of the literature on which she based her ideas. The inquiry cycle she described in her Instructional Framework was based on a system of variables much like those described by Etheredge and Rudnitsky (2003). This cycle also incorporated technology in a manner that mirrored the reasoning patterns of scientists, thus making it well aligned with ideas about information technology (Edelson et al., 1999). Her discussion of terms such as scaffolding and transfer during our conversations demonstrated that her interpretations of them aligned well with the literature she had read and that she was constantly thinking about how they applied to her classroom practice.

These characteristics led to my overall classification of Mrs. Patton's perceptions and interpretations as well aligned with the ITS Center's conceptual frame.

*Summary*

The five indicators used to interpret the three teacher cases illuminated many of the ways the cases aligned with the conceptual frame on which the ITS Center's PDE was based. Table 8.11 summarizes my overall interpretation of the data. Outcomes (i.e., teachers' perceptions and interpretations) associated with the ITS Center's PDE are congruent with teachers' personal ideas, behaviors, and classroom environments.

TABLE 8.11
Overall Comparison of Triadic Reciprocal Causation Factor Indicators with Perceptions and Interpretations

| *Triadic Reciprocal Causation Model Factor* | *Environment* | *Behavior* | *Personal* | | *Outcomes* |
|---|---|---|---|---|---|
| *Teacher* | *Classroom Context* | *NSES Recommendations* | *Adaptive Expertise* | *Orientation toward reform* | *Perceptions and Interpretations* |
| Mrs. Lewis | ● | ● | ● | ● | ● |
| Mrs. Major | ● | ● | ● | ◒/● | ● |
| Mrs. Patton | ◉ | ◉ | ◉ | ◉ | ◉ |

*Note.* Symbols indicate alignment with the characteristics and/or philosophy of science education reform as follows: ◉=well aligned, ◓=aligned, ○=neutral, ◒=removed, ●=far removed.

The condensed format of the data in the above table demonstrates that each teacher's personal ideas, behaviors, classroom environments, and perceptions and interpretations were similar in alignment with the ITS Center's conceptual frame. Those teachers who were poorly aligned with one characteristic were poorly aligned overall and the inverse was also true. While this representation provides insight and coherence to this analysis, it obscures the unique manner in which each teacher's qualities influenced the ways in which they perceived and interpreted the ITS Center's PDE. One might conclude from looking at the above table that Mrs. Lewis and Mrs. Major were very much alike, yet the descriptions included in the within-case and cross-case analyses demonstrate that this is far from true.

## Considerations of Theory

In thinking about how to best capture my thoughts on the explanatory power of Bandura's model, I was reminded of a quote by Harry Wolcott. He wrote:

> When you are ready to address matters of analysis and interpretation, consider proposing multiple plausible interpretations rather than presenting single-mindedly for a particularly inviting one. We need to

> guard against the temptation to offer satisfying, simple, single-cause explanations that appear to *solve* too facilely the problem we pose. Human behavior is complexly motivated. Our interpretations should mirror that complexity rather than suggest we are able to infer "real" meanings. Qualitative researchers should reveal and revel in complexity, striving, as anthropologist Charles Frake (1977) has suggested, to opaque. Leave for more quantitatively oriented endeavors efforts to tie things up into neat little bundles. Quantitative endeavors are better situated to do that, for, as Denzin and Lincoln observe, "Quantitative researchers abstract from this world and seldom study it directly (Wolcott, 2001 p. 10)

The benefit of adding Bandura's model to my interpretation was that it offered insight into the complexities of interaction involved in the present study. The interactions among personal, behavioral, and environmental factors, as Bandura described, lead to each individual's unique experiences and outcomes. The framework this model provided allowed for patterns of within-case congruence and cross-case variation to be more easily discussed and compared without losing the unique qualities that make understanding them so valuable.

Delving deeper into the thoughts and actions of the three teachers using current teaching and learning theories further demonstrated the power of using such a framework to guide thinking about teacher learning and transfer from complex PDEs. Research tells us that a teacher's prior knowledge is based on a complex system of beliefs (Jones & Carter, 2007). These beliefs have formed through a lifetime of experience and practice (Ball & Cohen, 1999; Lortie, 1975). They are deep-rooted, resistant to change, and often not well aligned with currently accepted theories (Vosniadou & Brewer, 1992). Much like the *Fish is Fish* (Lionni, 1970) story illustrates, new knowledge is constructed based on an individual's existing ideas, and these ideas become metaphorical fish with wings.

Taking these ideas into account, it is not surprising that each teacher's perceptions and interpretations aligned so closely with their personal ideas, behaviors, and classroom environments. Continuing the metaphor from the *Fish is Fish* story, these elements formed the ponds from which each teacher came and, with little exposure to any alternate world, used what they knew to make sense of the story they were told.

## Connections

My analysis and interpretation of the three teachers in this study connects to the ideas of other researchers' that have looked at the effects of various teacher characteristics on their perceptions and interpretations. To illustrate these connections I tie my ideas to those of two other studies I see as highly related (1) Yerrick, Parke & Nugent's (1997) discussion of the "filter effect of teachers' beliefs and (2) Smith and Southerland's (2007) comparison of two elementary teachers' practices, beliefs and interpretations of reform messages.

Yerrick et al. (1997) analyzed teacher interview data from before and after a PDE. The PDE focused on scientific knowledge and assessment strategies in the classroom. They found that while the ways teachers discussed various concepts had changed, their core beliefs had remained relatively consistent and, in fact, had appeared to inhibit their understanding of the ideas that were a focus of the PDE. Similar to to the study by Yerrick et al., the core beliefs of the three teachers in this study did not appear to change. Furthermore, the tables included in this interpretation demonstrate how these core beliefs influenced and often inhibited their understanding of the ideas central to the ITS Center's PDE.

Smith and Southerland (2007) compared the beliefs, practices and interpretation of reform messages of two elementary teachers. The found that each teacher's beliefs and practices appeared to influence their interpretation of reform more than reform influenced their teaching. These results align with the findings from the current study as teachers' personal practice theories influenced their interpretations of educational concepts from the ITS Center's PDE in similar ways.

The final chapter of this dissertation continues to explore these ideas as they are used to form the basis of the conclusions. These conclusions are then applied to recommendations for PDE design and directions for future research.

# CHAPTER IX

# CONCLUSIONS AND RECOMMENDATIONS

> "There are those who choose the swampy lowlands. They deliberately involve themselves in messy but crucially important problems and when asked to describe their methods of inquiry, they speak of experience, trial and error, intuition and muddling through. Other professionals opt for the high ground. Hungry for technical rigor, devoted to an image of solid professional competence, or fearful of entering a world in which they feel they do not know what they are doing, they choose to confine themselves to a narrowly technical practice" (Schön, 1983 p. 43)

This dissertation took a journey through the "swampy lowlands" that Schön so eloquently described. It attempted to reveal and revel in the richness of complexity that emerged from the interaction between learner and experience in the context of the ITS Center's PDE. The more than 300 pages that lead us to this point demonstrated that this complexity is not easily captured, described, analyzed or interpreted. So, what conclusions were drawn as we peeked into the lives of Mrs. Lewis, Mrs. Major and Mrs. Patton? What recommendations should be made from my close examinations of their perceptions and practices? These questions are addressed below.

To begin thinking about matters of conclusion and recommendation, I found it helpful to reflect on the reasons I set out on this journey in the first place: to inform the design of the ITS Center's PDE and the theories and ideas on which it was based. The predominantly qualitative mixed-methods multiple case study approach employed lends itself to informing theory through a deeper understanding of the subtleties and complexities involved in the orchestration of a complex PDE, one that is centered on the current vision of science education reform.

## Conclusions

I struggled with reaching conclusions after such intimate immersion in the cases of the three teachers included in this study. I found that at first, I shied away from looking at the relatively obvious claims that emerged from my analysis as "conclusions." I searched in vain for more profound ideas. It seemed that the more I hunted the further away from reality and substance I found myself. Eventually, after much thought and discussion with a wide variety of colleagues and friends, I found myself slowly turning back to the cases themselves and grounding my conclusions in the details that, even though obvious, illuminated the points I felt were critical.

The first two major conclusions that emerged from my analysis were inextricably linked. The first, and arguably most obvious, was that the three teachers had differed greatly in their perceptions and interpretations of the ITS Center's PDE. Secondly, the three teachers' perceptions and interpretations appeared to be closely aligned with the personal theories that drove their practices. The classroom practice of each teacher was grounded on the different understanding of teaching they held, understandings that stemmed from their ideas about multitudes of things including science, learning, students, and technology. The same ideas that appeared to drive their teaching also drove their learning, focusing them on different aspects of the ITS Center's PDE.

To illustrate this point, I'll briefly discuss three examples of concept interpretation that emerged from my analysis of the discussion and writing of each teacher. Mrs. Lewis interpreted inquiry as hands-on concept reinforcement, transfer as retention, and conceptual understanding as concept mastery. These ideas all aligned with her traditional approach to instruction and her concept mastery oriented instructional goals. Mrs. Major interpreted inquiry as information gathering, conceptual understanding as information gain and cooperative learning as peer-directed instruction. Again, these ideas aligned with her traditional-instructive views of teaching and her practices, which were aimed at minimizing opportunities for student mistakes. Mrs. Patton interpreted the concepts of inquiry, scaffolding and transfer in much the same way as the ITS Center's PDE intended. This aligned well with the understanding I developed of her as a reform-based teacher whose practice followed many of the recommendations of reform.

These various interpretations, and their alignments with the teachers' personal theories, demonstrated and lead to my third conclusion: that the teachers' personal theories and practices influenced what they focused on and/or noticed during the ITS Center's PDE and led to their interpretations. It appeared that what each teacher focused on or noticed depended on the problems they believed needed to be addressed within their own curriculums. These perceived problems stemmed from the various knowledge, skills, attitudes, and beliefs about teaching, learning, students, instructional goals, etc. the teachers brought with them to the ITS Center's PDE. I found that a quote from Schön's (1987) work illustrated what I am attempted to say here quite well:

> Depending on our disciplinary backgrounds, organizational roles, past histories, interests, and political/economic perspectives, we frame problematic situations in different ways. A nutritionist, for example, may convert a vague worry about malnourishment among children in developing countries into the problem of selecting the optimal diet. But agronomists may frame the problem in terms of food production; epidemiologists may frame it in terms of diseases that increase the demand for nutrients or prevent their absorption; demographers tend to see it in terms of a rate of population growth that has outstripped agricultural activity; engineers, in terms of inadequate food storage and distribution; economists, in terms of insufficient purchasing power or the inequitable distribution of land or wealth. In the field of malnourishment, professional identities and political/economic perspectives determine how people see a problematic situation, and debates about malnourishment revolve around the construction of a problem to be solved. Debates involve conflicting frames, not easily resolvable—if resolvable at all—by appeal to data. Those who hold conflicting frames pay attention to different facts and make different sense of the facts they notice. It is not by technical problem solving that we convert problematic situations to well-formed problems; rather, it is through the naming and framing that technical problem solving becomes possible.(p. 5)

Much like Schön's above description of different professionals framing the problem of malnourishment in different ways, so the three teachers in this study framed problems of learning. These conflicting frames focused their attentions on different ideas, leading to different perceptions of the problem(s) the reform literature addressed and different interpretations of the suggestions. Much like Schön's quote demonstrates, the problems the ITS Center's PDE sought to confront, which rested in the teachers' integration of IT and inquiry into their classrooms, were not named nor framed in the minds of Mrs. Lewis or Mrs. Major. The activities designed in this PDE, which focused on the technical solving of reform issues, were difficult, if not impossible; to begin before these frames were made.

My fourth conclusion emerged from my reflection on the first three. In order to help bring more traditional teachers, like Mrs. Lewis and Mrs. Major, to a place where they can begin to actively participate in the technical problem solving aspects of reform, we need to spend time helping them name and frame the problems we, as educational researchers, perceived as important. Without this vital first step, teachers approached the design and implementation of reform-based activities from a much different philosophy. This departure from the philosophy on which the ideas of reform are based can cause teachers' design and implementation of these ideas to become what Brown and Campione (1996) describe as "lethal mutations" where surface principles are enacted, yet deeper learning principles are left unnoticed. With the development of a common understanding of the problems reform addresses, the technical solving of those problems can begin, as Mrs. Patton's perceptions and interpretations demonstrated.

As the National Science Education Standards (National Research Council, 1996) declared, the enactment of the vision of reform they described requires substantive shifts in the thoughts and actions of many teachers. Traditional teachers, like Mrs. Lewis and Mrs. Major, are asked to learn large amounts of new knowledge, gain a large set of new skills and change attitudes and beliefs that have been formed through decades of observation and practice. Teachers are not being asked to name and frame the educational problems addressed by reform, they are being asked to enact the recommendations that are often steeped in research and philosophy alien to them. The final conclusion this study led me to is an understanding of the depth and breadth of the difficulty that confronted teachers and teacher educators as they traversed the swampy lowlands of reform.

So, how can PDE designers and teacher educators encourage and ease this path for teachers? What future research directions may help us better understand the challenges faced?

## Recommendations

The recommendations I make for the design of PDE stemmed from and were built on the conclusions drawn from this study. Much like the conclusions, each of the recommendations I describe is steeped in the complex philosophy that underlies many of the seemingly straightforward recommendations made by reform.

My first recommendation for the design of PDEs stemmed from both Schön's notion of naming and framing problems (1987), research on the design of effective learning environments (Bransford et al., 2000; Goldman et al., 1999; Loucks-Horsley et al., 2003) and what is known about adults as learners (Mundry, 2002). PDEs need to be based on learning goals that are meaningful and appropriate for both participants and instructors. Although this recommendation may sound simple, determining what a meaningful learning goal may be for a particular experience and audience is no simple task. As Broudy (1977) might have said, designers need to *know that* meaningful learning goals are important and what ideas may be meaningful and appropriate for a particular audience, *know how* to go about designing an experience that meets those goals and *know with* these understandings they can interpret the unique experience at hand and adapt them as need be.

Much like Schön discussed the differences between the views of nutritionists and economists when thinking about the problems of malnourishment, a goal that may be meaningful in the eyes of teacher educators may not appear meaningful to participants. I illustrate this point by returning to the cases of Mrs. Lewis, Mrs. Major and Mrs. Patton and my examination of their perceptions and interpretations of the ITS Center's PDE.

The educational learning goals of the ITS Center's PDE were grounded in a vision of reform-based practice. These goals were focused on facilitating teachers in the design, implementation and evaluation of inquiry cycles that involved IT and were based on current understandings about how students learn science. These goals were highly meaningful to the designers of the ITS Center's PDE and appeared to be meaningful for Mrs. Patton, a teacher whose practices were well aligned with the vision of reform. The more traditional teachers, Mrs. Lewis and Mrs. Major, did not seem to find the educational ideas and methods the ITS Center's PDE promoted to be as valuable. Their discussions of the educational research as not being relevant to their teaching and difficult for them to understand were evidence of the reduced value they held for it.

When asked about what they had found valuable, they discussed activities and information shown to them by the scientists. They appeared to interpret ideas included in the educational readings in a way that meshed with their personal practice theories, although they were removed them from the original philosophy, this turned the interpretations into what the educational community might consider “lethal mutations” (Brown & Campione, 1996). These placements of value and interpretations of ideas made the knowledge and skills the more traditional teachers gained from the ITS Center’s PDE much less meaningful in the eyes of reform, since they did not change the teacher-centered practices and personal theories the teachers held, nor did they foster an understanding of the vision of reform.

I defined the conflict I saw between the perceived meaningfulness and learning of the more traditional teachers from the ITS Center’s PDE as resting in the different problems that were named and framed by the different participants. Mrs. Patton was focused on a problem much similar to that of the ITS Center’s PDE. Her practice, discussions, IF and ARP focused on assessing the depth and flexibility of her students’ understanding. The problems Mrs. Lewis and Mrs. Major were focused on were, much like their practices and personal theories, more traditional in nature. Their problems involved student knowledge acquisition and retention. Without the naming and framing of a common problem, the learning goals that were so meaningful to those focused on reform, were difficult for those coming from more traditional perspectives to address.

In order for PDE developers to determine what learning goals may be meaningful and appropriate for their participants, an understanding of the participants’ perspectives is paramount. This idea frames my second recommendation, that an in-depth understanding of the knowledge, skills, attitudes, and beliefs of participants is necessary to determine what goals and methods may be most meaningful. As demonstrated by the analysis of the three teacher cases included in this study, understanding how they taught and what personal theories drove their practice was essential to understanding how they perceived and learned from the ITS Center’s PDE.

This is not to say that the designers of the ITS Center's PDE did not know or use this idea. How Students Learn (Donovan & Bransford, 2005), one of the main readings on which the design and delivery of the ITS Center's PDE was based, outlines the engagement of prior knowledge as the first of three fundamental ideas of learning. The team of education specialists involved in designing the ITS Center's PDE took great lengths to understand the technological skills and knowledge of reform the participants' demonstrated in their applications. Yet, the types of prior knowledge the designers had access to did not provide the type or depth of understanding necessary to determine what meaningful and appropriate learning goals were for all involved. They did not help us understand the array of different perspectives on teaching from which the participants came.

The three cases included in this study illuminated the importance of determining how closely aligned teachers' personal theories are with the goals of those involved in designing a PDE. These alignments are not easily uncovered. An instrument that allows the user to probe teachers ideas deeply, such as the Teacher Beliefs Interview (Luft & Roehrig, 2007), is necessary to sort through jargon that is often interpreted incorrectly and uncover the personal theories on which interpretations were based.

My third recommendation for the design and delivery of PDEs is that, in addition to understanding the personal theories teachers bring with them to a PDE, understanding how they develop throughout a PDE is essential. This can only be achieved through continuous and adaptive assessment that reveals, to both instructors and participants, how new ideas are understood and how personal theories are engaged, changed, and connected. Much like all learning environments, PDEs need to be metacognitive and designed to help teachers understand how their ideas relate to those of other teachers as well as the learning goals of the PDE and help them to take charge of their own learning (Donovan & Bransford, 2005).

Constructivist learning environments that support these ideas are complex (Mundry, 2002) and designing and delivering them is no simple task. The same levels of expertise needed by teachers to carry out inquiry-based practices discussed in Chapter II are necessary for teacher educators to carry out PDEs that effectively engage and change teachers' personal theories. This is the essence of my fourth recommendation. Teacher educators need to have high levels of pedagogical content knowledge (Shulman, 1987) (or perhaps andragogical content knowledge?) and the ability to creatively and efficiently adapt that knowledge as the complex decisions of reform-based teaching are confronted (Darling-Hammond & Bransford, 2005; Sawyer, 2004).

My final recommendation for the design and delivery of PDEs is that those involved in their execution remember that change is hard. The challenges involved in understandings and implementing the ideas of reform for those teachers, whose personal theories differ significantly, are numerous.

## Directions for Future Research

The recommendations for the design of PDEs outlined in the previous section indicate areas where more research may be beneficial. This final section recommends a focus of future research on two broad areas, teacher learning progressions and teacher educator PCK. It would be beneficial for future research to address these areas in order to better equip those involved in teacher education to face the challenges of facilitating reform.

The first of the two areas I described is that of the development of learning progressions for teachers of science. Learning progressions as described by Duschl (2008) are anchored on one end by what is known about the concepts and learners' abilities to reason about them and at the other end by the goals society expects learners to achieve. What a learning progression proposes is an intermediate of these two anchors, a "reasonably coherent network of ideas and practices that contribute to building a more mature understanding" (p. 220). Duschl goes on to say that "by thinking hard about what initial understandings need to be drawn on in developing new understandings, learning progressions highlight important precursor understandings that might otherwise be overlooked by teachers and educators" (p. 220).

An important area for future research is the development of learning progressions for teachers that are, as Duschl describes, anchored on one end by what is known about teachers' concepts and reasoning as it relates to reform and on the other by the vision of reform. As described in Chapter II, research abounds in many of the areas that would support the development of these progressions. Once developed, these learning progressions could facilitate the work of teacher educators and researchers by providing road maps of ideas that may facilitate the understanding of how to teach teachers who have differing opinions about reform. This understanding could, in turn, lead to a better understanding of the initial knowledge, skills, attitudes, and beliefs necessary for teachers to engage in the technical problem solving of reform. This understanding could also aid in determining the types of instructional activities that would contribute to teachers' development of a more thorough and sophisticated understanding of reform.

My second and final recommendation for future research deals with characterizing the PCK of teacher educators. In my search of the literature, I found a great deal of research that characterized the design of effective PDEs, yet found very little that described the necessary expertise of teacher educators. As described in Chapter II, research abounds on the crucial role teacher expertise plays in student learning and the different types of expertise, above and beyond knowledge of content, necessary to teach well. The knowledge needed by teacher educators is even more complex than that of traditional teachers. Teacher educators need to know, understand, and flexibly apply two layers of knowledge and skill. The first involves the content, curriculum, and pedagogical content knowledge of the learners' they instruct. The second involves the content, curriculum, and pedagogical content knowledge involved in designing and delivering PDEs that facilitate and encourage teachers to think about their practice in new ways.

For example, an extremely effective elementary teacher educator may not be as effective with high school teachers or college faculty. Although there may be many common elements, working with such vastly different groups of educators requires vastly different understandings, including those of content, pedagogy, and learners. In order to understand the differences and similarities, the domain-general and domain-specific skills, involved in the understandings of those who educate teachers and to widen the circle of those who understand reform and deliver effective PDEs, a great deal of research is needed.

These two areas of research, developing learning progressions and understanding teacher educator PCK, are complex and highly related. The understandings gained through research on one area will directly influence and facilitate understanding in the other. The development of learning progressions for different types of teachers and teachers with different orientations toward reform will directly implicate elements of pedagogical content knowledge important for teacher educators and vice versa. Both areas of research would also thicken the stock of understanding on which effective PDEs for both teachers and teacher educators are based.

## Concluding Remarks

In closing, I find it important to make explicit what I found to be the main take-home message of this study, a message I found most eloquently summarized in a short poem by noted psychologist Ronald D. Laing:

The range of what we think and do
Is limited by what we fail to notice
And because we fail to notice
That we fail to notice
There is little we can do
To change
Until we notice
How failing to notice
Shapes our thoughts and deeds

As this study illustrated, it is just as easy for those new to ideas to fail to notice or understand the essential features of them as it is for experts to fail to understand or notice the struggles of those who are new. It is only by keeping a mind open enough to begin to "notice how failing to notice shapes our thoughts and deeds" and helping others to do the same that current visions of science education reform may become reality.

# REFERENCES


Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckman (Eds.), *Action control* (pp. 11-39). Berlin, Germany: Springer-Verlag.

American Association for the Advancement of Science (1990). *Science for all Americans*. New York: Oxford University Press.

American Association for the Advancement of Science (1993). *Benchmarks for science literacy*. New York: Oxford University Press.

American Association for the Advancement of Science (2008). *Benchmarks for science literacy* (2nd ed.). New York: Oxford University Press.

Anderson, J. R., Reder, L. M., & Simon, H. A. (1996). Situated learning and education. *Educational Researcher, 25*(4), 5-96.

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*, 1-12.

Anderson, R. D., & Helms, J. V. (2001). The ideal of standards and the reality of schools: Needed research. *Journal of Research in Science Teaching, 38*(1), 3-16.

Au, K., & Jodan, C. (1981). Teaching reading to Hawiian children: Finding a culturally appropriate solution. In H. Tureba, G. Gunthrie & K. Au (Eds.), *Culture and the bilingual classroom: Studies in classroom ethnography* (pp. 139-152). Rowley, MA: Newbury.

Ball, D. L., & Cohen, D. K. (1999). Developing practice, developing practitioners: Towards a practice-based theory of professional education. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession* (pp. 3-32). San Francisco: Jossey-Bass.

Bandura, A. (1999). A social cognitive theory of personality. In L. Pervin & O. John (Eds.), *Handbook of personality* (2nd ed., pp. 154-196). New York: Guilford Publications.

Barber, M. (2002, April). *From good to great: Large-scale reform in England.* Paper presented at the Futures of Education conference, Universität Zürich, Zürich.

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn: A taxonomy for far transfer. *Psychological Bulletin, 128*(4), 612-637.

Barron, B. S. J., Schwartz, D. L., Vye, N. J., Moore, A., Petrosino, A. J., Zech, L. et al. (1998). Doing with understanding: Lessons from research on problem and project-based learning. *The Journal of the Learning Sciences, 7*(3&4), 271-311.

Battista, M. T. (1994). Teacher beliefs and the reform movement of mathematics education. *Phi Delta Kappan, 75*(6), 462-470.

Bell, A. W. (1982a). Diagnosing student misconceptions. *The Australian Mathematics Teacher, 1*, 6-10.

Bell, A. W. (1982b). Treating students' misconceptions. *The Australian Mathematics Teacher, 2*, 11-13.

Bell, R. L., Blair, L. M., Crawford, B. A., & Lederman, N. G. (2003). Just do it?: Impact of a science apprenticeship program on high school students' understandings of the nature of science and scientific inquiry. *Journal of Research in Science Teaching, 40*(5), 487-509.

Birman, B. F., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing professional development that works. *Educational Leadership, 57*, 28-33.

Bogden, R. C., & Biklen, S. K. (2003). *Qualitative research for education: An introduction to theories and methods* (4th ed.). Boston: Allyn & Bacon.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Bransford, J. D., & Schwartz, D. L. (1999). Rethinking transfer: A simple proposal with multiple implications. *Review of Research in Education, 24*, 61-100.

Bransford, J. D., & Stein, B. S. (1993). *The IDEAL problem solver* (2nd ed.). New York: Freeman.

Bransford, J. D., Stein, B. S., Vye, N. J., Franks, J. J., Auble, P. M., Mezynski, K. J. et al. (1982). Differences in approaches to learning: An overview. *Journal of Experimental Psychology: General, 3*(4), 390-398.

Brickhouse, N. W. (1990). Teachers' beliefs about the nature of science and their relationship to classroom practice. *Journal of Teacher Education, 41*(3), 53-62.

Broudy, H. S. (1977). Types of knowledge and purposes of education. In R. C. Anderson, R. J. Spiro & W. E. Montague (Eds.), *Schooling and the acquisition of knowledge* (pp. 1-17). Hillsdale, NJ: Erlbaum.

Brown, A. L., & Campione, J. C. (1996). Psychological theory and the design of innovative learning environments: On procedures, principles, and systems. In L. Schauble & R. Glaser (Eds.), *Innovations in learning new environments for education* (pp. 289-325). Mahwah, NJ: Erlbaum.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Brown, S. L., & Melear, C. T. (2006). Investigation of secondary science teachers' beliefs and practices after authentic inquiry-based experiences. *Journal of Research in Science Teaching, 43*(9), 938-962.

Brownlee, J., Boulton-Lewis, G., & Purdie, N. (2002). Core beliefs about knowing and peripheral beliefs about learning: Developing an holistic conceptualisation of epistemological beliefs. *Australian Journal of Educational & Developmental Psychology, 2*, 1-16.

Bruer, J. T. (1993). *Schools for thought*. Cambridge, MA: The MIT Press.

Campione, J. C., & Brown, A. L. (1987). Linking dynamic assessment with school achievement. In C. S. Lidz (Ed.), *Dynamic assessment: An interactional approach to evaluating learning* (pp. 82-114). New York: Guilford.

Carraher, T. N., Carraher, D. W., & Schiemann, A. D. (1985). Mathematics in the street and in school. *British Journal of Developmental Psychology, 3*, 21-29.

Chase, W. G., & Simon, H. A. (1973). Perception in chess. *Cognitive Psychology, 4*(1), 55-81.

Chinn, C. A., & Malhotra, B. A. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education, 86*(2), 175-218.

Cognition and Technology Group at Vanderbilt (1998). Designing environment to reveal, support, and expand our children's potentials. In S. A. Soraci & W. McIlvane (Eds.), *Perspectives on fundamental processes in intellectual fundtioning* (Vol. 1, pp. 313-350). Greenwich, CN: Ablex.

Cohen, D. K. (1990). A revolution in one classroom: The case of Mrs. Oublier. *Educational Evaluation and Policy Analysis, 12*(3), 311-329.

Collins, A. (2006). Cognitive apprenticeship. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 47-60). Cambridge, MA: Cambridge University Press.

Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the craft of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453-494). Hillsdale, NJ: Erlbaum.

Collins, K. M. T., Onwuegbuzie, A. J., & Sutton, I. L. (2006). A model incorporating the rationale and purpose for conducting mixed methods research in special education and beyond. *Learning Disabilities: A Contemporary Journal, 4*(1), 67-100.

Cooney, T. J., & Shealy, B. E. (1997). On understanding the structure of teachers' beliefs and their relationship to change. In E. Fennema & B. S. Nelson (Eds.), *Mathematics teachers in transition* (pp. 87-109). Mahwah, NJ: Erlbaum.

Cornett, J. W., Yeotis, C., & Terwilliger, L. (1990). Teacher personal practical theories and their influence upon teacher curricular and instructional actions: A case study of a secondary science teacher. *Science Education, 74*, 59-70.

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, V. M., Schlager, M., Toyama, Y., Riel, M., & Vahey, P. (2005, April). *Characterizing adaptive expertise in science teaching.* Paper presented at the American Educational Research Association, Montreal, Quebec, Canada.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage.

Cronin-Jones, L. L. (1991). Science teacher beliefs and their influence on curriculum implementation: Two case studies. *Journal of Research in Science Teaching, 28*(3), 235-250.

Darling-Hammond, L. (1997). School reform at the crossroads: Confronting the central issue of teaching *Educational Policy, 11*(2), 151-166.

Darling-Hammond, L., & Bransford, J. D. (2005). *Preparing teachers for a changing world: What teachers should learn and be able to do*. San Francisco: Jossey-Bass.

Darling-Hammond, L., & McLaughlin, M. (1995). Policies that support professional development in an era of reform. *Phi Delta Kappan, 76*, 597-604.

Davis, K. S. (2003). "Change is hard": What science teachers are telling us about reform and teacher learning of innovative practices. *Science Education, 87*(1), 3-30.

Desimone, L., Porter, A. C., Garet, M. S., Yoon, K. S., & Birman, B. F. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis, 24*(2), 81-112.

Detterman, D. K. (1993). The case for prosecution: Transfer as an epiphenomenon. In D. K. Detterman & R. J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition, and instruction* (pp. 1-24). Norwood, NJ: Ablex.

Dewey, J. (1933). *How we think*. Buffalo, NY: Prometheus Books.

Donovan, S. M., & Bransford, J. D. (2005). *How students learn: History, mathematics, and science in the classroom*. Washington, DC: National Academy Press.

Duschl, R. A. (2008). *Taking science to school*. Washington, DC: National Academy Press.

Edelson, D. C. (1997). Realising authentic science learning through the adaptation of scientific practice. In K. Tobin & B. Fraser (Eds.), *International handbook of science education* (pp. 317-332). Dordrecht, Netherlands: Kluwer.

Edelson, D. C., Gordin, D. N., & Pea, R. D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *The Journal of the Learning Sciences, 8*(3&4), 391-450.

Ericsson, K. A., Krampe, R. T., & Tesch-Romer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*(3), 363-406.

Etheredge, S., & Rudnitsky, A. (2003). Guidelines for developing inquiry units *Introducing students to scientific inquiry: How do we know what we know*. Boson, MA: Allyn and Bacon.

Feiman-Nemser, S., & Buchmann, M. (1986). The first year of teacher preparation: Transition to pedagogical thinking? *Journal of Curriculum Studies, 18*, 239-256.

Fishbein, M. (1967). A consideration of beliefs, and their role in attitude measurement *Readings in attitude, theory and measurement* (pp. 257-266). New York: Wiley.

Fullan, M. G. (1993). *Change forces: Probing the depths of educational reform*. London: Falmer Press.

Fullan, M. G. (2003). *Change forces with a vengeance*. London: RoutledgeFalmer.

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.

Geertz, C. (1973). Thick description: Toward an interpretive theory of culture *Interpretation of cultures* (pp. 3-28). New York: Basic Books.

Gess-Newsome, J. (1999). Pedagogical content knowledge: An introduction and orientation. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 3-17). Dordrecht, Netherlands: Kluwer.

Gess-Newsome, J., Southerland, S. A., Johnston, A., & Woodbury, S. (2003). Educational reform, personal practical theories, and dissatisfaction: The anatomy of change in college science teaching. *American Educational Research Journal, 40*(3), 731-767.

Goldman, S. R., Petrosino, A. J., & Cognition and Technology Group at Vanderbilt (1999). Design principles for instruction in content domains: Lessons from research on expertise and learning. In F. T. Durso, R. S. Nickerson, R. W. Schavaneveldt, S. T. Dumais, D. S. Lindsay & M. T. H. Chi (Eds.), *Handbook of applied cognition* (pp. 595-627). Boston: Wiley.

Gregoire, M. (2003). Is it a challenge or a threat?: A dual-process model of teachers' cognition and appraisal process during conceptual change. *Educational Psychology Review, 15*(2), 147-179.

Hasweh, M. Z. (1996). Effects of science teachers' epistemological beliefs in teaching. *Journal of Research in Science Teaching, 33*(1), 47-63.

Hatano, G., & Inagaki, K. (1986). Two courses of expertise. In H. Stevenson, H. Azuma & K. Hakuta (Eds.), *Child development and education in Japan*. New York: Freeman.

Henderson, C. (2005). The challenges of instructional change under the best of circumstances: A case study of one college physics instructor. *American Journal of Physics, 73*(8), 778-786.

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.

Jones, G. M., & Carter, T. (2007). Science teacher attitudes and beliefs. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education*. Mahwah, NJ: Erlbaum.

Kagan, S., & Kagan, M. (1998). *Multiple intelligences - The complete MI book*. San Clemente, CA: Kagan Cooperative Learning.

Kang, N.-H., & Wallace, C. S. (2005). Secondary science teachers' use of laboratory activities: Linking epistemological beliefs, goals, and practices. *Science Education, 89*, 140-165.

Klahr, D., & Carver, S. M. (1988). Cognitive objectives in a LOGO debugging curriculum: Instruction, learning and transfer. *Cognitive Psychology, 20*, 362-404.

Klausmeier, H. J. (1985). *Educational psychology* (5th ed.). New York: Harper & Row.

LaPlante, B. (1997). Teachers' beliefs and instructional strategies in science: Pushing analysis further. *Science Education, 81*, 277-294.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life*. Cambridge, MA: Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, MA: Cambridge University Press.

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. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching, 36*(8), 916-929.

Lieberson, S. (1992). Small N's and big conclusions: An examination of the reasoning behind comparative case studies based on a small number of cases. In C. C. Ragin & H. S. Becker (Eds.), *What is a case? Exploring the foundations of social inquiry*. Cambridge, MA: Cambridge University Press.

Lincoln, Y., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage.

Lionni, L. (1970). *Fish is fish*. New York: Dragonfly Books.

Lortie, D. C. (1975). *Schoolteacher: A sociological study of teaching*. Chicago: University of Chicago Press.

Lotter, C., Harwood, W. S., & Bonner, J. J. (2007). The influence of core teaching conceptions on teachers' use of inquiry teaching practices. *Journal of Research in Science Teaching, 44*(9), 1318-1347.

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.

Luft, J. A., & Roehrig, G. H. (2007). Capturing science teachers' epistemological beliefs: The development of the teacher beliefs interview. *Electronic Journal of Science Education, 11*(2), 38-53.

Lumpe, A. T., Haney, J. J., & Czerniak, C. M. (1998). Science teacher beliefs and intentions to implement science-technology-society (STS) in the classroom. *Journal of Science Teacher Education, 9*(1), 1-24.

Magnusson, S., Krajcik, J. S., & Borko, H. (1999). Nature, sources, and development of pedagogical content knowedge for science teaching. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 95-132). Dordrecht, Netherlands: Kluwer.

Manconi, L., Aulls, M. W., & Shore, B. M. (2008). Teachers' use and understanding of strategy in inquiry instruction. In B. M. Shore, M. W. Aulls & M. A. Delcourt (Eds.), *Inquiry in education* (Vol. 2, pp. 247-269). Mahwah, NJ: Erlbaum.

McCombs, B. L. (1996). Alternative perspectives for motivation. In L. Baker, P. Afflerback & D. Reinking (Eds.), *Developing engaged readers in school and home communities* (pp. 67-88). Mahwah, NJ: Erlbaum.

McLaughlin, C. W., & Thompson, M. (1997). *Physical science*. Westerville, OH: McGraw Hill.

McRobbie, C., & Tobin, K. (1997). A social constructivist perspective on learning environments. *International Journal of Science Education, 19*(2), 193-208.

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.

Monk, D. H. (1994). Subject area preparation of secondary mathematics and science teachers and student achievement. *Economics of Education Review, 13*(2), 125-145.

Mundry, S. (2002). Honoring adult learners: Adult learning theories and implications for professional development. In J. Rhoton, P. Bowers & P. Shane (Eds.), *Science teacher retention: Mentoring and renewal* (pp. 123-132). Arlington, VA: National Science Teachers Association Press.

National Center for Education Statistics (2000). *NAEP 1999 trends in academic progress: Three decades of student performance*. Washington, DC: U.S. Department of Education.

National Research Council (1996). *National science education standards: Observe, interact, change, learn*. Washington, DC: National Academy Press.

National Research Council (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Academy Press.

Newman, D., Griffin, P., & Cole, M. (1989). *The construction zone: Working for cognitive change in school*. New York: Cambridge University Press.

No Child Left Behind Act (2001). Pub L. No 107-110, 115 Stat 1425 Retrieved July 6, 2008, from http://www.ed.gov/legislation/ESEA02

Orum, A. M., Feagin, J. R., & Sjoberg, G. (1991). The nature of the case study. In J. R. Feagin, A. M. Orum & G. Sjoberg (Eds.), *A case for the case study* (pp. 1-26). Chapel Hill: University of North Carolina Press.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.

Palinscar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 1*(2), 117-175.

Pezdek, K., & Miceli, L. (1982). Life span differences in memory integration as a function of processing time. *Developmental Psychology, 18*(3), 485-490.

Porter, A. C., Garet, M. S., Desimone, L., & Birman, B. F. (2003). Providing effective professional development: Lessons from the Eisenhower program. *Science Educator, 12*(1), 23-40.

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4-15.

Salomon, G., & Perkins, D. N. (1989). Rocky roads to transfer: Rethinking mechanisms of a neglected phenomenon. *Educational Psychologist, 21*(2), 113-142.

Sawyer, R. K. (2004). Creative teaching: Collaborative discussion as disciplined improvisation. *Educational Researcher, 33*(2), 12-20.

Schön, D. A. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions*. San Francisco: Jossey-Bass.

Schwartz, D. L., Bransford, J. D., & Sears, D. (2005). Efficiency and innovation in transfer. In J. P. Mestre (Ed.), *Transfer of learning from a modern multidisciplinary perspective* (pp. 1-51). Greenwich, CT: Information Age.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Simon, H. A., & Chase, W. G. (1973). Skill in chess. *American Scientist, 61*, 394-403.

Singley, K., & Anderson, J. R. (1989). *The transfer of cognitive skill*. Cambridge, MA: Harvard University Press.

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), 5-36.

Smith, L. K., & Southerland, S. A. (2007). Reforming practice or modifying reforms? Elementary teachers' response to the tools of reform. *Journal of Research in Science Teaching, 44*(3), 396-423.

Smith, T. M., Desimone, L. M., Zeidner, T. L., Dunn, A. C., Bhatt, M., & Rumyantseva, N. L. (2007). Inquiry-oriented instruction in science: Who teaches that way? *Educational Evaluation and Policy Analysis, 29*(3), 169-199.

Southerland, S. A., Smith, L. K., Sowell, S. P., & Kittleson, J. M. (2007). Resisting unlearning: Understanding science education's response to the United States national accountability movement. *Review of Research in Education, 31*, 45-77.

Stake, R. E. (2006). *Multiple case study analysis*. New York: Guilford Press.

Stuessy, C. L. (2002). Visualizing complexity in science classroom learning environments. *Proceedings of the Information Systems Education Conference (ISECON), 19*, 224d.

Stuessy, C. L. (2005). *Texas A&M University EDCI 666 Course Syllabus*.Unpublished manuscript.

Tashakkori, A., & Teddlie, C. (2002). *Mixed methodology: Combining qualitative and quantitative approaches*. Thousand Oaks, CA: Sage.

Vesilind, E. M., & Jones, G. M. (1998). Gardens or graveyards: Science education reform and school culture. *Journal of Research in Science Teaching, 35*(7), 757-775.

Vosniadou, S., & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology, 24*, 535-585.

Vosniadou, S., & Ioannides, C. (1998). From conceptual development to science education: A psychological point of view. *International Journal of Science Education, 20*(10), 1213-1230.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wenger, E. (1998). *Communities of practice: Learning meaning and identity*. Cambridge, MA: Cambridge University Press.

White, B. Y., & Frederiksen, J. R. (2000). Metacognitive facilitation: An approach to making scientific inquiry accessible to all. In J. Minstrell & E. H. van Zee (Eds.), *Inquiring into inquiry learning and teaching in science* (pp. 331-370). Washington, DC: American Association for the Advancement of Science.

Wiggins, G. (1998). *Educative assessment*. San Francisco: Jossey-Bass.

Wiggins, G., & McTighe, J. (1998). *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development.

Wolcott, H. F. (1992). Posturing in qualitative inquiry. In M. D. LeCompte, W. L. Millroy & J. Preissle (Eds.), *Handbook of qualitative research in education* (pp. 3-52). San Diego, CA: Academic Press.

Wolcott, H. F. (1994). *Transforming qualitative data: Description, analysis, and interpretation*. Thousand Oaks, CA: Sage.

Wolcott, H. F. (2001). *Writing up qualitative research* (2nd ed.). Thousand Oaks, CA: Sage.

Wright, S. P., Horn, S. P., & Sanders, W. L. (1997). Teacher and classroom context effects on student achievement: Implications for teacher evaluation. *Journal of Personnel Evaluation in Education, 11*(1), 57-67.

Yerrick, R., Parke, H., & Nugent, J. (1997). Struggling to promote deeply rooted change: The "filtering effect" of teachers' beliefs on understanding transformational views of teaching science. *Science Education, 81*, 137-157.

Yin, R. (1994). *Case study research: Design and methods*. Thousand Oaks, CA: Sage.

Yore, L. D. (2001). What is meant by constructivist science teaching and will the science education community stay the course for meaningful reform? *Electronic Journal of Science Education, 5*(4).

# APPENDIX A

# ITS PDE SUMMER I SYLLABUS

## EDCI 666: Advanced Secondary Science Methods
## Department of Teaching, Learning, and Culture

Second Summer Session 2005

**Instructor of Record**

Dr. Carol L. Stuessy
Texas A&M University – 4232 TAMU
Harrington 348f
College Station, TX 77843-4232
Voice: 979-845-8256
Email: c-stuessy@tamu.edu

**Office Hours**

Office hours, constrained by the AM-PM schedules of ITS science and education courses offered during the three weeks of instruction, are made by appointment only. Please contact the instructor by person or e-mail to arrange a time to meet.

**Meeting Place and Times**

1:00-5:00, Harrington Tower, Room 636 and CRP Meeting Rooms

| | | |
|---|---|---|
| | *Mon, July 11 | *Mon, July 18 |
| Tues, July 5 | *Tues, July 12 | *Tues, July 19 |
| *Wed, July 6 | *Wed, July 13 | *Wed, July 20 |
| *Thurs, July 7 | *Thurs, July 14 | Thurs, July 21 |
| Fri, July 8 | Friday, July 15 | Friday, July 22 |

* Indicates 4:00-5:00 PM Forum Options

**General Course Overview**

The aim of this course is to contribute to the ITS Center's model for professional development by guiding ITS participants to connect findings from **scientific research using information technology** and **education research from the learning sciences** to create **new types of science learning environments** in their classrooms. This course, specifically customized for ITS participants, is offered as a graduate-level science education course in the Department of Teaching, Learning & Culture (College of Education and Human Development). ITS participants include:

- Classroom practitioners (K-16)
- Full- and part-time science education graduate students
- Full- and part-time science graduate students

In EDCI 666, ITS participants will work and learn in a community of **distributed expertise**. Members of school and university communities come together to share their expertise and experiences so that they can learn from one another. Individuals bring their own expertise in teaching, learning, and research to explore answers to a complex yet practical question about the teaching of science:

**How can scientific research using information technology** and **education research from the learning sciences** be connected to create **new types of science learning environment that enhances my students' conceptual understanding of science?**

The Instructional Team of EDCI 666 includes eleven graduate student mentors (CRPS, short for "Campus Resource Persons") and numerous university educators. They join an even larger team that includes five Scientific Teams and approximately sixty ITS participants. Together they will explore, investigate, design, and test new types of K-16 classroom science learning environments. Together these collaborators will advance knowledge about how best to use **information technology** (IT, that is, hardware and software for visualization, modeling, and manipulation of complex data sets in scientific research contexts), **authentic scientific research**, and **research from the learning sciences** to the design of **science classroom learning environments** to enhance science **classroom learners' conceptual understanding** of how the world works.

**What are the learning goals of EDCI 666 for ITS participants and their students?**

This course has two tightly woven goals. They address (a) **the enhancement of science classroom learners' understanding** about the natural world and how scientists use IT to create new knowledge about it, ***through*** (b) **the enhancement of science teachers' understanding** about how information from the communities of education and science can be combined in their teaching to enhance their learners' understanding of science. This **second goal** (b) is accomplished in the intensive three-week courses provided by the ITS Institute. The **first goal** (a) is accomplished when ITS participants can apply and connect their new learning in their own teaching contexts. While this three-week course focuses on the professional development of ITS participants (Goal b), the first goal (Goal a) occurs with classroom application that occurs after the three-week course in completed.

How are the learning goals of EDCI 666 connected to the goals of the morning course I am taking with a team of scientists?

The first summer of the ITS professional development program completes one-half of the course work required for the ITS Certificate, which spans a full two years and two summers of work with scientists and university educators. In their work with **scientists**, ITS participants engage in **collaborative scientific research** within a laboratory environment to learn about, investigate, and discover aspects of the natural world through the use of IT. In their work with **university science educators**, ITS participants engage in **collaborative problem solving to design ways** to bring the scientific experiences they have had in working in their scientific teams into their own classrooms with the purpose of enhancing students' conceptual understanding of science. Learning goals for EDCI 666 are consistent with research-based practices from the learning sciences, which will be described, discussed, and applied by ITS participants. Participants will design and implement their designs of instruction, which we call Instructional Frameworks (IFs). Design specifications for IFs are **consistent not only with research-based practices regarding teaching and learning;** they are also **consistent with the scientific experiences that participants have had in their laboratory work with scientists**.

**How are the learning goals of Summer I connected to the learning goals of Summer II?**

Participants bring back with them in Summer II the results of their implementation experiences to share with the members of their Scientific and Instructional Teams. In Summer II, participants again will engage in collaborative scientific research in their time with their Scientific Teams. The second summer, participants will be more finely tuned to perfect knowledge and skills they themselves will need in order to better address the learning needs of their students. In their second summer course with the Instructional Team, participants again will engage in collaborative problem solving to result in **two learning products**: (a) **A revised IF**, sometimes called the "intervention," that has been informed by the implementation of a "pilot test" during the first year; and (b) **A Research Blueprint** that will formally test the effects of the IF on student learning outcomes. In Summer II, the Instructional Team's focus turns to answer questions about how we know what effects the IF has had on student outcomes, which may include enhanced scientific understanding, new or renewed interest in science, motivation to do further inquiries on their own, and others.

**Connections appear to be very important in the way that the ITS professional development experience is designed. Would you please provide more details about how the different experiences relate to one another?**

At the end of the two-year professional development sequence, ITS Participants will be able to bring knowledge from **two disciplines** (science and education) together to **explain, apply, and connect information** about

- How **scientific research using IT** can contribute to new knowledge and new ways of learning about how the world works; and
- How **educational research about how people learn (HPL)** can contribute to new knowledge about new ways to teach and learn science

Please see Figure 1 to see how processes and products of the ITS Center connect between Scientific and Instructional Teams, between summer institutes and school year implementations, and between Summer I and Summer II experiences.

***What theory, research, and practice have guided the design and delivery of this course?***

**Thinking about the design of the course learning environment.--** Recent research and development in theories and practices of the learning sciences are summarized in the book entitled *How People Learn* (HPL, Bransford, Brown, & Cocking, 2000) and more recently in the textbook for this course, *How Students Learn* (HSL, Donovan & Bransford, 2005). Information from the learning sciences as presented in these two books has guided decision-making involved in the design and delivery of this course. The goal of the Instructional Team has been to create a learning environment for ITS participants that uses the lenses of the learning scientist to create a learner-, knowledge-, assessment-, and community-centered learning environment. Use of these lenses is modeled in this course. They are directly transportable to participants' own classrooms and provide practical methods for designing more effective learning environments. Different formats for teaching and learning, which include CRP Meeting Groups, PM Forum, Large-Group Presentations, and One-on-One Meetings, have all been developed to model an interactive learning environment based on the HPL Principles.

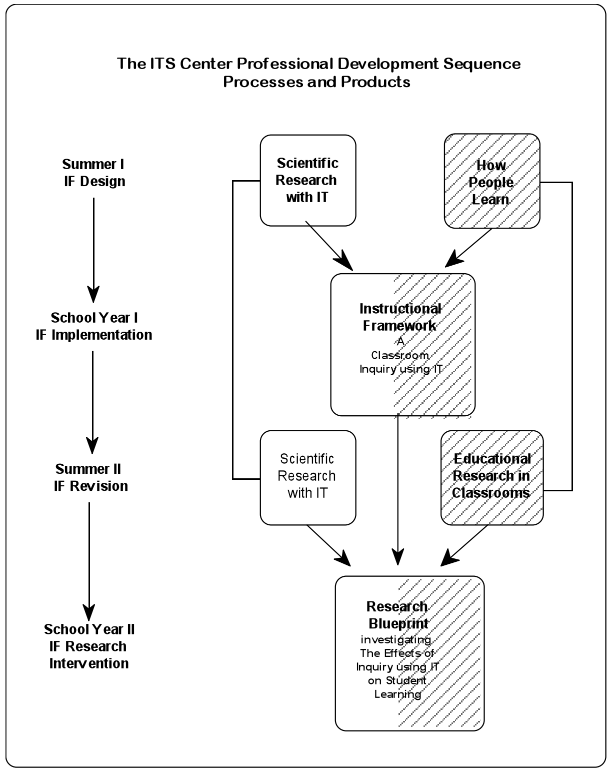


*Figure 1.* Diagram illustrating how **scientific research using IT** and **educational research about how people learn (HPL)** contribute to participants' practical knowledge and abilities to design research about the effects of that practice on student learning outcomes.

**Thinking about the design of authentic science research learning experiences that use information technology in the classroom.--** Edelson's (1998) paper outlining research and development of strategies to adapt authentic scientific practice for the classroom has also informed development of this class. Edelson develops a strong rationale for making science learning more like scientific practice. He outlines potential benefits by saying that "Students become active learners, they acquire scientific knowledge in a meaningful context, and they develop styles of inquiry and communication that will help them to be effective learners" (p. 1). Edelson makes a strong case for adapting scientific practice to be as authentic as possible. He provides guidelines for curriculum, teacher preparation, and the development of learner-appropriate resources, tools and techniques to achieve authenticity in the science learning environment. The authenticity of the science learning experience is the key to closing the gap that usually exists between how science is taught and learned in the classroom and how science is actually done in the scientist's laboratory. Edelson's practical suggestions and useful advice have advanced the Instructional Team's understanding about how best to assist ITS participants in adapting their authentic scientific experiences in their Scientific Teams to fit the context of their own classrooms. Edelson's paper has informed the development of the curriculum structure of the Instructional Framework (IF). ITS participants will use their IF to communicate their ideas about transforming authentic laboratory research to classroom settings; their new visions of classroom inquiry and assessment for conceptual understanding; and their work with scientists to transport, build, and/or modify the IT that is used in the laboratory to make it appropriate for classroom use.

**Thinking about an immersion approach to inquiry.--** In regard to inquiry, the Instructional Team has have been informed by the work of Bonnstetter (1998), who presents a quite reasonable and understandable framework for classroom inquiry; Chinn & Malhotra (2002), who address complex issues surrounding the nature of classroom inquiry; and Etheredge & Rudnitsky (2002), who have written a charming and practical book about designing inquiry instruction. This methods book focuses on designing instruction that leads students to understand the role of evidence in supporting claims to *know* something. These authors view inquiry instruction as an iterative process of **immersion** with the variables within the system, from which **researchable questions** are developed, **student research** is planned and implemented, and new knowledge is used in the completion of **consequential tasks** that require learners to apply their knowledge in new contexts. Etheredge and Rudnitsky's simple model has been chosen as the heuristic to guide and inform participants' thinking about the design of their own classroom inquiries.

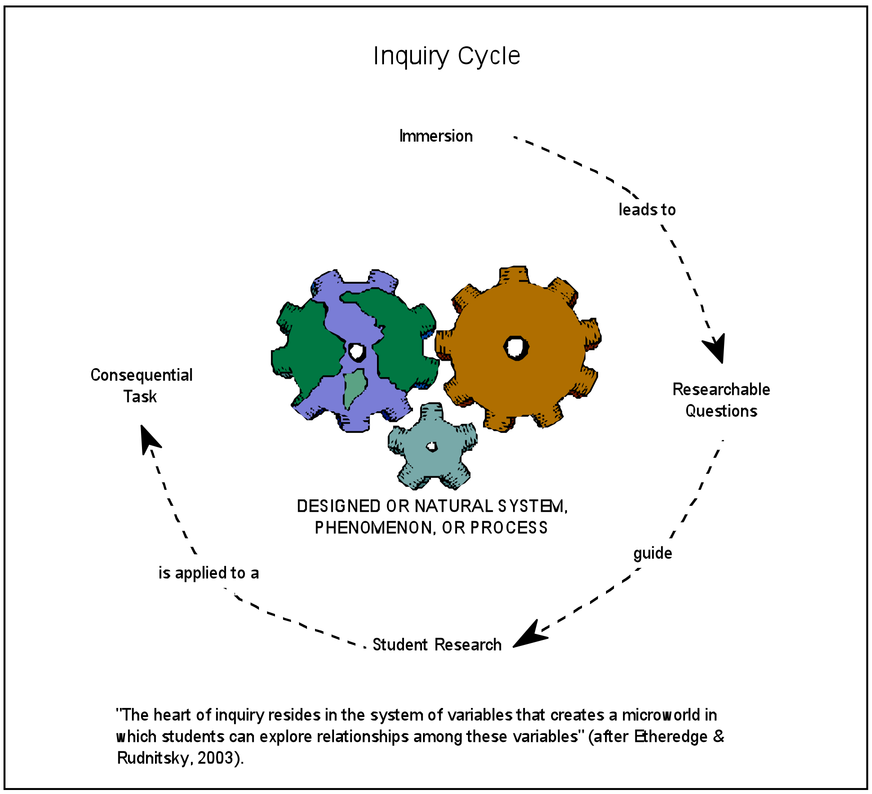


*Figure 2.*The inquiry model for the design of the Instructional Framework (terminology from Etheredge & Rudnitsky, 2003).

**Thinking about assessment for conceptual understanding. --** Compatible with inquiry resources is the work of Wiggins and McTighe (1998), whose conceptualization of the "backwards design" approach has had a major impact on the assessment of students' understanding. In their approach, curriculum is the means to the end. "One starts with the end—the desired results (goals or standards)—and then derives the curriculum from the evidence of learning (performances) called for by the standard and the teaching needed to equip students to perform" (p. 8.). Also of use to us in thinking about assessment has been the book by O'Sullivan & Weiss (1999), written for the U.S. Department of Education and Office of

Educational Research and Improvement to explain and provide excellent examples of assessments from the National Assessment of Educational Progress (NAEP).

**What do the HPL Principles "look like" in the course? In other words, would you please explain the application of the HPL Principles a little more?**

***Knowledge-Centered Principles***. – We strive to be clear about the learning goals of this course. By the end of the course, participants will be able to explain how educational theory and research about how people learn can drive teachers' decision-making about the design of an inquiry-based learning experience for their students. Participants should also understand how inquiry-based teaching and learning can achieve authenticity in the classroom and how an assessment plan centered on conceptual understanding and applied through a process of backward design can assist teachers in deciding what is important for students to learn and be able to do. We also strive to link our focus on inquiry-based learning environments to participants' experiences in their authentic scientific research communities, which we hope will be accomplished as participants become more familiar with how their scientific communities operate, and how similar experiences can be designed for students that increase their knowledge of science, scientific process, the use of information technology, and related real-world problems and issues.

The concept map appearing as Figure 3 demonstrates relationships between and among the seven concepts organizing the conceptual structure of this course: *Conceptual Models, Scientific Inquiry, Authentic Scientific Research Communities, HPL-Like Classroom Learning Communities, Scientific Knowledge and Skills, Evidence,* and *Knowledge Claims.* When reading this map, there are a few simple conventions to follow in terms of lines, arrows and links. **Lines** show that concepts are linked. The **arrowhead** indicates the direction of the link between them. **Double arrows** mean that both concepts influence each other equally. **Words** appearing on the arrows define the relationship between the concepts. **Crosslinks** connect concepts in two different strands. As such, crosslinks strengthen the coherence of the map and can demonstrate novel, deeper, and/or creative connections between concepts.

Note a few details in Figure 3. Hierarchically, *Conceptual Models* occurs at the highest level in the map, thus signifying its role in organizing the concepts falling below it. Links established between both types of communities and *Conceptual Models* are similar in that they both construct and assess *Conceptual Models,* which can be developed, evaluated, and revised on the basis of *Evidence* provided in the *Knowledge Claims* derived from them. Concepts at the next level, *HPL-Like Classroom Learning Communities, Scientific Inquiry*, and *Authentic Scientific Research Communities,* are linked to *Conceptual Models* and to each other, with *Scientific Inquiry* placed between the two communities. The communities are also cross-linked as each becomes more like the other in professional development environments such as ITS where inquiry becomes the focus of experiences for participants and their students. Links emanating from *Scientific Inquiry* show its central role in the course scheme, as it not only links both communities but also links to *Scientific Knowledge and Skills*. Note also the central position of *Scientific Knowledge and Skills*, which are further delineated at the bottom of the map, and the other relationships with concepts in the map. Especially note that *Scientific Knowledge and Skills* are used to build both *Evidence* and *Knowledge Claims*, which are revealed in scientists' and learners' explanations, applications, and

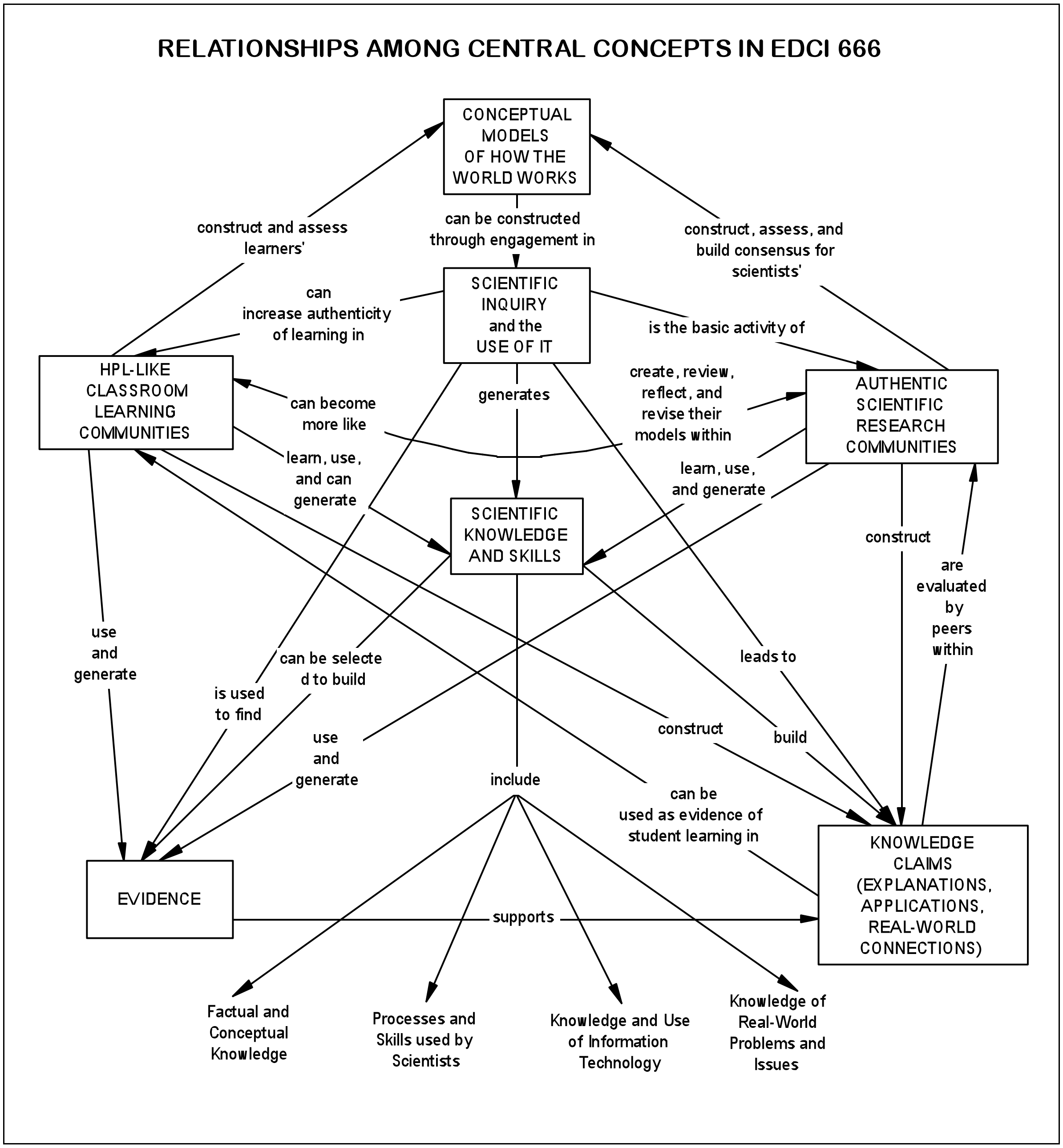
RELATIONSHIPS AMONG CENTRAL CONCEPTS IN EDCI 666
CONCEPTUAL MODELS OF HOW THE WORLD WORKS
can be constructed through engagement in
construct and assess learners'
construct, assess, and build consensus for scientists'
SCIENTIFIC INQUIRY and the USE OF IT
can increase authenticity of learning in
is the basic activity of
HPL-LIKE CLASSROOM LEARNING COMMUNITIES
AUTHENTIC SCIENTIFIC RESEARCH COMMUNITIES
generates
create, review, reflect, and revise their models within
can become more like
learn, use, and can generate
learn, use, and generate
SCIENTIFIC KNOWLEDGE AND SKILLS
construct
are evaluated by peers within
use and generate
can be selecte d to build
is used to find
leads to
use and generate
construct
build
include
can be used as evidence of student learning in
EVIDENCE
supports
KNOWLEDGE CLAIMS (EXPLANATIONS, APPLICATIONS, REAL-WORLD CONNECTIONS)
Factual and Conceptual Knowledge
Processes and Skills used by Scientists
Knowledge and Use of Information Technology
Knowledge of Real-World Problems and Issues

***Figure 3.*** Conceptual framework for developing conceptual understanding (conceptual models) about how the world works by using scientific inquiry and information technology (IT) to link classroom learning communities and authentic scientific research communities. While appearing very different, learning and research communities can share similar goals and outcomes when linked by scientific inquiry and IT. Generation, use, and learning of scientific knowledge and skills can be the focus of both communities. Knowledge claims can be made and supported by evidence and evaluated on the basis of the evidence presented. This concept map provides one conceptualization of "how the pieces fit together" and by no means represents the only model that can be constructed to represent the place of this course in the totality of the professional experiences provided by the ITS Center.

problem solutions. *Knowledge Claims* are evaluated by peers within *Authentic Scientific Research Communities* and can also be used as evidence of student learning in *HPL-Like Classroom Learning Communities*. Altogether, the conceptual framework reflected in the concept map shows how ITS summer experiences are linked, as well as how the aspects of this course are not only linked within the course but across both AM and PM courses.

***Learner-Centered Principles***. – The learning environment for EDCI 666 has been designed to be learner-centered. The Instructional Team has debated and deliberated about best ways to make participants comfortable within the structure of a course designed to present new information about new ways of teaching so that their students can experience new ways of learning science. Members of the Instructional Team have reviewed, discussed, and reflected on the most current perspectives (see Mundry, 2003) regarding the differences in learning that occur in adults and children, and resolution of these ideas has led to decisions about formats and instructional leaders. The Team chose to **minimize** Large Group Presentations because of the limited opportunities for participants to initiate and engage in discussion. Large Group Presentations are designed to provide information from the perspective of experts in the field. As we realize that one time hearing most things is not enough, particularly when information is new, complex, and requires accommodation with prior knowledge, the PowerPoints supporting Large Group Presentations are made available on the Sharepoint portal for ease in retrieval and review. The time spent in CRP Meeting Groups has been **maximized** to provide ample time for discussion, sharing, justifying, resolving, revising, and/or strengthening new understandings. We realize that experienced teachers who come to the class with a wealth of knowledge and experience at times may actually come into conflict with newer approaches to learning, teaching, and assessing conceptual understanding, even in the light of convincing evidence supported by new research findings. In these instances, discussion must support the resolution of conflicts in understanding and with that in mind, CRPs are charged with maintaining the learner-centeredness of the environment. They will not only present new information in an informal, interactive setting but also monitor and adjust the environment to remain supportive of discourse, debate, reflection, and revision – elements at the heart of learning.

***Assessment-Centered Principles***. – The two goals of this course were explained earlier (see page 2). To review, the two goals address the (a) **enhancement of science classroom learners' understanding** about the natural world and how scientists use IT to create new knowledge about it, ***through*** (b) **the enhancement of science teachers' understanding** about how information from the communities of education and science can be combined in their teaching to enhance their learners' understanding of science. HPL assessment principles are applied daily yet unobtrusively within the structure of the class with frequent, continuous, informal formative assessments that occur during CRP Meeting Group discussions and at the end of each day. Daily assessments from participants will be used to address prevailing concerns and to adapt plans for the next day of instruction to better meet the needs and concerns of participants. Weekly assessments made by the project's internal evaluator, Dr. Lee Nichols, will allow global concerns to be met in a timely fashion and to assess the overall effectiveness of

Scientific and Instructional Teams separately and together in meeting the goals of the ITS Center's summer program.

Assessment of participants' conceptual understanding is reflected in each participant's ability to explain, apply, and connect their learning. Formative assessment of Explanation will occur daily in the discussion and questioning that occurs in the CRP Meeting Groups, and ending with the participants' display of a poster explaining the IF to other participants on the last day of class. Formative assessment of Application will occur informally on a daily basis during CRP Meeting Groups and on a weekly basis when CRPs administer the IF Weekly Progress surveys. (These will be administered on Friday afternoons of Weeks 1 and 2.) These formative assessments will be read by the Instructional Team to assess progress in the development of each participant's IF. The final written IF will be used to assess the coherence of the written explanation as evidence of the participant's conceptual understanding of the learning goals of the course. In a very similar way, Connections also will be assessed formatively during CRP Meeting Groups and summatively within the IF.

***Table 1.***
**Plan for Formative and Summative Assessments during EDCI 666**

| **Embedded Assessment Activity** | **Evidence of Understanding** Explain | Apply | Connect | **# Times Assessed** |
|---|---|---|---|---|
| ***Formative*** | | | | |
| • Daily CRP Meeting Groups (I)* | ✓ | ✓ | ✓ | 12 |
| • Weekly Friday Surveys | ✓ | ✓ | ✓ | 2 |
| ***Summative*** | | | | |
| • Poster Presentation – due 3rd Friday | ✓ | | | 1 |
| • Written IF – due 3rd Friday | | ✓ | | 1 |
| • Instructional Team Final Survey – administered 3rd Friday | | | ✓ | 1 |

*Throughout discussion and interactions during the CRP Meeting Groups, CRPs will be informally assessing participants' abilities to explain, apply, and connect their new learning. At the end of the day, CRPs will also collect Participant Concerns Sheets that request short responses by participants regarding their perceptions of the instructional day. At Debriefing Meetings, which occur daily after PM Forums are completed, the Instructional Team will share their observations, assess the effectiveness of the day's work, and make revisions if necessary to strengthen participants' learning experiences for the next day.

**Grades** will be calculated on the basis of depth, thoroughness, and accuracy. Rubrics specifying the details by which the final poster and written IF ill be distributed when assignments are made regarding the poster and IF.

| | |
|---|---|
| Survey Responses (11% each) | 33% |
| Poster | 33% |
| IF | 33% |

| | |
|---|---|
| A = 90-99 | D=60-69 |
| B = 80-89 | F=below 60 |
| C = 70-79 | |

**Community-Centered Principles. —**HSL (Donovan & Bransford, 2005) suggests that the principles of knowledge-, learner-, and assessment-centeredness come together within the context of a learning community, such as the one that the ITS Center provides for its scientists, university educators, graduate students, and classroom teachers. Goldman, Petrosino et al. (1999) also support community-centered learning environments in their chapter elaborating design principles for instruction in science. Additionally, Standards for Teacher Development and Professional Conduct prepared by the National Research Council in 1996 and reproduced in 2001 (*Educating Teachers of Mathematics, Science, and Technology: New Practices for the New Millennium*) call for new kinds of professional development that **integrates knowledge** of science, learning, pedagogy, and students and also **applies that knowledge** to science teaching (Standard C); and that builds understanding and ability for lifelong learning through professional development activities that **support the sharing of teacher expertise** by preparing and using mentors and other professionals; with "regular, frequent opportunities for individual and collegial examination and reflection on classroom and institutional practice" (p. 144). Standard D calls for coherent and integrated professional development experiences that "recognize the developmental nature of teacher professional growth and individual and group interest, as well as the need of teachers who have varying degrees of expertise, professional expertise, and efficiency" (National Research Council, pp. 144-145); and "collaboration among the people involved in programs, including teachers, teacher educators, … scientists, … with clear respect for the perspectives and expertise of each" (p. 145).

We have used these guidelines to develop our plans for the learning community we hope to build that will support ITS participants' learning in EDCI 666. The Instructional Team welcomes ITS Participants to join the ITS professional community as experts in the practical aspects of science teaching. We invite ITS participants as professionals who will inform us while learning with us about best ways to transform science classrooms to better reflect the goals and methods of scientists. CRPS, scientists, and university science educators have developed a new type of community structure that combines separate communities of research and practice and blurs traditional boundaries in the hopes of discovering new ways to advance the teaching and learning of science.

**How does SharePoint "fit" with the HPL perspectives?**

This course is supported by the ITS SharePoint Community Portal, which facilitates information sharing and communication across all AM and PM teams and individuals. As such, SharePoint is a technology that enhances Learner-, Knowledge-, Assessment-, and Community Principles. For example, CRPs have their own subwebs to facilitate the communication and exchange among the members of their CRP Groups; the EDCI 666 webpage links directly to whole-course information and shared documents; and PM Forum information is provided on the ITS webpage for ease in participant choice from options available. All assignments and surveys are posted on SharePoint for ease of sharing, distributing, providing formative feedback, and final assessment of learning. Participants should make themselves very familiar with the ITS Portal early during the first week, as proficiency in using this technology resource will be expected by the end of the first week.

**What will I be able to take back to my classroom as a result of this course?**

Participants will take new understandings about how people learn and the role of information technology in doing science -- practical understandings that result from the course presentations, discussions, activities, and review of scholarly works. Participants will be able to explain, apply, and develop ways to connect their understanding to instruction in their own instructional settings. Textbook, readings, and learning activities in this class will provide perspectives about the teaching and learning process that reflect the research of learning scientists. While participants are here during the summer, they will be exposed to new information technologies that are used by scientists in their work. Also while they are here, participants will learn about ways to use information technology to teach science in ways that are consistent with scientific practice in the laboratory.

Each participant will leave the ITS Summer I experience with a specific curriculum innovation called the Instructional Framework (IF). The IF is a unit of instruction that participants design and customize to fit the needs of their particular set of learners. The IF integrates classroom-based inquiry strategies, information technology, and HPL principles into a coherent instructional "intervention" that is built on some part of the participant's Scientific Team experience. Participants must implement their IFs in order to return to the second summer of the ITS Program.

Beyond the implementation of the specific IF, we hope our participants will also take away an understanding of new principles of learning, teaching, and assessment that can be connected in other ways to their teaching.

**How are the PM Team learning experiences organized? Who are the members of the PM Instructional Team and what are their roles?**

This summer we are serving approximately 60 participants who are distributed across the state, nation, and world. Formats for instruction, discussion, revision, and reflection vary in the afternoon, depending upon the learning goals of the experience. Responsibilities are described by format as follows.

***PM Forums. --Dr. Susan Pedersen,*** an educational technologist in the Department of Educational Psychology, has organized the PM Forum, which occurs from 4:00-5:00 during 9 days of instruction. (See asterisks on page 1 of this Syllabus.) While your attendance is required at PM Forums on the days that they are offered, you have options as to which one you wish to attend. Daily options are posted on the EDCI 666 SharePoint site for participants to sign in for the session they wish to attend. Session types include either round-table (small informal discussion groups) or large-group (more formalized) presentations. If one or more participants have an idea for a PM Forum they would like to offer in round-table or large-group, they should contact Dr. Pedersen to schedule the Forum with her.

***CRP Group Meetings.*** —These meetings occur every day in small group for review, discussion, reflection, and revision. Participation in your CRP Group Meetings is required. Two ***Campus Resource Persons (CRPs)*** have been assigned to lead your Group Meetings. The CRPs are full-time graduate students pursuing Ph.D.s at the ITS Center. They have successfully completed their ITS Certificates and at least one three-hour graduate course in mentoring and professional development. They offer their expertise as specialists in laboratory research and science classroom teaching as they debrief Large Group Meetings, lead discussions, and orchestrate group and individualized work of the participants in their team. CRP Group Meetings form the core of the learning environment for participants, providing a personal context for learning and discussion among members within the small group.

***Large Group Presentations.*** —These meetings are scattered throughout the three-week session to present information to the ITS PM Learning Community as a whole. ***Dr. Carol Stuessy*** often will be the person making presentations in large group, although other speakers have been scheduled to provide information from their areas of expertise. Dr. Stuessy is a science educator who has worked in statewide and national reform for the past 15 years at Texas A&M University. She offers information from a broad experience base that includes eleven years of teaching in middle and high school science; 5 years of participating as a member of scientific research teams at Harvard University and Ohio State University; and 20 years of teaching science methods and graduate courses in science education. She has directed several nationally and state-funded projects involving the professional development of K-12 science teachers and is currently directing a National Science Foundation-supported research project that will contribute to our knowledge base about the recruitment, induction, and retention of high school science teachers.

Large Group Presentations have been organized to provide information about science education from the university professor's point of view. As opportunities for discussion in the Large Group format are limited, these presentations are designed primarily to present information that has been coherently organized in a more formal format, which will be debriefed in the more interactive CRP Meeting Groups.

***Personal One-on-One Meetings***. —Upon request by a participant, one-on-one meetings can be scheduled during the PM Forum, over lunch, or at another convenient time to discuss matters of concern. Participants should feel free to make appointments with instructors, CRPs, or administrators of the ITS Center at arranged times convenient to all concerned

***Assigned Readings***
***Required Text***

Donovan, M. S., & Bransford, J. D. (Eds.). (2005). *How Students Learn: History, Mathematics and Science in the Classroom.* Washington, DC: The National Academies Press.

***Required and Recommended (*) Readings***

*Bransford, J., Brown, S., & Cocking. (2000). *How People Learn*. Washington, DC: National Academies Press.
*Bonnstetter, R. J. (1998*). Inquiry: Learning from the past with an eye on the future. *Electronic Journal of Science Education, 3(1).*
Chinn, C.A., & Malhotra, B.A. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education,* 86, 175-218.
Edelson, D.C. (1998). Realising authentic science learning through the adaptation of science practice. In G.J. Fraser & K. Tobin (Eds.), *International Handbook of Science Education* (pp. 317-331). Dordrecht, The Netherlands: Kluwer.
Etheredge, S. & Rudnitsky, A. (2003). *Introducing Students to Scientific Inquiry: How Do We Know What We Know?* Boston: Allyn & Bacon.
Goldman, S.R., Petrosino, A.J., & Cognition and Technology Group at Vanderbilt (1999). Design principles for instruction in content domains: Lessons from research on expertise and learning. In F.T. Durso, R.S. Nickerson, R.W. Schvandeveldt, S.T. Dumais, D.S. Lindsay and M.T.H. Chi (Eds.), *Handbook of Applied Cognition* (pp. 595-627). Boston: Wiley.
Kozma, R. B. (2003). The use of multiple representations and the social construction of chemistry. In M.J. Jacobson, & R. B. Kozma, *Innovations in Science and Mathematics Education: Advanced designs for technologies of learning* (pp. 11-46). Mahwah, NJ: Erlbaum
*Mundry, S. (2003). Honoring adult learners: Adult learning theories and implications for professional development. In J. Rhoton & P. Bowers (Eds.) *Science Teacher Retention: Mentoring and Renewal* (pp. 123-133). Arlington, Virginia: NSTA Press.
O'Sullivan, C.Y. & Weiss, A.R. (1999). *Student Work and Teacher Practices in Science: A Report on What Students Know and Can Do*. Washington, DC: U.S. Department of Education and Office of Educational Research and Improvement.
Wiggins, G., & McTighe, J. (1998). Understanding by Design. Alexandria, VA: Association for Supervision and Curriculum Development.

***Standards***

Benchmarks for Science Literacy http://www.project2061.org/tools/benchol/bolintro.htm
National Science Education Standards http://www.nap.edu/readingroom/books/nses/html/
Texas Essential Knowledge and Skills http://www.tenet.edu/teks/science/

***On-Line Assessment Resources***

(PALS): http://pals.sri.com/
(NAEP): http://nces.ed.gov/nationsreportcard/science/whatmeasure.asp

**University Policies**

***Policy on Scholastic Dishonesty:*** Students who violate University rules on scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and/or dismissal from The University. Since such dishonesty harms the individual, all students, and the integrity of The University, policies on scholastic dishonesty will be strictly enforced.
For guidelines on writing with academic integrity:
http://www.utexas.edu/depts/dos/sjs/academicintegrity.html

***Plagiarism:*** As commonly defined, plagiarism consists of passing off as one's own the ideas, words, writings, etc., which belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even if you should have the permission of that person. Plagiarism is one of the worst academic ailments, for the plagiarist destroys the trust among colleagues without which research cannot be safely communicated.

***Americans With Disabilities Act:*** The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all class members with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Office of Support Services with Disabilities in Room 126 of the Koldus Building. The phone number is (409) 845-1637.

***Statement on Diversity (approved by the Department of TLAC):*** The Department of Teaching, Learning and Culture (TLAC) does not tolerate discrimination, violence, or vandalism. TLAC is an open and affirming department for all people, including those who are subjected to racial profiling, hate crimes, heterosexism, and violence. We insist that appropriate action be taken against those who perpetrate discrimination, violence, or vandalism. Texas A&M University is an Affirmative Action and Equal Opportunity institution and affirms its dedication to non-discrimination on the basis of race, color, religion, gender, age, sexual orientation, domestic partner status, national origin, or disability in employment, programs, and services. Our commitment to non-discrimination and affirmative action embraces the entire university community including faculty, staff, and students.

**Organizing Questions by Day (Tentative)**

| | Date | Day | Organizing Question | Resources |
|---|---|---|---|---|
| **Days 1-5: Focus on Learning Goals and Assessment for Conceptual Understanding** | | | | |
| Day 1 | July 5 | Tue | Who are we? Where are we going? | Syllabus |
| Day 2 | July 6 | Wed | What can scientific research and practice tell us about teaching and learning science? How can standards-based resources help me decide what my students should learn? What factual and conceptual information should my students know? | TEKS, NSES, Benchmarks |
| Day 3 | July 7 | Thu | What can scientific research and practice tell us about teaching and learning science? What processes, skills, and uses of IT should my students be able to use? Why has ITS chosen inquiry learning? What is the general sequence of immersion inquiry instruction? | Bonnstetter |
| Day 4 | July 8 | Fri | What are its benefits of inquiry in learning science? What type of inquiry will serve my students best? What is recommended as the general sequence of inquiry to follow? What is my early thinking about the design of my IF? | Edelson Etheredge & Rudnitsky [Chinn & Malhotra] |
| Day 5 | July 11 | Mon | Why the focus on assessment for conceptual understanding? What does it mean to conceptually understand something? What is backwards design? | O'Sullivan & Weiss, Wiggins & McTighe |
| **Days 6-9: Focus on Research from Education and Science informing Classroom Learning Environment Design** | | | | |

| | | | | |
|---|---|---|---|---|
| Day 6 | July 12 | Tue | How does assessment change teaching? What are the benefits of feedback, reflection, and revision? How can I design an environment based on feedback, reflection, and revision? How can formative assessments provide feedback for reflection and revision? How will my students' final products of learning be used to assess conceptual understanding? | Goldman et al. Lewin & Shoemaker |
| Day 7 | July 13 | Wed | How does research from the learning sciences inform design of instruction for conceptual understanding? What do I need to know about the role of IT in science? In science learning? In developing and expressing conceptual understanding? | HPL, Ch. 1 Kozma |
| Day 8 | July 14 | Thu | What are the characteristics of the science classroom learning environment proposed by the ITS Center? | HSL, Ch. 14 [Review Edelson] IF |
| Day 9 | July 15 | Fri | What is my early thinking about the design of my IF? How is it coming together? | IF |
| **Days 10-13: Focus on My Classroom Learning Environment: Applying the Learning and Connecting It to Classroom Practice** | | | | |
| Day 10 | July 18 | Mon | Rubrics for Assessment of Posters and IFs Issues of Instructional Framework, I, II, III | Rubrics, IF |
| Day 11 | July 19 | Tue | Issues of Instructional Framework, Part IV | IF |
| Day 12 | July 20 | Wed | Issues of Instruction Framework, Part V How do I make my poster? How do I assemble the final IF? Work Day | |
| Day 13 | July 21 | Thu | Work Day | |
| Day 14 | July 22 | Fri | Poster Presentations Posting the IF Final Survey | |

**Week One**
**Daily Outline with Approximate Times and Assignments (Tentative)**

| | Date | Day | Organizing Question | Resources |
|---|---|---|---|---|
| **Days 1-5: Focus on Learning Goals and Assessment for Conceptual Understanding** | | | | |
| Day 1 | July 5 | Tue | **Who are we? Where are we going?**<br>1:00-2:10 Large group<br>2:10-2:25 Break<br>2:25-4:00 CRP Groups | In CRP Groups<br>**Review** Syllabus<br>**Learn** SharePoint<br>**Take** Surveys |
| Day 2 | July 6 | Wed | **What can scientific research and practice tell us about teaching and learning science? How can standards-based resources help me decide what my students should learn? What factual and conceptual information should my students know?**<br>1:00-2:00 CRP Groups<br>2:00-2:50 Computer Task<br>2:50-3:05 Break<br>3:05-3:50 CRP Groups<br>4:00-5:00 PM Forum | For Thursday<br>**Bring** a description of an Inquiry Activity or Scientific Research Activity that you have led or participated in<br><br>**Read** Bonnstetter |
| Day 3 | July 7 | Thu | **What can scientific research and practice tell us about teaching and learning science? What processes, skills, and uses of IT should my students be able to use? Why has ITS chosen inquiry learning?**<br>1:00-2:15 CRP Groups<br>2:15-2:30 Break<br>2:30-3:20 Large Group<br>3:20-3:50 CRP Groups<br>4:00-5:00 PM Forum | For Friday<br>**Read** Edelson<br><br>**Read** Etheredge & Rudnitsky<br><br>[**Scan** Chinn & Malhotra] |
| Day 4 | July 8 | Fri | **What are its benefits of inquiry in learning science? What type of inquiry will serve my students best? What is recommended as the general sequence of inquiry to follow? What is my early thinking about the design of my IF?**<br>1:00-2:20 CRP Groups<br>2:20-2:35 Break<br>2:35-3:20 Large Group<br>3:30-4:00 Large Group: Surveys | For Monday<br>**Read**<br>O'Sullivan & Weiss, Wiggins & McTighe |

# APPENDIX B

## PHASE I INTERVIEW QUESTIONS

1. Thinking back over your experience with the ITS center over the past 2 summers and school year, what have been the highlights of your experience?

2. In what other ways has the ITS experience been valuable to you?

3. From your perspective, what do you think the ITS center's learning goals were for participants?

4. What, if anything have you learned from the ITS experience that has changed your teaching or how you think about your teaching?

5. How has what you've learned affected your teaching over the past year? Can you give me a specific example?

6. Do you see the possibility that your teaching or how you think about teaching will continue to change as a result of this summer's experience?

7. If I came to visit your classroom tomorrow how might I see your learning from the ITS experience reflected in your teaching or how you think about your teaching?

8. Could you give me some more detail about how the readings influenced your learning?

9. Could you give me some more detail about how the CRPs influenced your learning?

10. Could you give me some more detail about how the science faculty influenced your learning?

11. Could you give me some more detail about how the education faculty influenced your learning?

# APPENDIX C
# PHASE II INTERVIEW QUESTIONS

Section 1 Interview 1

1. When did you first know that you wanted to be a teacher?
2. Why did you decide to be a teacher?
3. What was your certification process like?
4. What are some of the highlights of your job as a teacher?
5. What is the most important thing about your job as a teacher?
6. What are some of biggest hurdles in your job as a teacher?
7. Do you collaborate with other teachers in your school often?
8. Do you participate in a lot of professional development?

Section 1 Interview 2

1. How did you find out about the ITS program?
2. Why did you decide to come to the ITS center's courses over the two summers?
3. What did you know about the ITS Center before you decided to come to the summer courses?
4. How was the ITS Center's PD different from other professional developments you have attended?

Section 2 – Interviews 1 & 2

1. Tell me a little more about the lesson I observed.
2. Why did you invite me to come observe this particular lesson?
3. Was this a typical lesson you would teach or was it out of the ordinary in any way?
4. When was the first time you taught a lesson on this topic?

5. How has your thinking about teaching this lesson changed since the first time you taught it?

6. How did you plan for this lesson?

7. Was there anything you would change about how the lesson went?

8. Did the ITS center experience have any specific influence how you planned or taught this lesson in any way? If so how?

9. How do you think you would have taught this lesson differently before you went through the ITS center's PD experience?

10. When you plan your lessons, does anything that you learned from the ITS Center come to mind? Like, are there any guiding ideas that seem to pop into your mind that you could attribute to the ITS Center? If there are, what are they?

11. When you teach science, how important is it to you that you also teach kids about the way that scientists go about finding out about things? Do you think your experience with the ITS Center has changed the way you think about scientists and what they do when you are teaching?

12. Overall, what has been the BIGGEST THING that you think the ITS Center has contributed to your thinking about the way you teach science to your kids?

13. What effect do you think your implementation of the IF had on your thinking about how you teach science? Were there any things in particular that you have changed as a result of the implementation of the IF?

14. Did you, or are you planning to, implement your Research Plan? Where are you in that whole thing?

15. If you have already implemented your RP, what effects do you think that implementation has had on your science teaching?

16. Do you think you would ever decide to do a RP on your own about something in your class that you would like to improve? Are there things now in your classroom that you might be able to investigate to improve your teaching or to improve your student's learning? What new questions do you have that you might want to investigate about your own teaching or student learning after completing your RP?

17. Think back about the ITS experience. What things do you think the ITS Center could have done to have made a bigger impact on your thinking about teaching? On your actual teaching? On your assessment of students' learning?

# APPENDIX D

# CLASSROOM LEARNING ENVIRONMENT SURVEY

**Florida State University**
**Classroom Environment Survey**

Grade: 6 7 8 9 10 11 12 Subject: ____________

Please circle appropriate to indicate your gender and ethnic background:

| | |
|---|---|
| Male | |
| Female | |

| | | |
|---|---|---|
| American Indian | African-American | Caucasian |
| Hispanic | Asian | Other |

Circle number for each question and scale.

| | | | | |
|---|---|---|---|---|
| 1= Almost Never (less than once a month) | 2= Seldom (once a month) | 3= Sometimes (weekly) | 4=Often (about once per lesson) | 5=Very Often (more than once per lesson) |

| In this class: | How often does this happen in your class? | | | | | How often would you like this to happen in your class? | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Almost Never | Seldom | Some-times | Often | Very Often | Almost Never | Seldom | Some-times | Often | Very Often |
| 1. I ask other students about their ideas. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 2. I decide how to solve problems. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 3. The teacher asks me what I have learned in the past. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 4. I am interested in the lessons. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 5. Other students make it hard for me to learn. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 6. I talk with other students about solving problems. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 7. The teacher shows the correct way to do problems. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 8. I see the importance of what I learn. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 9. I am willing to learn. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 10. The teacher starts class on time. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 11. I tell my ideas to other students. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 12. I decide how much time to spend on an activity. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 13. New activities are connected with what I have done in the past. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 14. What we do is important to me. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 15. The teacher interrupts my learning. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 16. I try to understand other | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| students' ideas. | | | | | | | | | | |
| 17. I decide if my answers are correct. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 18. I learn about things that interest me. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 19. I try my best. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 20. The noise in this class makes it hard for me to learn. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 21. I listen carefully to other students' ideas. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 22. The activities I do are set by the teacher. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 23. The activities I do are about real problems. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 24. I pay attention. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 25. The way the classroom is organized makes it hard for me to learn. | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |

The following scales are represented by the questions as indicated:

Participation: 1,6,22,16,21
Autonomy: 2,7,12,17,22
Relevance: 3,8,13,18,23
Commitment to learning: 4,9,14,19,24
Disruptions to learning: 5,10,15,20,25

**McRobbie, C. & Tobin, K. (1997). A social constructivist perspective on learning environments. *International Journal of Science Education, 19*, 193-2**

# APPENDIX E

# INSTRUCTIONAL FRAMEWORK GUIDELINES

## The Instructional Framework

**I. Conceptual Understanding Goal**

A. What should my students conceptually understand as a result of their inquiry experience?
B. Why is this goal important?

**II. Assessment of Conceptual Understanding**

A. How will I know that my students have made gains in their understanding?
B. What explanations, applications, and real-world connections are appropriate for the inquiry experience in which they will be engaged?
C. In what ways can I seamlessly integrate their explanations, applications, and real-world connections into their inquiry experience?
   1. What should they be able to explain? (Where could that appropriately occur in the inquiry sequence?)
   2. In what context should they be able to apply their knowledge and skills? (Where could that appropriately occur in the inquiry sequence?)
   3. What connections to the real-world should they be able to make? (Where could those connections appropriately occur in the inquiry sequence?)

**III. Supportive Knowledge and Skills**
What knowledge and skills should my students be able to use in their explanations, applications, and connections?

A. Factual knowledge and skill
B. Processes and skills used by scientists
C. Knowledge and use of IT in scientific discovery
D. Knowledge of scientific connections in the real world

**IV The Inquiry Sequence**

A. HPL Perspectives
How will I apply HPL perspectives to enhance effectiveness of the inquiry?
   1. Community
   2. Learner
   3. Knowledge
   4. Assessment
B. Immersion
   1. In what phenomenon on system will my students become immersed?
   2. How will they use IT in that experience?
   3. Will an assessment be included here? For what purpose?
C. Researchable Questions
   1. How will research questions be derived?
   2. Will an assessment be included here? For what purpose?

D. Student Research
   1. How will student research be applied in a consequential task?
   2. How will they use IT in their student research?

E. Consequential Task
1. How will results of the student research be applied in a consequential task?
2. How will they use IT in the consequential task?
3. Will an assessment be included here? For what purpose?

F. Benchmark Experiences
1. Will you need to provide a benchmark experience in the use of IT? Where would that we sequenced in the instruction?
2. What other benchmark experiences will you need to provide?

G. Details of the Inquiry Sequence
1. Your choice of Type of Inquiry and why
2. Duration and timeline
3. Activities (Immersion, Researchable Questions, Student Research, Consequential Task)
4. Assessments
5. Benchmark Experiences

**V. Preparation for the Inquiry**

A. At the Classroom Level
1. IT Adaptations
2. Materials, Classroom Rearrangements
3. Use of Scientists
4. Use of CRPS
5. Documentation (teacher logs, still pictures, videotapes, student work)

B. At the School and Community Level
1. Development of a Justification
2. Notification of Administrators and Other School Personnel
3. Notification of Parents
4. Notification of Local Papers, etc.
5. Notification of other teachers, Opportunities for Professional Development that you might provide

# APPENDIX F

## SCHOOL YEAR I SUMMARY PAPER GUIDELINES

**Guidelines for ITS Cohort III's**
**Instructional Framework Implementation Summary Paper**

To qualify for your second $500 stipend, you must submit a paper based on the following guidelines. An electronic or hard copy of an acceptable paper must be received by Dr. Schielack before June 1, 2006. Acceptability of a paper will be determined by the following guidelines. It is difficult to set a number of pages for a paper of this type, but a range of 5 – 7 pages, double-spaced, for the paper (not including the appendix) seems reasonable to be able to cover the guidelines well.

The theme of the paper should be to describe and analyze the implementation of your *Instructional Framework* in relation to the ITS Center's Enduring Understanding (use of information technology in the form of visualization, modeling, or complex data analysis to embed inquiry into the teaching and learning of science).

### Part I: Description

The first part of the paper should begin with a clear *description* of the inquiry you and your students did as a result of the implementation of the Instructional Framework, along with a short *rationale* explaining why you decided to implement this particular Instructional Framework (curriculum requirement, major misconception in students, classroom interest, etc.).

### Part II: Analysis

The second part of the paper will provide an opportunity for you to analyze your Instructional Framework in terms of the components of inquiry outlined in *Introducing Students to Scientific Inquiry: How Do We Know What We Know* (Etheredge & Rudnitsky, 2003). This includes:
A description of the Immersion Experience
A summary of the researchable questions produced and how they were elicited
A description of the student research activities that emerged
A description and rationale for the consequential task used for making learning visible
A discussion of difficulties you had or thought you would have in implementing your framework and how you overcame (or didn't overcome) those difficulties
Reflection on what you would do to improve your implementation next time

### Part III:

Appendix: The appendix consists of two parts: (1) *references* of any citations in your paper, and (2) any *artifacts* you would like to share, such as time lines, lesson plans, and/or student products related to your implementation.

Etheredge, S., & Rudnitsky, A. (2003). Introducing students to scientific inquiry: How do we know what we know? Boston: Allyn & Bacon.

# APPENDIX G

# ACTION RESEARCH PLAN GUIDELINES

## ITS Research Project Blueprint

Project Title
Project Team Members and Roles

I. Redesign/Refinement of Instructional Framework
    A. Summer I Rationale
        What student outcome(s) did you want/expect as a result of your IF?
        What IT and level of inquiry did you use to obtain these outcomes?
        Why did you think – prior to implementation – that this particular IT and inquiry would cause these outcomes?
        Personal experience? (experiences in ITS research team, classroom experience)
        Evidence from other research and theory? (review of prior research)
    B. IT and Inquiry Implementation
        What happened? Did the IF implementation go as planned?
        Did you change anything? If so, how?
        What went well and what did not go well?
        Did anything unanticipated occur as a result?
    C. Redesign
        Would you modify the IT as a result of your experience?
        Would you modify the components and/or sequence of the inquiry cycle as a result of your experience? If so, how?
        What do you expect will happen now as a result of your changes?
        What questions did the implementation raise?

II. Theoretical Framework/Rationale
    A. Summer II Rationale
        What problem or challenge to student learning or behaviors are you addressing?
        Why is this important?
        How will IT and/or inquiry address this challenge?
    B. Theoretical Framework
        What research has been done in this area? What theory or theories typically guide this research?
        What methods and samples have researchers typically used?
        What are the findings?
        What still needs to be studied?
        What is the purpose of your study and/or the general question (the big question) you are asking related to what still needs to be studied?
    C. General Study Design
        How will you set up a study to answer your question?
        Why do you think this is the best way to do it?

III. Description of IT Inquiry Intervention (modified IF)
    A. Who?
        Who will use the IF? (What level? What class?)
        What do the students look like (age, gender, ethnicity, ability)
        Will others (scientists, community members, parents, CRPs, administrators) be involved? If so, how?
        Will other students or classes be used for comparison? If so, what will they look like?
    B. What?

What IT will you or others use?
What inquiry components will you use in conjunction or for implementation?
What materials/equipment will you need?

C. When?
When will you do this?
How long will it last?

D. Where?
Will this require relocation to the field or to a computer or science lab?

E. So what?
What do you expect to happen as a result?
What would you like to know more about based on the first IF?
What questions do you have about the modified IF and its impact?
Why is this important? (educational significance)

IV. Development of Data Collection Plan

A. Inquiry Questions
What specific questions related to your big question will you address?
Are your questions specific and clear enough that someone else would know what you are doing?
Do they address the big question you identified?
Do they reflect the intervention you are doing?
Do they specify the target of the IT intervention?
Are they observable/measurable?
Are they focused on student learning or behaviors?
What research has been done in a similar area of inquiry and how has it informed your decisions?

B. Methods
*Who*
Who will you collect data from? (Everyone who experienced the intervention? A smaller group?) How were they chosen?
Who will assist you with the data collection?
*What*
What would learners know or do as a result of the IT intervention that would indicate to you (or others) that the intervention had (or had not) made a difference?
What data will you collect to determine this?
If you obtain these data, will they enable you to answer your questions?
*How*
How will you obtain the data? (steps or procedures, tools, instruments)
How will others help you with your process?
*When*
When will you collect data? (timeline for data collection)
*Why*
Why are you using this way to collect data?
Are the time and effort needed to collect the data worth the information you will get?

V. Determination of Analysis, Interpretation, and Dissemination Plan
What roles will you and others have in the analysis?
What kind of data will you get? (scores? descriptions? categories?)
How do you plan to analyze/display your data so you can see if it answers your questions? So you can discuss it with others?
How will you convince others that your findings answer your questions or were a result of the intervention?
What else might cause these findings and how have you addressed them in your plan?

# VITA

| | |
|---|---|
| Name: | Lisa Ann Brooks |
| Address: | Washington University<br>One Brookings Drive<br>Campus Box 1137<br>St. Louis, MO 63130 |
| E-mail Address: | lbrooks@wustl.edu |
| Education: | B.S. Animal Science, Rutgers University, 2001<br>M.Ag. Plant Protection, Texas A&M University, 2003<br>Ph.D. Curriculum and Instruction, Texas A&M University, 2009 |