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Exploring the Beliefs and Practices of Five Preservice Secondary Science Teachers From Recruitment through Induction in a University Preparation Program : A Longitudinal Study

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Exploring the Beliefs and Practices of Five Preservice Secondary Science Teachers From Recruitment through Induction in a University Preparation Program : A Longitudinal Study

by

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Exploring the Beliefs and Practices of Five Preservice Secondary Science Teachers From Recruitment through Induction in a University Preparation Program : A Longitudinal Study

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This three-year longitudinal study explores the evolving beliefs and practices of five prospective secondary science teachers in a university preparation program from recruitment through their first year in the classroom. As an interpretive qualitative study, the format for data collection and analysis utilizes a case-study methodology with cross-case analysis. Data was collected through semi-structured interviews, collected artifacts, and classroom observations. There are a number of important conclusions from this study. First, the teachers' beliefs about teaching initially shift to a contemporary focus during the program, but ultimately return to a didactic orientation by their first year in the classroom. At the same time, the teachers' beliefs about learning remain consistently more contemporary in nature. Second, the participants believe that they practice teaching science as inquiry at a higher level than are indicated by researcher observations. Third, while participants value advanced content and educational theory coursework, they do not always see the link between these experiences and their development as science teachers. Fourth, the findings from this study reveal that internal and external contextual factors impacted, to varying degrees, the development of the science teachers. The findings from this study contribute to a deeper understanding of the development of science teachers from preservice education to the induction years, which indicates a pattern that is not linear. The findings from this study also reinforce the importance of internal and external contextual factors on the development of science teachers. Ultimately, this study is important to the field of secondary science teacher education as it depicts the complex interactions between the individual, the preparation program, and the school placements that impact the beliefs and practices of preservice and beginning teachers.

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CHAPTER 1: INTRODUCTION

It is a complex time to be involved in science education. The dramatic nature of national education policy (see No Child Left Behind Act), nationally adopted guidelines suggested for science teachers (see National Science Education Standards), an increasing diversity of student populations, and the rapid advancement of science and technology have created a complex mixture of variables for science teacher educators to work with in training the next cadre of teachers for the classroom. To add to this complexity, poor US secondary-student scores in international and national science assessments (see NAEP, TIMMS) along with a continuing attrition of beginning science teachers (Ingersoll, 2001) have put pressure on science teacher educators to produce highly qualified teachers in record time with excellent pedagogical and subject matter skills.

In response to this challenging environment, science education researchers have chosen many pathways of inquiry in an effort to inform science teacher educators. Some researchers decide to work within the framework of the current climate. For example, Simmons et al. (2005) worked with government agencies and elected officials to attempt to build policy in science education. Attention to policy and to scientific research reflects attention to some of the external factors that complicate the preparation of teachers. As a part of this mission, Simmons et al. called for "the need to identify and pursue careful scientific research on what we still need to know about learning and teaching in science" (p. 249). This attention to empirical data continues with, "[E]ach person needs not only to serve as an advocate for scientifically based scholarship, but be proactive in policy initiatives at all levels" (p. 249).

Others have completed research focused on internal factors that affect teachers' growth. For example, researchers have studied the role of emotion on teaching (Elbaz, 1991; Hargraves, 1998; Zembylas, 2002). Others have examined the role attitudes play in teaching (Richardson, 1996) and how teacher knowledge structures affect instructional choices (Adams & Krockover, 1997; Grossman, 1992), including teacher beliefs and knowledge. Keys and Bryan (2001) suggested a research focus that addressed the domains of teacher beliefs, knowledge, and practices in implementing inquiry in the classroom. They stated, "The proposal of a research agenda for inquiry approaches that are centered on teacher beliefs and knowledge may accelerate the production of a research literature that bridges the important theory-practice gap in this important area" (p. 631).

To address this concern, a common recommendation for future study includes the examination of science teacher preparation programs in more depth with regard to teacher beliefs and practices (Fullan, 2001; Holmes Group, 1986). The research for this dissertation rests therefore in the domain of teacher development with particular attention paid to the relationship between teacher beliefs about science teaching and how these beliefs relate to actual practice in the field.

SCIENCE TEACHER BELIEFS

Along with external factors that can influence science teachers' development, there are also inner forces at work, and this area is perhaps the hardest for science educators to understand and challenge in their students. Beginning science teachers enter teacher preparation programs with a variety of internal factors that may influence their actions in the classroom. One area of research that has been argued as a significant part of understanding teacher development examines the role of teachers' beliefs. The inner landscape of beginning science teachers is already crowded with ideas about teaching, learning, and science when they reach their initial teacher preparation coursework. These ideas have been gleaned from their general life experience, their cultural and social backgrounds, and their prior experience as learners. Researchers have pointed for a number of years to the role teachers' personal beliefs play in planning and enacting classroom instruction. Foundational work by Fenstermacher (1979), Nespor (1987), Pajares (1992), and others argued that understanding the nature of teachers' beliefs is crucial for successful teacher development and that teacher beliefs research forms a critical component to teacher effectiveness research (Pajares, 1992).

SCIENCE TEACHERS' PRACTICES

The guiding document of science teaching in the United States is the National Science Education Standards (NSES) (NRC, 1996). These standards were developed by experts in science, education, and research to provide concrete goals and objectives for what students should know and be able to do in science from kindergarten through high school. The standards address the need for science instruction for all students, regardless of background, culture or special need. However, the standards' central posit is the goal for a scientifically literate workforce in the United States. Although there are differences of opinion regarding what constitutes scientific literacy (Hodson, 2002), this dissertation will adopt a common definition found in the NSES:

> Scientific literacy enables people to use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society. A sound grounding in science strengthens many of the skills that people use every day, like solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning. And the economic productivity of our society is tightly linked to the scientific and technological skills of our work force. (p. ix)

Scientific literacy includes both a working knowledge of the central concepts in science as well as an understanding of the processes involved in doing science. According to the standards, the route to scientific literacy is through teaching and learning science in an inquiry-based manner that includes both hands-on and minds-on learning, and integrating scientific knowledge with reasoning and thinking skills (NRC, 1996, p. 2). Despite this call to action, many teachers' practices in the field do not align with either their stated beliefs or the inquiry-based instructional training in their preparation program. It is crucial to understand these gaps between both theory and practice and beliefs and practice if we are to prepare secondary science educators to teach in a inquiry-based manner.

Interestingly, despite earlier recognition that studying beliefs is an important part of the research base of understanding teacher effectiveness, there is still a paucity of published research in this area, especially of a longitudinal nature. In science education, research on secondary science teachers' beliefs has been highlighted as an important area for further study, especially as it relates to inquiry-based practices (Keys & Bryan, 2001) as well as studies that are longitudinal in nature (Kagan, 1992), but the library of work in this area is still slim. The intent of this work is to help fill that gap.

SCIENCE TEACHER PREPARATION

The influence of the preparation programs on overall teacher effectiveness has been debated recently at a number of levels. Proponents of traditional teacher preparation programs contend that prospective teachers need a strong grounding in pedagogy, including topics that address learning and cognitive development, addressing the needs of diverse learners and special-needs students with appropriate instructional and curricular modifications, and learning basic skills for managing the classroom environment (National Commission on Teaching and America's Future, 1996; Wilson, Floden, & Ferrini-Mundy, 2001).

Conversely, some feel that teacher preparation programs are outdated and that strong content knowledge and general academic capability are sufficient for teachers (US Department of Education, 2002). Darling-Hammond (2000) reported that supporters of this view suggest reframing teacher education to emphasize content knowledge and verbal ability, and reduce attention to teacher education training.

Darling-Hammond (2000) studied a large data set of six years' worth of student achievement data that linked scores in mathematics and reading with the teachers' levels of experience and certification status. Results from this study show that certified teachers showed significantly stronger student achievement gains than uncertified teachers.

In science teacher education, being a content expert is not enough if the goal is to prepare teachers who can teach in a contemporary way. Science teachers must learn how to address prior beliefs and alternate conceptions, scaffold student understanding, and extend student thinking to model the characteristics of scientific inquiry. There is a real need for research that examines the factors of successful preparation programs and the development of future science teachers.

STATEMENT OF PROBLEM

The intention of this dissertation is to help bolster the body of literature on secondary science teacher beliefs about teaching and knowledge in an inquiry-based preparation program. With this goal in mind, the main research question asks, "How do the beliefs and practices of beginning secondary science teachers evolve through a traditional university teacher preparation program?"

The exploration of this question encompasses the journey from recruitment through the first year in the classroom for beginning teachers, and includes three years of interviews, observations and artifact collection from participants in an effort to build an understanding of both the efficacy of the preparation program and the in-service setting, as well as the participants' individual reconciliation between their emerging beliefs about teaching science and their classroom practice.

SIGNIFICANCE OF STUDY

Leaders in the field of science education have called for more research on secondary science teachers and the factors that influence the teaching of reform-based practices. This dissertation fills a critical gap in the research on science teacher development and may inform work that examines the incongruence between theory and practice that has been demonstrated by many beginning teachers as they attempt to negotiate the realities of the public-school classroom with theories learned as students. This study also contributes to the slim database on longitudinal studies in secondary science teacher preparation. In addition, this study will inform the development and direction of university science teacher preparation programs by providing data on how these programs influence and are influenced by beginning teachers' beliefs and practices.

OVERVIEW OF FOLLOWING CHAPTERS

The second chapter of this work includes three parts. Part one includes a review of two pilot studies that contributed to the current research question. The first pilot study examined the nature of recruitment of beginning secondary science teachers in a university teacher preparation program, and the second study explored the relationship of an early field experience with the development of reflective practice and science as inquiry. Part two of this chapter will outline the structure and goals of the university teacher preparation program. Part three contains a review of the literature related to the research contained in this study. The three areas pertinent to this study include literature on secondary science teacher beliefs, preservice field experiences for secondary science teachers, and the nature of reform-based practices of secondary science teachers.

Chapter three characterizes the research design, the methodology, and the data collection and analysis methods for the study.

Chapter four will present the cases of the five teachers who are the sample for the study. These cases are constructed through analysis of multiple data sources, and the resulting discussion will address individual findings in a chronological order to best capture the changing nature of these teachers' beliefs over time.

Chapter five will discuss the data points and what they mean for the field of science teacher education.

LIMITATIONS

The nature of interpretive qualitative research negates issues of generalizability but does bring up possible limiting factors that include misinterpretation of data during analysis, lack of data sources and types to ensure triangulation, and researcher bias issues.

Because belief systems are constructed through personal experience, are ill-structured and messy constructs, and are bound to the context of the moment, my own belief systems may have filtered the findings and interpretation of the data and in turn led to misrepresentation of the participants' views based on my own prior knowledge about the preparation program, teacher beliefs, and inquiry-based science. In addition, my role with some of the participants was more involved than with others, leading to potential bias and weighting of data. Students may have felt pressured to respond in a certain way because of our work relationship. In an effort to limit these potential problems and reduce researcher bias, four researchers worked collaboratively on the data collection and analysis over the period of the study. The participants were provided with the results from their cases and their feedback was examined (when supplied) to ensure the accuracy of the results. All participants who responded agreed that their cases were accurate.

The strength of longitudinal qualitative studies rests in the ability to fully explore each member's personal growth through extended observation and interview data. One potential limitation is the lack of extended observation data for the participants' practice for this study. When interviewing and observing teachers in the field, teachers' schedules and observation days were challenging to work with, and the resulting interviews were somewhat rushed for a few of the teachers as they attempted to eat lunch and answer beliefs questions during their planning period. When this was the case, the researcher called by telephone later in the day to collect any additional information that may have been missed. Later interviews were conducted at a different time to compensate for this. Although this issue was addressed through triangulation with other data sources, the risk does still exist that isolated observations of the teachers in their first year is not a true reflection of their practice.

SUMMARY

This dissertation is concerned with the teaching beliefs and practices of secondary science teachers as they evolve through a traditional preparation program and into the classroom. It adds to the data on the nature of beginning science teacher beliefs and how these beliefs develop over time, both in preservice preparation programs and in their professional setting. It also adds to the literature on science teacher programs and how these programs can be designed to attend to teacher beliefs and reform-based practices. In so doing, this dissertation helps to fill research gaps on developing science teacher beliefs and inquiry-based practices longitudinally through the continuum of development from recruitment to induction. Ultimately, student success depends on teacher quality (Darling-Hammond, 1999). The quality of the science teaching force depends on the quality of teachers' preparation and how they integrate their previous experience and beliefs about science teaching with the guidelines concerning their practice set forth by teacher preparation programs. Therefore, adding to the knowledge base on teacher development is the real importance of this work.

CHAPTER 2: THE PROGRAM, PRELIMINARY WORK, AND A REVIEW OF RELEVANT LITERATURE

This chapter is divided into three separate parts. Part one describes the context of the teacher preparation program. Part two is designed to facilitate an understanding of the preliminary work completed to inform the current study. Part three reviews the appropriate literature related to this work.

Part One – The Teacher Preparation Program

The teacher preparation program in this study offers a traditional four-year course sequence for undergraduates and a three-semester option for post-baccalaureate students who hold a mathematics or science undergraduate degree. The program integrates secondary science and mathematics education students in a series of courses taught by either experienced classroom teachers or university faculty. Typically, the first two courses in the sequence are taught by former mathematics and science teachers who are employed by the program as master teachers. These recruitment courses are designed to give students an early opportunity in the field as teachers. Later courses in the sequence are typically taught by College of Education (COE) faculty, although some courses are taught by College of Natural Sciences (CNS) faculty as well. This program has been highlighted in national reports as promoting exemplary mathematics and science teachers who embody reform-based teaching.

PROGRAM HISTORY

The teacher preparation program originated in 1997 as a commitment by both the CNS and COE to strengthen secondary mathematics and science teacher preparation at the university. This partnership was extended to a large urban school district interested in a pipeline of young, well-trained science and mathematics teachers. The first cohort of 28 students was selected for the fall of 1997, and the program has grown to over 400 enrolled students per year. As of Spring 2005, a total of 212 mathematics and science education students have graduated from the program, and 175 (83%) are currently teaching (LaTurner, 2005). The program has enjoyed attention and support both from the university chancellor and administration as well as from national reports touting its innovative nature and retention rate (National Academy of Sciences, 2006; US Department of Education, 2003).

PROGRAM OBJECTIVES

The program has many strategies for producing successful teachers. These include:

- Aggressive recruitment targeting diverse teacher candidates
- Creation of a supportive and sustained learning community from recruitment through induction years
- Development of graduates with exemplary content and PCK skills

- Placement of students in early field experiences located in urban schools
- Infusion of technology into all aspects of instruction
- Critical and self-directed reflection of progress through program by students
- Critical reflection of program efficacy through research and evaluation
- Commitment to collaborative leadership

PROGRAM ORGANIZATION

The program is jointly directed by the CNS and COE, although the program is normally associated more with the CNS, and the undergraduate students who are recruited come primarily from that college (LaTurner, 2005).

Role of College of Natural Sciences

The dean of the CNS originally brought together experienced mathematics and science practitioners and administrators from the K–12 setting to create the teacher preparation program based on national standards, educational research, and the teachers' experience in the classroom. Introductory recruitment courses are typically taught by experienced classroom teachers as an entrée into teaching for students pondering teaching careers, and the CNS pays for the tuition of this introductory coursework. Additionally, the CNS is responsible for the administrative, admissions, and academic counseling of the students in the program, as well as the internal auditing and evaluation to determine the program's efficacy.

Role of the College of Education

The dean of the COE originally created a leadership team of science and mathematics educators to restructure the university coursework for teacher preparation at the same time that the CNS was meeting to design the teacher preparation program. The role of the COE is to teach integrated science and mathematics courses that prepare students to teach in an inquiry-based manner, understand student cognitive processes, and prepare curricula aligned with effective strategies for student success (for example, the Project-Based Instruction course). In addition, issues of equity and the uses of technology are embedded in the coursework, and students are placed in urban schools for exposure to the challenges and opportunities of working in this setting.

SEQUENCE OF COURSEWORK

The coursework for the teacher preparation program consists of recruitment courses and latter courses designed to prepare students for the classroom. The description of these courses will be broken into two sections. Table 2.1 shows the suggested sequence of the courses in the program.

Program Recruitment Courses

The first two courses (Step 1 and Step 2) are designed to introduce students to teaching as a career choice through repeated early teaching experiences in elementary classrooms, and to provide an important introduction to the constructivist principles that are the basic framework for the program. For the first course, students typically teach four one-hour lessons to elementary students over the course of the semester, and meet at the university once a week for a one-hour class. The meeting time at the university allows master teachers to model appropriate pedagogical skills and help students prepare for their teaching assignments. The students co-teach from popular kit-based curricula aligned with inquiry-based practices (FOSS kits). The second course in the sequence (Step 2) continues giving students early experience in the field with middle-school students. The teachers plan and execute three lessons with a partner. The lessons are typically adapted from kit-based curriculum, and are required to be aligned within the 5-E instructional model, an inquiry-framework.

Table 2.1: Sequence of courses for the teacher preparation program.

	Freshman	**Sophomore**	**Junior**	**Senior**
Fall	Step 1	Knowing and Learning	Classroom Interactions	Project-Based Instruction
Spring	Step 2	Research Methods	Perspectives	Student Teaching

General Program Coursework

Following (or concurrent with) the recruitment courses, students take a variety of courses designed to prepare them for the classroom. A brief description of each course follows to help the student understand the program's general goals and philosophy.

Knowing and Learning: Course objectives are to broaden student understanding of current theories of child development, learning, and conceptual development (for example, Piaget, Vygotsky).

Classroom Interactions: Course objectives are to focus on teaching and learning in the classroom. Students complete a series of early field experiences totaling 9–15 hours, and typically teach self-created lessons that focus on inquiry-based methods. Attention to interactions between teacher and pupils is emphasized.

Research Methods: Course objectives are to give students a grounding in primary-scientific-research-implementing technology and inquiry-based methods. Students design, carry out and statistically analyze four investigations.

Perspectives: Course objectives are to introduce the historical and philosophical nature of science to students through investigations of five significant episodes in science history.

Project–Based Instruction: Course objectives are to build student understanding of unit-long authentic investigations in science. Students plan 6-week units and teach either marine science or astronomy lessons to secondary students.

Student Teaching

Students spend four hours a day at local secondary schools, where they are responsible for teaching two hours of instruction per day. Students are observed and evaluated weekly by university facilitators, and also attend a weekly seminar class for self-reflection on their progress and for help as they transition to the classroom. During this time, students also complete a teaching portfolio that is evaluated to determine their fitness for teaching.

Part Two – Preliminary Work

An important part of the research for this dissertation was completed as two pilot studies that were designed to inform the final study. Both of these studies fill additional gaps in the research. These studies were crucial subcomponents of the main study and offer additional information on the recruitment and early field experiences of beginning science teachers in the program. They will be discussed below.

STUDY 1: EARLY RECRUITMENT OF BEGINNING SCIENCE TEACHERS: PROMISING OR PROBLEMATIC STRATEGY

Research Focus

This was an exploratory study that examined the knowledge and experiences of students enrolled in a recruitment course in a science, mathematics and computer science teacher preparation program. It specifically sought to identify commonalities among participants to better inform other developers of recruitment courses.

My Role in the Recruitment Study

My duties for this study included data collection through interviews, coding belief maps, researching and writing proposals for acceptance to annual meetings of science education professional organizations, presenting findings at annual meetings of professional organizations (ASTE, NARST), and preparing drafts of the final published paper. Dr. Luft directed the research, completed interviews and edited my written work.

Recruitment Study Context

There is a concern about the current and looming shortage of mathematics and science teachers. In response to this concern, several reports have been issued discussing the shortage of teachers and suggesting potential reform and policy measures (e.g., National Commission on Mathematics and Science Teaching for the 21st Century, 2000; National Commission on Teaching & America's Future, 1996). Recommendations to address the need for science and mathematics teachers have resulted in the development of programs that provide different pathways for certification, such as one-year programs that offer certification and a graduate degree, or programs that allow a content expert to receive pedagogical training on the job. There are also programs that offer financial incentives for mathematics and science teachers in hard-to-staff areas, which include forgiving student loans and signing bonuses and housing allowances. Another effort, which has not been discussed in depth in teacher development literature, pertains to the recruitment of students into the educational pipeline. Recruitment programs are often combined with teacher education programs as a means of increasing the pool of applicants.

This study looked at students who were participating in a recruitment course in a secondary science, mathematics, and computer science teacher education program. The value of the study was that by examining the experiences and knowledge of students in such a program, the developers of the program could understand the disposition of participating students toward teaching, and devise mechanisms that may have provided better information pertaining to the recruitment of potential teachers. A better understanding of both the students in the program and the program's goals could ultimately suggest a direction for the recruitment program, the content and process of such a program, and the means by which students should be recruited to participate in this early teacher education experience.

Recruitment Study Procedure

Students were interviewed at the beginning and end of the recruitment courses (Step 1 and Step 2 classes), and completed the VNOS-C questionnaire (see Chapter Three, "Sources of Data," for detailed description of VNOS and interview protocol). At each interview, participants were asked to bring documents that demonstrated their growth as science teachers. These artifacts were photocopied and the originals were returned to the students. The resulting data was examined for salient trends. Interviews were transcribed when appropriate, and demographics information was collated. The instrumentation described in the general methods section was used to compare participants' responses.

Recruitment Study Findings

Findings from this study have been categorized into three areas:

Recruitment Circumstances

Students who joined the program were informed about the teacher preparation program through a variety of methods, entered the program as juniors or seniors, and were actively seeking a career in teaching. They did not initially plan to pursue a degree in education, but it was now an option for a variety of reasons. The students' reasons for considering the education profession ranged from finding a degree that allowed them to work with people and science, to dissatisfaction with the courses and instructors in their current science or engineering program.

Participants

Students were involved in education for different reasons, from a primary interest in working with children to using a teaching degree as a backup to another career. In addition, students held primarily teacher-centered and transitional beliefs about teaching and learning that related to their prior experiences in education and expressed limited views of the nature of science.

Experiences Related to the Recruitment Course:

Field experiences and relationships with others in the program were a positive feature in the early recruitment course. Each student in Step 1 valued the opportunity to teach different lessons from a science kit in an elementary classroom and the chance to be a part of a teaching community.

STUDY 2: LESSONS FROM THE TEACH/RETEACH: REFLECTIVE PRACTICE AND SCIENCE AS INQUIRY IN AN EARLY FIELD EXPERIENCE

Research Focus

This study was designed to explore the relationship between participants' level of reflection and their ability to teach with an inquiry-based orientation in an early field experience. It was concerned with the development of reflective practice through field experiences as well as the correlation between level of reflection and the ability to understand and teach science as inquiry.

My Role in the Teach/Reteach Study

For the Teach/Reteach study, my role was as the principal investigator. My responsibilities included writing and submitting the Institutional Review Board (IRB) application; receiving human-subjects clearance; organizing the participant pool; interviewing participants; observing participants during the field experience; collecting artifacts; analyzing and coding data; transcribing and coding verbal interviews; creating case studies and cross-case comparisons; presenting preliminary findings at regional and national science education conferences; and preparing a paper to be submitted to the *International Journal of Research in Science Education.* Dr. Luft has served as a faculty advisor, and assisted in editing the written work.

Teach/Reteach Study Context

Many beginning teachers struggle with the tension between the science-teaching methods they experienced as students and the inquiry-based methods that are advocated in colleges and universities today. Prior beliefs about what constitutes "good teaching" may interfere with learning about contemporary teaching philosophies that espouse student-centered, active learning environments.

Standards that guide science education reform in the US leave little doubt that inquiry-based methods are superior to previous teaching styles. In fact, the first content standard of the National Science Education Standards (NRC, 1996) forcefully articulates science as inquiry. This perspective is further supported by current research into student cognition. This research advocates that children learn best when they are forced to question their own ideas about natural phenomena, refine their ideas through experience and social interaction, build conceptual knowledge about enduring ideas in science, and apply this knowledge to new and novel situations (Driver et al., 1985; 1994; Rosebery et al., 1992).

Facilitating the growth of beginning science teachers who use current constructivist epistemological frameworks to teach science as inquiry in the classroom is also a difficult task. Critical reflection about the design, execution, and evaluation of an inquiry-based science lesson is an important part of the science-teaching process (NRC, 1996; Teaching standard A). Science teacher educators rely on a number of techniques to develop the reflective abilities of their students. One mechanism for building the reflective capacity of teachers combines an early field experience with the teaching and re-teaching of inquiry-based lessons. This study explored preservice teachers' levels of reflective practice during this assignment and how the ability to reflect at different levels may affect their ability to plan and teach science as inquiry in the classroom.

This study was important for two reasons. First, it filled a gap in the research on the impact of early field experiences on the development of contemporary science-teaching practices in preservice teachers. Although a number of studies have focused on aspects of early field experiences including diversity (Tiezzi and Cross, 1997; Proctor et al, 2001) and other issues, the relationship between level of reflective practice and science as inquiry had not been explored. Second, this study informed the development and implementation of university science teacher preparation programs by providing data on how early field experiences with a three-day Teach/Reteach science-as-inquiry lesson could affect their ability to teach thoughtfully in a standards-based manner.

Teach/Reteach Study Procedure

The course that contained the Teach/Reteach field component was designed to provide prospective teachers with the opportunity to examine and analyze classroom instruction. During the course, students were introduced to various aspects of science and mathematics instruction and related topics. An important part of the course entailed working in a high-school classroom. In addition to observing secondary science teachers throughout a semester, students in the course were required to plan and teach two three-day lessons.

For the Teach/Reteach assignment, students selected partners that had the same content interests. Each team then designed a science lesson that fit with the classroom teachers' schedule and content needs, and utilized a science-as-inquiry framework. The students spent a few hours observing the classroom culture and establishing a relationship with the classroom teacher, and then taught their lesson in this class for three consecutive days. The students videotaped (and some audiotaped) themselves teaching for later analysis. In addition, all prospective science teachers in each section worked together to develop a class-scoring rubric that defined effective science-as-inquiry instruction. This rubric was used by the students as a guide for developing the science-as-inquiry lessons and in evaluating their instruction. This rubric contained categories such as "science as inquiry" and "assessment," and defined their conception of standards-based teaching in the classroom. After the first three-day teach, students had three weeks to digitize and watch their videos, analyze the successes and challenges of the first teach with regard to content and pedagogy, and revise the original lesson for a re-teach of the same topic. Conversely, the students may have re-taught another topic to the same students within a science-as-inquiry framework (this depended upon the district and mentor teachers' curriculum schedule). They then revisited another class and re-taught the lesson, again with video- and audiotape data collection. The final product was a detailed written reflection, and a presentation that included video highlights from the experience.

Ultimately the Teach/Reteach assignment provided students with an opportunity to use the instructional methods they were learning about (e.g. learning cycle, problem solving, alternative assessment, etc.), practice reflecting in and on their practice (Zeichner & Liston, 1996; Schön, 1983a), connect pedagogy and content knowledge (Shulman, 1986), and develop the language found in science education while collaborating with their peers (Rosenholtz, 1989).

Participants were interviewed before and after the Teach/Reteach field experience in the Spring 2004 semester. Interview protocol included general questions to draw out their concerns about the experience, their level of reflective practice, and their knowledge about science as inquiry. Participants also completed a VNOS-C questionnaire at the first meeting. During the semester, I was the teaching assistant for the course that included the Teach/Reteach assignment, and made observations of the participants as they taught.

After all interviews had been transcribed, a preliminary instrument was created to determine the participants' levels of reflective practice and place the students in categories. In addition, a chart of the continuum of inquiry-based science practice was utilized to code students' understanding of science as inquiry and the coding protocols already described in the general methods section for beliefs and VNOS-C data. All of these instruments are included in Appendix A.

Teach/Reteach study findings

Brief findings from the Teach/Reteach study are as follows:

Level of Reflection

Findings indicate that the Teach/Reteach did not appear to have a significant impact on the students' level of reflection. Although participants mentioned that the writing assignments for the Teach/Reteach forced them to think more deeply about the impact of the lesson, none of the participants' final products (interviews, artifacts, observations) showed a change in their level of reflective practice. Also, some students' levels of reflective practice may correspond with a deeper understanding of science as inquiry. Students in the study who were categorized with deeper levels of reflective ability also showed a trend toward a more complete view of science as inquiry. Unfortunately, student concerns regarding classroom management and pupil interest were found to interfere with reflection on science-as-inquiry lessons. Students in this study were preoccupied with concerns about classroom management and pupil motivation during the Teach/Reteach assignment.

Science as Inquiry

Findings from this study indicate that the students' length of time in the teacher preparation program correlates with a greater understanding of science as inquiry. Participants with the most experience in the program seem to have a deeper understanding of science as inquiry. However, this aptitude for understanding the concepts of science as inquiry did not necessarily translate to practice during the field experience. For example, Angie (pseudonym) had a deep, conceptual appreciation for the tenets of inquiry, but was unable to translate this to practice during the Teach/Reteach Experience. Concerns about student motivation, interpersonal issues with her partner, and time constraints dominated her post-teaching interview.

Teacher Beliefs

The Teach/Reteach challenged students' initial beliefs about teaching in a reform-based manner. Students were challenged to think differently about their practices and beliefs about teaching inquiry from this early field experience. This experience was the first multi-day teaching event in the program, and the students were given more autonomy in the class than in previous experiences. This freedom and responsibility gave the students a sense of the logistical challenges to doing inquiry.

Part Three – Review of Literature

TEACHER DEVELOPMENT

Teacher development is the overall theoretical frame that encompasses this work. Many models of teacher development exist in the literature, and these models ultimately reflect the vision of teaching of the researcher who developed them. Grossman (1992) aptly pointed this out in a critique of Kagan's review of professional growth in teachers when she remarked, "How researchers frame teaching inevitably colors both the questions they choose to study and the models they create for teacher preparation" (p. 171). Sharon Feiman-Nemser (1990) examined teacher development from different structural orientations that reflect some of the goals and ideas that drive teacher preparation programs. These orientations are briefly outlined below:

a) Academic Orientation: Teacher preparation programs that follow this conceptual model attend primarily to the preparation of teachers that have a strong conceptual understanding of the discipline they are teaching.
b) Personal Orientation: Teacher educators that use this model place the teacher candidate at the center of the program, and pay particular attention to the personal growth of the student.
c) Critical Orientation: Teacher preparation from this viewpoint is seen as a vessel for promoting and rectifying social inequalities, and for challenging the common paradigms that have preserved hegemony of the traditional school system.
d) Technological Orientation: This model is based on the idea that scientific reasoning and research are the best ways to shape preservice teacher education. Attention is paid to the skills and processes of teaching that have been empirically tested and deemed effective.

e) Practical Orientation: This model for preservice teacher development requires the teacher candidate to apply craft and technique in an apprenticeship of learning. The teacher candidate interacts with peers and mentors to establish experience and practice in the field.

As an alternative, Bell (1998) suggested framing teacher development from the interrelated aspects of professional, social, and personal growth. Professional growth refers to the development of skills and knowledge related to curriculum choices, instruction, and subject matter. Social development in this context refers to reframing one's experience from the perspective of teacher rather than student and using social skills to negotiate this process with colleagues and mentors. Finally, personal development refers to the individual cognitive work needed to integrate new beliefs and challenges about teaching that were introduced through the social and professional realms.

Finally, a recent perspective grounded in a situated view of cognition was put forth by Putnam and Borko (2000) that highlights the importance of authentic field experiences, discursive social interaction with colleagues and peers, and the understanding that teacher cognition is stretched or shared across individuals, the community, and the various tools needed to successfully integrate the professional knowledge needed to teach.

While details vary among the different frameworks of teacher development, there are some assumptions about developmental stages common to all the models.

First, beginning science teachers develop their knowledge and skills progressively (Bell, 1998). Preservice teachers have pre-existing knowledge and beliefs about the teaching of science that are the result of 12 or more years of schooling. Teacher preparation programs strive to interact with this prior knowledge and belief base by introducing education students to the theories and practices of their chosen profession. Second is the operationalization of learning as preservice teachers enact that knowledge in course work and in the student-teaching classroom. Field experiences are an essential part of preservice teacher growth in facilitating the reinforcement, modification or reconstruction of beliefs (Anderson and Mitchener, 1994; Putnam and Borko, 2000). Finally, as preservice teachers progress through the preparation program, the school context, student learning, and teachers' need to "survive" have a direct impact upon their existing knowledge and belief base. Additionally, national, state, and district guidelines for inquiry-based teaching often run contrary to preservice science teachers' beliefs and practices regarding instructional practices and understandings of the nature of science.

These three common elements—teacher beliefs, early field experiences, and the practices of prospective teachers in an era of science-teaching reform—will be highlighted in the following sections.

TEACHER BELIEFS

Teacher Beliefs about Education

The shift from process-product research, most commonly associated with behaviorist psychology, toward research that resides within the realm of cognitive psychology has led to increased interest in the role of teacher thinking and, in particular, teacher beliefs. As a construct, teacher beliefs have been difficult for the research community to define clearly. Differences in definition of the term "belief," the confusion over the relationship between beliefs and knowledge, and the nature of the concept itself have kept this construct from a clear and focused line of research.

Defining Beliefs

Educational researchers have used a range of terms in defining beliefs. A review of the literature reveals beliefs labeled variously as conceptions (Clark and Peterson 1986; Strike and Posner, 1992), attitudes (Bunting, 1984), orientations (Brousseau, Book & Byers, 1988), implicit theories (Clark, 1988; Clark and Peterson, 1986; Weinstein, 1989), personal theories (Tann, 1993), anticipatory theories (Buchman & Schwille, 1983), perceptions (Tabachnick, Poplewitz & Zeichner, 1979), repertoires of understanding (Munby, 1982), and perspectives (Clark and Peterson, 1986; Hollingsworth, 1989).

Along with the variety of expressions listed above, researchers have also proposed alternate definitions used to describe the term "belief."

In response to the research communities lack of a coherent framework surrounding the belief construct, Nespor (1987) proposed a theoretical model for defining belief systems. Nespor's work describes four main structural features to defining beliefs that teachers hold and includes two additional features that describe how beliefs function in systems. The four main features are a) Existential Presumption, b) Alternativity, c) Affective and Evaluative Aspects, and d) Episodic Structure. Drawing on the work of Abelson (1979), Nespor found that mathematics teachers held strong beliefs about qualities they defined as laziness or maturity in their pupils. Nespor characterized these attributes as "labels of entities thought to be embodied in the students" (p. 318) by the teachers, and noted their importance as factors perceived by teachers to be immutable. In this way, abstract attributes took on the qualities of real entities.

Nespor also related the efforts teachers make to create classroom environments based on some alternative vision of what good teaching entails. These alternative, idealized conceptions often run counter to the realities of the classroom but can still influence instruction significantly. Belief systems are partially developed through personal interaction with one's culture, family, and background, and gain their power through personal episodic experiences that reinforce their legitimacy. In this way, they become powerful tales that we tell ourselves about how the world works.

Finally, Nespor found that belief systems are also value laden. They are influenced by moods, feelings, and the relative value the teacher places on the subject matter being taught. Nespor also defined two additional factors that are common to belief systems as a whole, rather than to individual beliefs. The first, *non-consensuality*, recognizes that belief systems are driven by personal, idiosyncratic factors that are, in principle, subject to dispute by others. This characteristic differs from knowledge systems, which are governed by well-defined and established lines of argument. The second feature, *unboundedness*, refers to the unstable and highly variable nature of belief systems when applied to novel situations. In other words, people apply their set of beliefs in unpredictable ways to understand and deal with disparate events or phenomena that may not be related to the original context of the belief system.

In composing a definition of belief for this study, a number of sources were consulted, including major reviews of beliefs research by Kagan (1992) and Pajares (1992), along with an examination of the role of beliefs in the practice of teaching by Nespor (1987) and of a chapter by Richardson (1996) on the role of attitudes and beliefs in learning to teach. In general, researchers agreed on a number of common attributes surrounding beliefs, and these are the tenets that will be adopted for this study. These elements include a) recognition that the statements contain propositions accepted as true (Richardson, 1996; Pajares, 1992), b) recognition that beliefs are separate from knowledge (Nespor, 1987; Richardson, 1996), and c) recognition that beliefs are developed in personal experience, are value laden, and reflect the personal stories that we create to understand and negotiate our existence in the world (Nespor, 1987).

For the purpose of this dissertation, therefore, beliefs are psychologically held understandings, premises, or propositions about the world that are felt to be true (Kagan, 1992; Richardson, 1996) but, unlike knowledge, do not require a condition of truth (Richardson, 1996). In addition, beliefs are formed from episodic events that are contextually derived from personal experience and/or cultural mores (Nespor, 1987).

What the Research Says about Teacher Beliefs

There are a number of central comments about teacher beliefs that are useful to examine for this dissertation. The following section will elucidate these findings, and a separate section will focus on science teachers specifically. The first part defines commonly held ideas about the nature of teacher beliefs and practice. The second part examines the relationship of teacher beliefs and change. Finally, the third part organizes work on teacher beliefs that has been done with beginning teachers, including science education.

Teacher Beliefs and Practice:

It has been established that teaching-related beliefs of teachers are related to and interact with actions in the classroom (Kagan, 1992; Pajares, 1992; Richardson, 1996), although the exact mechanism for how this interaction occurs is not clear (Kagan, 1992; Luft, 1999; Richardson, 1996; Skamp & Mueller, 2001). In fact, Pajares (1992) suggested that an individual's set of belief systems may be more useful as predictors of classroom practice than the individual's knowledge systems due to the complexity and nature of teaching itself. Teachers make instructional decisions based on their belief and knowledge systems. This combined mess of belief and knowledge structures influence a range of classroom decisions, from selecting objectives, tasks, and activities (Clark, 1988), to enacting instructional strategies (Pajares, 1992; Richardson, 1996), to evaluation of student work (Keys and Bryan, 2001).

Happily, recent work exploring science teacher educational beliefs has begun to pull apart the layers around these issues and make explicit the complexity of the relationship between beliefs and practice.

Findings from a recent study by Bryan (2003) underscore the convoluted nature of prospective science teachers' belief systems and the interaction of those belief systems with actions in the classroom. Bryan examined the belief systems of a preservice elementary science teacher (Barbara) as she progressed through a university preparation program, and charted these beliefs against the same teacher's actions in the classroom as she student-taught. Findings from this study show that Barbara had a complex and interrelated set of beliefs that included foundational and dualistic systems. The foundational beliefs related to the nature of science and classroom management, and were stable throughout her preparation. The dualistic set of beliefs included didactic beliefs that guided her observed practice and more contemporary student-centered beliefs that guided her vision of her practice. This dichotomy between the promoted and the performed beliefs points to the importance of identifying and studying more completely the relationship between beliefs and practice.

This disparity between beliefs and practice has been documented elsewhere. For example, Fang (1996), in a review of research on teacher beliefs and practice, noted that contextual factors (e.g. school climate, district mandates and evaluation, and resources) may be powerful influences on teacher practice that outweigh espoused belief systems. In a report from a large-scale study on beginning teacher beliefs and classroom practices, Simmons et al (1999) reported a marked difference between the views espoused by beginning teachers during interviews and the observed practices enacted in the classroom.

Teacher Beliefs and Change:

The literature on teacher beliefs and change suggests that foundational beliefs about education are formed at an early age and result from experiences as a student (Knowles, 1992; Knowles & Holt-Reynolds, 1991; Pajares, 1992) as well as from the development of values, personal beliefs, and a sense of "self as teacher" (Hawkey, 1996; Helms, 1998). These early beliefs are considered foundational because they form a core set of assumptions about teaching and learning that shape how the teacher perceives the roles of student, teacher, curriculum, and the surrounding culture of the school community. They are firmly established by the start of the preparation program (Wilson, 1990).

Research suggests that the core beliefs that teachers hold are resistant to change (Rokeach, 1968, Nespor, 1987). However, when teachers enter formal preparation programs, they are often exposed to new perspectives or novel experiences. In this case, new beliefs may develop that are tentative in nature. These beliefs may be subject to evaluation and or change more readily than the more stable, core beliefs (Pajares, 1992; Rokeach, 1968). The work of Green (1971) presents a useful way to discuss belief structures through multiple levels of analysis. Green examined three aspects of belief structures that are practical for this study. Green characterized belief structures as being either primary or derivative in nature, centrally or peripherally placed (based on their psychological strength), and held in clusters that are isolated and protected from other sets of beliefs (p. 48). For example, a centrally held belief about student understanding is stronger than one derived from that belief. Similarly, central beliefs are held more firmly than peripheral ones. These two constructs relate to one another as well. Additionally, belief clusters are held in isolation when they have little chance to interact with one another or are not challenged. The central propositions from Green's work are that belief structures exist in multidimensional relationships and that they may be present in concert with and/or contradiction to each other.

This level of complexity when considering belief systems is valuable to keep in mind. One major challenge for teacher educators is to guide beginning teachers into an examination of the beliefs that guide their actions and offer options if those belief systems do not mesh with current research on how children learn science. The opportunities to understand prior beliefs and their influence on teacher preparation thus lie in preservice science teacher preparation programs (Brookhart & Freeman, 1992; Clark, 1988; Richardson, 1996).

Beliefs and Preservice Teachers:

Although it has been noted that a) the duration of preservice programs can limit the impact of new conceptions on a teacher's beliefs (Bullough, 1992), b) beliefs don't begin to change until the end of the induction period for teachers (Kagan, 1992; Richardson, 1996; Simmons et al, 1999), and c) beliefs are well-established by the preparation program (Wilson, 1990), many researchers have noted the importance of studying beliefs when planning preservice programs (Feiman-Nemser, 2001; Haney, Czerniack & Lumpe 1996). In particular, longitudinal studies that examine change over time in science teacher beliefs have been recommended in the literature (Lederman & Gess-Newsome, 1991; Scamp & Mueller, 2001). Scamp and Mueller (2001) examined the influence of the practicum on elementary science teachers' conceptions of effective science practice over their preservice program, and note the following in their introduction:

> These studies which have longitudinally mapped student teachers' conceptual changes related to science teaching are rare in the research literature (Lederman and Gess – Newsome, 1991: 414), and this could be the only such study at the primary level. Therefore, there is virtually no empirical data to inform teacher

> educators about who and what influences student teachers' views about teaching primary science as they progress through their degrees. (p. 227)

Beliefs and Science Education

There are a number of considerations related specifically to teaching science that emerged from a review of relevant literature on beliefs. These issues include the characterization of the nature of science as a discipline (Brickhouse, 1990; Gallagher, 1991), science curriculum implementation (Cronin-Jones, 1991), epistemological beliefs (Hashweh, 1996), and the importance of understanding the cultural framework of science teachers (Tobin & McRobbie, 1996). A review of the studies examined in major reviews by Clark and Peterson (1986) and Kagan (1992) indicates that a majority of research on teacher beliefs has focused on elementary-level teachers (Abell et al, 1995; Brickhouse & Bodner, 1992; Briscoe, 1991; Bryan, 2003; Scamp & Mueller, 2001; Tobin & LaMaster, 1995).

The literature on beliefs in science education is enriched by the discipline of science itself. The nature of science and how this is defined and negotiated by science teachers has been the focus of many researchers in the field (see the work of Lederman, Schwartz, Abd-El-Khalick, Bell and others).

FIELD EXPERIENCES

In one section of a review of current teacher preparation research prepared for the US Department of Education, Wilson, Floden and Ferrini-Mundy (2001) summarized the status of research on field experiences in the United States. Their findings are helpful in understanding the variety of types, objectives, and settings of field experiences, and are outlined below. First, most science teacher preparation programs now include a variety of field experiences. These experiences can have different intentions. Field experiences may be orchestrated simply to give students an idea of what teaching is all about. Some may reinforce a narrow set of teaching skills in classroom management, classroom procedures, or time management strategies. Still others may be designed to allow teachers the opportunity to transform university coursework into practice. The settings allotted for field experiences may also vary from haphazard settings with ill-matched mentor teachers to highly structured Professional Development Schools (PDS) with explicit focus on professional development for both novice and experienced teachers. Field experiences also vary in length, from early field experiences that require a few hours of observation per semester to one-year student-teaching assignments. Huling, Raffeld, and Salinas (1998) examined data on field experiences in Texas and found that 49% of preservice teacher educators had spent over 90 hours in the field by their junior year of university study, while the remaining 51% spent 16–90 hours in the field.

McIntyre (1983) listed several reasons for including early field experiences for preservice teachers. These include a) practice and early exploration of teaching as a potential career, b) increased student motivation by working directly with pupils early in their preparation program, c) help and an infusion of contemporary ideas and strategies for the regular classroom teacher, and d) a critical opportunity to practice theories and ideas presented during university education coursework.

The Ecology of Field Experiences

Regardless of the type, setting, or length, research suggests that field experiences are viewed as powerful by both beginning and experienced teachers (Wilson, Floden, & Ferrini-Mundy, 2001). This enthusiasm may or may not translate to more effective teaching, but it does provide insight into the importance that the participants place on this type of activity. Field experiences are complicated, and deconstructing what teachers actually learn from them is a difficult undertaking (Huling, 1998). Some suggest framing field experiences ecologically, as complex systems with myriad interactions (Mewborn, 2000; Wideen, Mayer-Smith & Moon, 1998). These interactions may include the interface of physical and cultural boundaries, as well as the relationships between students, prospective teachers, teacher colleagues, mentor teachers, and administrators at the site, and with supervisors and faculty at the university (Mewborn, 2000).

As with any ecological system, the route to eventual homeostasis is punctuated by tensions and conflicts that help define the path. In the research on field experiences, the news is quite serious. Beach and Pearson (1998) identified four categories of tensions and conflicts in their study of students in a year-long field experience. These issues included problems with

a) curriculum and instruction (for example, conflicts with mandated curriculum, student interests and motivation, use of inquiry/constructivist teaching techniques, and timing);

b) interpersonal relationships (for example, conflicts with peers, students, mentor teachers, administration, and university supervisors);

c) role (for example, tension surrounding the shift from student to teacher, or uncertainty as to role as teacher vs. friend); and

d) contextual and institutional issues (for example, differences in beliefs/values from school culture).

These tensions are echoed by the work of other researchers. For example, Moore (2003) reports that beginning teachers reflect the early concerns first introduced by Fuller (1969). Moore found that the teachers in her study predominantly held concerns about classroom procedures, time management, and classroom discipline and management strategies rather than the hoped-for concerns about student learning. One reason for this may be that teachers are not given enough time to reflect on their experiences while in the field (Hewson et at, 1999; Lanier & Little, 1986), and thus do not develop a deeper level of comprehension and application of theories learned in methods classes to the field experience.

The Theory-to-Practice Gap

Many researchers report that prospective teachers complain that field experiences are incongruent with university coursework (Beeth & Adadan, 2006; Beach & Pearson, 1998; Hollingsworth, 1989; Roth, Masciota & Boyd, 1999; Roth and Tobin, 2001). In other words, after spending a considerable time period preparing for teaching through university coursework, students report that they were unable to see the connection between their formal education and practice in the field (Roth & Tobin, 2001).

The role of field experiences is to give students practice in teaching according to the current trends in quality education. However, some research indicates that field experiences may not be reinforcing current theories of teaching and learning, but may instead be socializing prospective teachers in traditional approaches to teaching (Anderson and Mitchener, 1994), reinforcing the status quo (Wilson, Floden & Ferrini-Mundy, 2001), or focusing on fulfilling the objectives of the textbook or calendar rather than honoring student thinking (Hewson et al., 1999). In one study, students in a university program that provided little guidance during early field experiences began to align their views of teaching with the "teach to the test" ideology of the cooperating teachers (Goodman, 1985). Munby and Russell (1996) reported that the culture of the school may run counter to the tentative and newly emerged beliefs about teaching carried by the beginning teacher and may not support the fledgling ideology carried by the student. With this in mind, some argue that the proper placement of students in the field is crucial, especially with regard to the cooperating teacher (Hewson et al, 1999), in order to give students the best opportunities for learning and support for student-centered and constructivist beliefs.

The Role of the Mentor Teacher

Most research indicates that the role of the mentor teacher is a powerful one. The voice of the classroom teacher offers experience and daily relevancy unmatched by most university observers who may visit infrequently. Hewson et al (1999) found that cooperative teachers who teach "against the grain" can model effective teaching for prospective teachers and thus positively support their growth as teachers. This relationship has its own tensions, however. As Wilson, Floden and Ferrini-Mundy (2001) pointed out, the cooperating teacher in the classroom can positively challenge the prospective teacher to think differently, or can intimidate the novice into following established classroom protocol without offering a chance for the apprentice's development. This observation has been noted elsewhere. Countering intuitive reasoning, Hollingsworth (1989) found that typical placements may hinder intellectual growth for the prospective teacher. In contrast, placing students with dissimilar mentors seems to elicit some form of growth:

> Further, it appears that contrasting viewpoints were helpful in clarifying complex aspects of classroom life and promoting comprehensive learning when accompanied by an expectation and support for preservice teachers to try out their own and program-related ideas. The study challenges the common sense notion that preservice teachers should be placed with teachers with whom they agree and that cooperative teachers should be chosen who are model teachers according to program philosophy. Such teachers tend to promote rote copying or modeling of their behavior, limiting the depth of preservice teachers' processing of information and change in beliefs. The matched pairing, in other words, hindered knowledge growth. (Hollingsworth, 1989, p. 186)

Roth and Tobin (2001) did not place emphasis on the experience or philosophical alignment of the cooperating teachers they used in field placements, and instead attempted to create intellectual communities composed of pupils, apprentice teachers, cooperating teacher, and university supervisors during field experiences. Ken Tobin remarked:

> Most of my colleagues insist that the best placement for a new teacher is with an exemplary cooperating teacher. This has not been my experience. In the long term new teachers who learn most are those who have to contend with *event full* classrooms. Teaching with an exemplary cooperating teacher might limit the diversity of the events that arise and hence the opportunities to develop a teaching *habitus* to contend with emergent issues that simply do not arise. On the other hand, teaching with someone who has much to learn about teaching can provide experience with an event-rich environment that is conducive to the development of a robust teaching *habitus*. (Roth and Tobin, 2001, p.748; original emphases)

In Roth and Tobin's work on co-teaching, pairs of beginning teachers take turns leading lessons, and the university supervisor and cooperating teacher play an active role. Their work suggests that beginning teachers find this arrangement begins to diminish the theory-practice gap (Roth, Masciotra & Boyd, 1999; Roth & Tobin, 2001). The work of Bullough et al. (2002) supports this. After comparing single vs. partnership student teaching, they found that students in partnership-teaching situations felt better supported and were able to take more risks with management and instructional strategies than were those in single-placement settings. Additionally, there appeared to be a corresponding trend toward increased student retention of content, although this was not measured as a part of the study.

Despite the grim prognosis of the preceding examples, some hope remains for a positive role for field experiences in the development of the preservice teacher. Cochran-Smith (1991), herself an experienced science teacher and educator, reported on the results of an innovative three-year teacher education program. She found that mentor teachers who were committed to change, challenged the schools' culture and status quo, and worked with student teachers were able to expose these teachers to alternative visions for teaching. The student teachers then reported that they changed their conceptions of teaching based on the intersection of these experiences with their university coursework.

INQUIRY-BASED PRACTICES

Research shows that teaching science through an inquiry-based frame satisfies many current theories about how children learn science best. Harlen (2004) summarizes why we should teach in an inquiry-based manner. Harlen's first point is that inquiry-based science aligns with contemporary views of how people learn. The shift in educational psychology from behaviorism (Skinner, 1974) through cognitive science to the currently popular social constructivist stance (Solomon, 1989; Vygotsky 1978) has determined that children learn through social interaction that includes discussion and debate. Secondly, there is a major mismatch between how science is taught in the majority of schools and how the field of science works as a whole. Students need exposure to the view that science is tentative, value laden, and subject to the culture and personal biases of those involved, rather than a rigid set of facts. Third, theories come from shared thinking among the community of scientists and are influenced by the mores of that community. It is important for students to recognize that theories are subject to revision. Finally, teaching science with an inquiry framework allows teachers the opportunity to assess students' prior knowledge about science concepts.

Definition of Inquiry-Based Instruction

"Science as inquiry" has become a hackneyed phrase. Science teachers and others involved in science education tend to use the phrase with abandon, but may not have a clear understanding of what it means, how it evolved, how it relates to current theories of human cognitive development, and how it relates to the practice of science teaching as well as the discipline of science itself. With these clarifications in mind, a brief definition from the NSES (NRC, 1996) sums up the commonly accepted view of this term:

> 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. (NRC, 1996, p. 23)

This definition serves as a general definition, but researchers, teachers, and others involved in science education reform often use many terms to describe the various levels of inquiry that can be enacted. Windschitl (2003) captured the basic levels of inquiry, and these will be used to define the levels of inquiry in this study. These levels are outlined in Table 2.2.

Table 2.2: Levels of inquiry defined by Windschitl (2003).

Level of Inquiry	**Characteristics of Level** (from Windschitl, 2003)
Confirmation Exercises (Cookbook Lab)	Students verify known scientific principles by following a given procedure.
Structured Inquiry	Students are given a question for which they don't have an answer, and are then given a procedure to follow to complete the inquiry.
Guided Inquiry	Teacher provides a problem but students are given freedom in devising methods to solve it.
Open Inquiry	Students develop their own questions, design and carry out investigations, and report findings with guidance from teacher.

History of Inquiry in Science Teaching

Prior to the work of Dewey in the early 1900s, the dominant perspective of the education community was that scientific knowledge was best learned through direct instruction (Bybee & Deboer, 1993). Recognizing that students' passive nature did little to elicit deep comprehension of the subject matter, Dewey (1933) began to call for attention in science education to the processes and habits of mind necessary for scientific thought, not just accumulation of facts. Dewey championed the notions that children learn best through experience and that education through active experience provides more opportunities for students to cognitively make sense of and store information. In other words, experience is made meaningful by the way that we process it cognitively.

Attention was diverted during the 1930s and 1940s by other national concerns, and attention only returned to science preparation in the mid-1950s, during the turmoil caused by Sputnik and the resulting call for increased technology and science preparation. This attention focused money (20 million dollars over the resulting 20 years) and energy on the effective preparation of students in science in an effort to match the soviet advances in space science and technology in general. The incredible energy invested in science education during this time produced a number of results that helped prepare the groundwork for the current attention on inquiry-based learning.

First, a 1961 report from the Educational Policies Commission on the central mission of US Education outlined 10 "rational powers" for students to gain while in school. These included recalling and imagining; classifying and generalizing; comparing and evaluating; analyzing and synthesizing; and deducing and inferring. Another product from this era (sometimes referred to as the "alphabet soup" era due to the acronym-rich labeling of the efforts) was the emergence of curriculum reform efforts in science education that purposefully attempted to introduce elements of active student learning to current secondary-science curriculum. Examples of these efforts include the Biological Sciences Curriculum Study (BSCS), the Science Curriculum Study (SCIS), the Elementary Science Study (ESS), and the Physical Science Study Committee (PSSC).

By the 1980s, the success of Japanese business and technology applications created another ripple in US education as policy makers and the public began to question the lagging achievement of US students in math and science (Yager, 2000). The response was to pour more effort into creating a vision for the future of US science education. For example, in 1983 the National Commission on Excellence in Education published *A Nation at Risk*, which warned of "a rising tide of mediocrity" in US schools. At the same time, the American Association for the Advancement of Science (AAAS) was developing *Science for All Americans* (1989), which warned of poor student achievement in US science scores, especially for minority and female students, and outlined key recommendations for improving the science literacy of all. Some of these recommendations included bolstering an understanding of the nature of science, developing habits of the mind necessary for inquiry, and recognizing how historical developments in science influence current thinking in the sciences.

From this start, the AAAS subsequently published the *Benchmarks for Science Literacy* in 1993. This manual provided specific guidelines for each of the areas addressed in *Science for All Americans*. While this effort was occurring, another group was also framing ideas about science literacy and inquiry-based practices. In 1991, the National Academy of Sciences was asked to oversee the development of comprehensive national standards that would integrate current learning theory with guidelines for effective science teaching and learning. This effort led to the creation of the *National Science Education Standards* (NRC, 1996), the main guiding document for science teachers and science curriculum developers at the state, district, and local levels (Keys & Bryan, 2001). The *Standards* continue to strongly influence curricular and classroom reform efforts in science education, and their strong alignment with both science as inquiry and social constructivist learning theory make them an important document to mention in this study. Figure 2.1 includes some of the teaching behaviors and strategies recommended by the standards and shows them in relation to previously described classroom actions.

Figure 2.1: Overview of the changing emphasis of teaching behaviors advocated by the National Science Education Standards (NRC, 1996, p. 52).

LESS EMPHASIS ON	MORE EMPHASIS ON
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 curriculum	Selecting and adapting curriculum
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 the 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

Inquiry and Science Teacher Practice

How the reforms suggested by the *Standards* and other documents translate into practice is the focus of this section and will primarily address preservice teachers. Despite the mandates and requirements from district and national standards that require science teachers to include inquiry-based instruction in their classrooms, the research indicates that many preservice teachers exit preservice preparation programs without the skills, experience, or understanding of inquiry-based practices to be successful with these techniques (Adams & Krockover, 1997; Hashweh, 1987). There are a number of factors that may affect the teachers' ability to translate the theories of the university setting to effective classroom practice.

For example, prior beliefs about teaching and science influence teachers' abilities to teach in this manner (Richardson, 1996). Also, students' content preparation seems to have a large impact on their views of science and science teaching (Hewson et al, 1999). In other words, undergraduate science classes are typically taught in a dogmatic manner, reinforcing the notion to students that science is a disparate set of facts to be memorized. Students then enter teacher preparation courses with beliefs about the nature and processes of doing science that are not aligned with reform-based documents. Another outcome of traditional science instruction is that students also have limited experience with inquiry-based instruction (Crawford, 1999; Helms, 1998; Volkmann & Anderson, 1998). Typical science laboratory courses at the university level (especially those with large enrollment) perpetuate science investigations as verification of the previous day's lecture rather than authentic inquiry-based experiences. Students therefore never benefit from seeing science modeled using an inquiry framework.

Other challenges for prospective science teachers include the length of time allotted for field experiences and the relationship of the beginning teacher to the classroom teacher (see Field Experiences section), as well as the classroom mentor teacher's teaching orientation. The relatively short and fragmented nature of early field experiences makes planning, implementing, and reflecting on science as inquiry a difficult task (Fletcher & Luft, in progress). Wideen, O'Shea, and Pye (1997) found that a high-stakes testing environment also negatively influenced inquiry-based practices in the classroom due to teacher preoccupation with coverage of required content in classes and perceived difficulty with teaching in this manner.

Despite these constraints, researchers have found some preservice science teachers can effectively plan and execute inquiry-based lessons (Crawford, 1999; Windschitl, 2003). Crawford followed one preservice secondary science teacher (Denise) through her student teaching practicum and found that Denise planned and carried out two inquiry-based projects during her placement. Crawford created a case study from this experience and arrived at the following recommendations for guiding preservice teachers to incorporating more inquiry in their practice. Crawford's recommendations include a) challenging teachers to explore their own beliefs about teaching and science as a first step to further reflection about inquiry, b) including authentic inquiry research experiences for teachers, c) modeling effective inquiry-based teaching during field placement or video case study, d) scaffolding long-term unit planning of inquiry-based lessons for teachers, and e) promoting active teacher self-reflection regarding one's own teaching and learning.

Windschitl (2003) also found that student teachers who had previous extended experience with scientific research were more likely to promote inquiry-based instruction in their classrooms than those students who had less research experience but a deeper theoretical grasp of inquiry tenets. So in conclusion, the pathway for preservice teachers to enact inquiry-based instruction is a difficult one and requires careful and focused attention to the multitude of factors that can affect the successful experience.

CHAPTER 3: RESEARCH FRAMEWORK

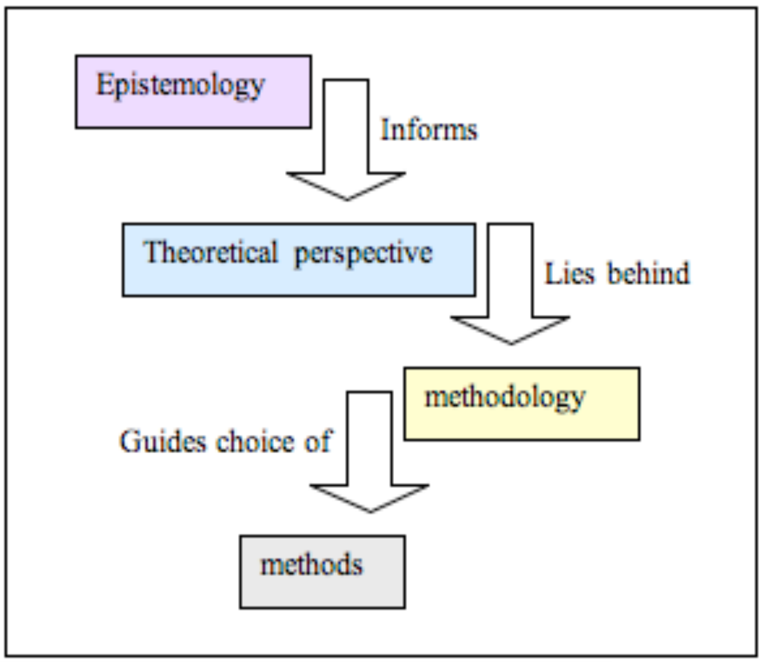
Research Design

This study was designed to explore the evolving beliefs and practices of prospective secondary science teachers as they progressed through a university preparation program and into the classroom. Because beliefs are grounded in the experiences, culture, and backgrounds of those who hold them (Nespor, 1987; Pajares, 1992) and are ill-structured and "messy" as a construct (Pajares, 1992), this approach was chosen because it offers important ways to address issues that can help explain the data gathered from the interviews, artifacts, and observations of the participants.

Denzin and Lincoln (2000) explained salient characteristics of qualitative research in an introduction to the *Handbook of Qualitative Research* (3rd Edition). Three points from this introduction are useful for understanding why this study was approached in a qualitative way. To begin, using a qualitative approach captures the participants' point of view in a detailed way through personal interviews and observation. Also, qualitative researchers are "…more likely to confront and come up against the constraints of the everyday social world" (p.12), which is where the nature of beliefs may be most evident (Pajares, 1992; Richardson, 1996). This commitment to an emic, idiographic, case-based perspective sets them apart from qualitative researchers, who seek to remove the researcher from any constraints of everyday life (p.12). Finally, the nature of qualitative research ensures rich description of the social and personal worlds of the participants, which is also important to understanding the complex nature of belief systems (Bryan, 2001).

The model of framing the research for this dissertation uses the relationship between epistemology, perspective, methodology, and methods set out by Crotty (1998). Figure 3.1 shows the relationship between layers within Crotty's model that will be explained in further detail below.

Figure 3.1: Crotty's (1999) conceptualization of the research design process.



Crotty's perspective recognizes a clear link between how methods and methodology should align with an epistemological framework and theoretical perspective, and guides both the assumptions made about the topic and the methods used to collect and analyze the data. The following sections describe the layers that comprise the research design for this study and relate the ideas presented to the context of this study in particular. Additionally, my perspective and background will be presented to clarify my personal perspective and philosophical bias when interpreting the participants' verbal, written, and observed data. Finally, issues related to research validity and verification will be addressed.

EPISTEMOLOGY AND THEORETICAL PERSPECTIVE — INTERPRETIVISM

An important first step when planning research is to clarify and make explicit the philosophical assumptions about the nature of reality (ontology), the nature of knowledge (epistemology), and the way that we plan to go about collecting and interpreting information (methodology) from the research. By doing this, the researcher aligns the reader with the assumptions and choices being made concerning appropriate methodology and methods for the work. For this research study, the epistemological assumptions and theoretical perspective were framed within the interpretivist tradition. Interpretivism is a position that carries the following assumptions for the researcher:

- Individuals seek meaning of their world through work and experience. Researchers that work within this paradigm therefore use open-ended questions so that participants can express their views (Crotty, 1999).
- Meanings are constructed subjectively, based on social interaction with others (Vygotsky, 1978). Therefore the researcher works inductively, attempting to generate meaning from the data collected in the field (Crotty, 1999).
- Meanings are framed within a historical and cultural context. Researchers thus attempt to work personally within the culture of the participants to understand the influence of these factors on the information gathered (Creswell, 2003).

The beginnings of this theoretical movement lie in the work of Weber and Husserl (phenomenology), as well as Dilthey and other German philosophers who were interested in hermeneutics (the interpretation of meaning) (Crotty, 1999; Mertens, 1998). From the positivist world of explanation and analysis of fact, Weber focused instead on a model of understanding as a keystone for his ideas (Crotty, 1999, p. 67). For Weber and later interpretivists, understanding the way that we construct knowledge and reality is of much more use in the social sciences than mere explanation.

Significance for this Study

Using an interpretivist theoretical perspective made sense for this research because of my interest in the nature of the beliefs and practices of the participants. Nespor (1987) characterizes belief systems as relying on subjective and affective components and derived from personal experience with cultural "folklore" (p. 320). In addition, Nespor frames belief systems as highly variable and uncertain in relation to real-world events. In other words, beliefs are bound in the emotional, episodic, personal experiences of the individual (p. 321). In order to capture a complete understanding of the belief systems of the teacher participants in this study, therefore, it makes sense to use interpretivist strategies and view the question in a broad way while attempting to make meaning inductively from interviews and field observations.

METHODOLOGY — CASE STUDY / CROSS-CASE ANALYSIS

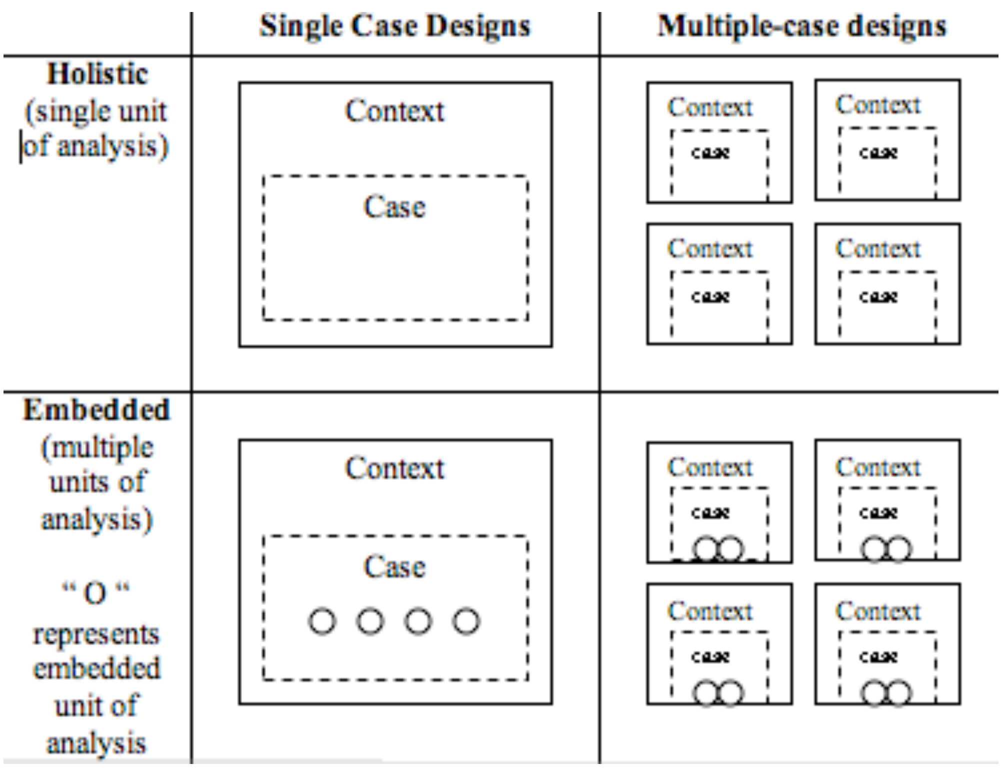
Case Study

The methodology (also called strategies of inquiry [Creswell, 2003]) of the research serves to inform the choice of methods (observations, open-ended interviews, etc.) while aligning with the theoretical perspective. Methodologies in qualitative research are varied and can include narratives, phenomenology, ethnography, grounded theory research (Glaser & Strauss, 1967), or case studies (Creswell, 2003). For this inquiry, a case study methodology was chosen. There are different interpretations of what one studies when doing case study research. For example, Yin (2003) viewed a case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 13). Yin was interested in using case studies to explore contextual conditions that may be pertinent to the research being conducted. Yin saw case study as a research strategy:

> …[T]he case study as a research strategy comprises an all-encompassing method, covering the logic of design, data collection techniques, and specific approaches to data analysis. In this sense, the case study is not either a data collection tactic or merely a design feature alone but a comprehensive research strategy. (Yin, 2003, p. 14)

Yin also clarified differences between different types of case studies. Some of the variations of case study design presented by Yin are represented in Figure 3.2.

Figure 3.2: Yin's conceptualization of case study designs.



Yin described four different types of case study design scenarios. Common to every instance are the relationship of the case(s) to the greater contextual circumstances (represented by a dotted line around the cases to show that there is a dynamic relationship between case and context). The four-case study designs may be single-case and holistic (Type 1), single-case and embedded (Type 2), multiple-case and holistic (Type 3), or multiple-case and embedded (Type 4).

Yin lists five rationales for choosing a single-case design over a multiple-case design (p. 41–42). These are listed below:

1. Critical Case: If the case tests and challenges a well-established and formulated theory and can contribute to the knowledge base around that theory in a powerful way, the use of a single-case design may be justified.
2. Extreme or Unique Case: If the case can document an extraordinary or rare circumstance and contribute to the knowledge base on the circumstance or phenomena in a powerful way, then it may be justified.
3. Representative or Ordinary Case: If the case documents the experiences of an average or commonplace situation and is informative with regards to the typical, everyday person or institution, then it may be justified.
4. Revelatory Case: If the case can uncover phenomena or experiences previously unavailable to scientific investigation, then it may be justified.
5. Longitudinal Case: If the study is able to investigate the same case at two or more different times, and the theory that informs the case study indicates that different times may indicate important changes, then it may be justified.

In addition to the rationales for choosing a single-case study, Yin also delineated the difference between holistic and embedded case studies. Holistic single-case studies are used when only the global nature of the situation is of interest. If the single case has subunit(s) that are also of interest and add to the overall understanding of the case, then this type of study is recommended.

Yin also described the merits and rationales that are necessary for a multiple-case study research design. First, Yin cautioned that multiple-case studies require extensive time and resources, and should be viewed as multiple experiments (Yin, 2003, p. 47) rather than multiple samples or respondents within a survey, for example. Yin refers to this as replication logic, as opposed to sampling logic. Replication logic is related to the ideas of replicating the results from one scientific experiment by reproducing the conditions as closely as possible, or by changing one or two variables of the experiment to see if the findings remain the same. Replication logic works the same for case studies, where significant results from a preliminary case are replicated by conducting further cases. Building a rich theoretical framework to support the further case experiments is an important step in this type of case study (p. 47).

In contrast to Yin and the focus on case study research as a comprehensive research strategy, other researchers focus on defining the unit of study, or the case itself. Stake (2005) said, “ Case study is not a methodological choice but a choice of what is to be studied” (p. 443). In other words, Stake is careful to define cases by their “boundedness” or specificity. For example, a program that prepares teachers for inquiry-based teaching may constitute a case, but the reasons that teachers struggle with these methods, or the policies that determine what students are taught in such a program, are not the case. Stake considers topics like this as generalities, while cases are specific (Stake, 2005, p. 444).

Stake defines three types of cases:

Intrinsic case studies: Intrinsic case studies are designed to understand an individual case with no motive other than deeply understanding the case involved. One studies the case for the case's sake alone.

Instrumental case studies: Stake defines instrumental case studies as those that provide a backdrop for other issues that the researcher is studying. The case provides context or highlights important facets of the other issue studied by the researcher.

Multiple- or collective-case studies: Multiple-case studies form the third category. These studies employ a number of cases simultaneously to explore a concept or idea of interest. Individual cases are chosen to clarify the larger question being explored and may or may not be related.

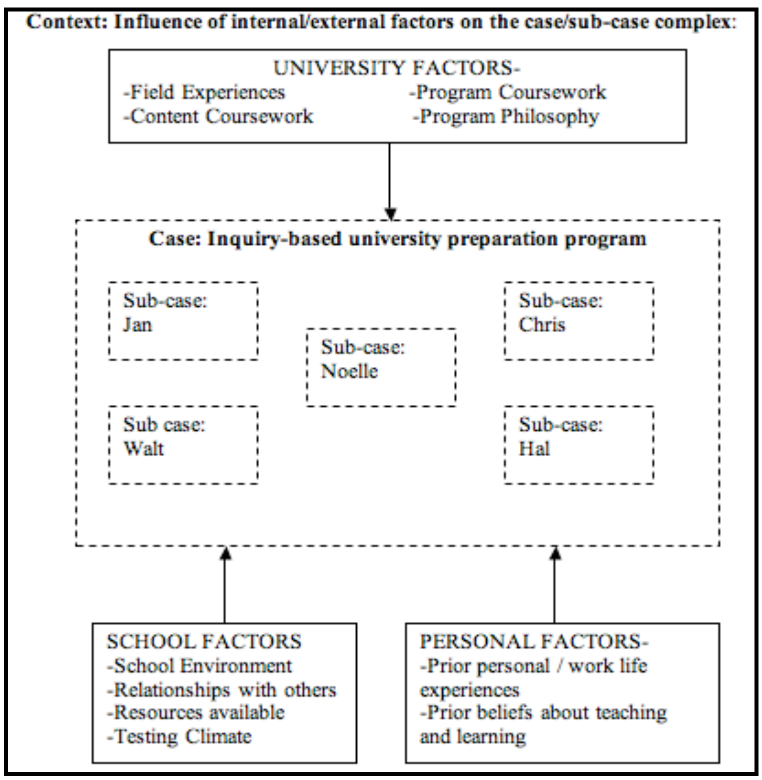
Merriam (1998) first defined case studies by their end product — "A qualitative case study is an intensive, holistic description and analysis of a single instance, phenomenon, or social unit" (p. 21) — but later changed her perspective to align more closely with Stake and Smith (1978) by centering on the bounded nature of the case: "I have concluded that the single most defining characteristic of case study research lies in delimiting the object of study, the case" (Merriam, 1998, p. 27).

Miles and Huberman (1994) define the case as "…a phenomenon of some sort occurring in a bounded context" (p. 25). The cases may be a) individuals (example: a talented teacher within the context of the school setting), b) roles (example: the role of a principal in the context of the school setting), c) small groups (example: a group of teachers attempting reform in the context of a repressive school district), d) an organization (example: an inner-city high school engaged in a major reform), or e) a community, settlement, or nation (example: an ethnic neighborhood, or a country struggling with internal revolt). These examples are concerned with a variety of sizes and structures that relate to social situations. Miles and Huberman also extend their definition to include locating cases spatially or temporally, and caution researchers to attend to all dimensions of the case, including its conceptual nature, social size, physical location, and temporal extent (p. 27).

Significance for this Study

The case study design for this research project is outlined in Figure 3.3 and follows the guidelines set forth by Yin (2003). The term “sub-case” refers to Yin’s preferred “embedded unit of analysis” in the following description of the data.

Figure 3.3: Case study design for this study (note: Pseudonyms used for sub-cases).



For this study, Yin’s (2003) single–case/embedded (Type 2) research design was used as the methodology to explore the research question. This model was adopted for the following reasons: First, the research question and context of the study fits this model well. An important rationale for using Yin's single-case study design is the critical case (p.40). The critical-case rationale relies on a study that explores how a situation can support or challenge an established theoretical framework. In this circumstance, the general theoretical framework of teacher development is examined against the studied teacher preparation program and the development of the participants' beliefs and practices. For example, the studied teacher preparation program utilizes a progressive series of recruitment courses designed to introduce the prospective teachers to the craft of teaching and challenge their beliefs about teaching and learning through inquiry-based field experiences at the elementary and middle-school level. In addition, the program promotes early field experiences and actively supports student learning in applied situations through paid internships and other opportunities in the local school systems (Marder, 2005). As a critical case, the program will be examined in this study to see if it supports the assumptions of the teacher development model.

Perhaps most importantly, the sub-cases within the case serve to deepen the understanding of how prospective teachers' beliefs and inquiry-based practices develop throughout the program and into the first year of teaching. These sub-cases were chosen to clarify the research question and to provide a rich and meaningful description of how individual beliefs can play a critical role in teacher development. Their inclusion lends power to the overall findings and may provide clues for themes and issues of importance to secondary science teacher educators. These themes are evidenced through a research methodology called cross-case analysis.

Cross-Case Analysis

Beyond examining the singular bounded context of the individual-participant cases, many researchers now study multiple-individual cases or complex situations that involve multi-case designs and methods (Miles & Huberman, 1994). The reason for embarking on these types of studies may include a desire for results that may point to trends or larger applications, or the ability to develop more powerful explanations for research that may be too complex for simple within-case analyses (Miles & Huberman, 1994). Although there are a variety of ways to compare the individual cases against each other, the longitudinal nature of this study matched a time-ordered approach.

METHODS — PARTICIPANTS, TIMELINE, SOURCES OF DATA

Participants

The participants for this study were chosen from a larger pool that comprised the original sample from the inception of the research in 2003. The original study recruited 17 preservice science teachers who were enrolled in the first recruitment course for the program. The selection process was as follows: First, the primary investigator or an associate researcher visited each section of the recruitment class and made a brief announcement outlining the nature of the research project, the rights of the participants, and the required time needed from volunteers. All students in all sections of the recruitment course who indicated that they were science majors were then contacted through e-mail about participating in the study. Of the students who were contacted, 17 indicated a willingness to participate in the study. Potential participants then reviewed and signed informed consent paperwork and officially joined the study.

The current status of the original participants is as follows: Eight participants have dropped out of the preparation program, and have either left to pursue different undergraduate degrees/programs (example: pharmacy or pre-med) or have left the university completely. Three participants are still completing subject matter prerequisites or teacher preparation coursework, including student teaching. Five are in the current study and are teaching at the secondary level locally, and one is an astronaut trainer at the NASA space center in Houston. The five participants selected for this study were chosen as a sample of convenience. They were the only five from the original study to be teaching locally at the secondary level, and have the most complete sets of data available for analysis. Table 3.1 gives a brief overview of the students who comprise this study.

Table 3.1: Background of participants in study.

Teacher (Pseudonym)	**Gender/ Ethnicity**	**Academic Degree**	**Student-Teaching Demographics/ *Position***	**Current Teaching Demographics/ *Position***
Jan	F/Anglo	B.S. Biology	Urban, Low SES/ *Biology*	Suburban, High SES/ *AP Enviro Sci, Pre AP Biology*
Walt	M/Anglo	B.S. Chemistry	Urban, High SES/ *Honors IPC*	Suburban, Mixed SES/ *IPC*
Chris	M/Anglo	B.S. Chemistry	Urban, Low SES/ *IPC, Chemistry*	Rural, Low SES/ *Chemistry*
Noelle	F/Anglo	B.S. Chemistry	Urban, Low SES/ *IPC*	Suburban, Mixed SES/ *IPC, Pre AP Chem*
Hal	M/Anglo	B.S. Biology	Urban, High SES/ *Honors Bio, Bio*	Rural, Low SES/ *Biology*

Timeline

The data collection schedule included three years of data collection and is outlined in Table 3.2.

Table 3.2: Timeline of data collection for participants.

Jan	**Interview 1**	**Interview 2**	**Interview 3**	**Interview 4**	**Interview 5**
TBI	02/03	10/03	03/04	05/05	03/06
Interviews	02/03	10/03	03/04	05/05	03/06
Artifacts	02/03	10/03	03/04	05/05	03/06
Observations	04/03	10/03	04/04	05/05	03/06
VNOS	02/03		03/04		
Walt	**Interview 1**	**Interview 2**	**Interview 3**	**Interview 4**	**Interview 5**
TBI	10/03	09/04	03/05	11/05	03/06
Interviews	10/03	09/04	03/05	11/05	03/06
Artifacts	10/03	09/04	03/05	11/05	03/06
Observations	11/03	11/04	04/05	09/05	03/06
VNOS	10/03		03/05		
Chris	**Interview 1**	**Interview 2**	**Interview 3**	**Interview 4**	**Interview 5**
TBI	02/03	09/03	04/04	11/04	12/05
Interviews	02/03	09/03	04/04	11/04	12/05
Artifacts	02/03	09/03	04/04	11/04	12/05
Observations	02/03	10/03	04/04	11/04	12/05
VNOS	02/03		04/04		03/05
Noelle	**Interview 1**	**Interview 2**	**Interview 3**	**Interview 4**	**Interview 5**
TBI	11/03	02/04	10/04	11/05	03/06
Interviews	11/03	02/04	10/04	11/05	03/06
Artifacts	11/03	02/04	10/04	11/05	03/06
Observations	11/03	03/04	10/04	11/05	03/06
VNOS	11/03			10/05	
Hal	**Interview 1**	**Interview 2**	**Interview 3**	**Interview 4**	**Interview 5**
TBI	02/03	09/03	03/04	01/05	03/06
Interviews	02/03	09/03	03/04	01/05	03/06
Artifacts	03/03	09/03	03/04	01/05	03/06
Observations	02/03	10/03	03/04	02/05	03/06
VNOS	02/03			04/05	

Participants completed a variety of interviews, completed written nature-of-science questionnaires, submitted artifacts for review, and were observed in both early field experiences, during student teaching, and also during their first year in the classroom. A detailed timeline for each participant is presented in Table 3.2. One of the challenges of the data collection for this study was the changing number of graduate-student researchers who assisted with data collection. In addition, the professor who originated the study and oversaw the data collection and analysis left the university for another position. Despite these challenges, the various forms of data were collected for each participant at five points over the course of the study.

Sources of Data

A number of different data collection strategies were employed to assist in exploring how the participants' beliefs and practices evolved over the duration of the study. A detailed description and justification for using each research method and how this method relates to the question is outlined below.

General Interview

To collect general demographical data from the participants, a general interview was conducted at the beginning of each meeting. The information collected focused on the students' areas of specialization, status in the program, and other courses that were currently being taken. Also, at the first interview, background information about the participants' highest degree, experience as a teacher, and family background were collected. The interview protocol for these sessions can be found in Appendix C.

Teacher Beliefs Interview

To document the participants' beliefs, a modified version of the Teacher Philosophical and Pedagogical Inventory (TPPI) was used. The TPPI was originally developed by Salish researchers (Salish Research Project, 1997), and has been described in detail by Richardson and Simmons (1994). The original interview questions were modified by Luft and Roehrig (in review) to focus on seven central questions that concerned teachers' ideas about their teaching beliefs and practices in the classroom. This modified interview was called the Teacher Beliefs Interview (TBI). The TBI utilized a semi-standardized interview format to probe the participants' beliefs more deeply. Berg (1998) stated that a semi-standardized interview involves a number of predetermined questions that address the research goals and that are presented in an order and language appropriate for the people in the study. The interviewer can digress or probe beyond the pre-developed questions in order to gain further understanding of the topic discussed. Questions were adapted for each successive interview over the duration of the study to explore more fully the salient topics for that time frame and stage of development in the teacher. This interview protocol was chosen to untangle the complex and messy nature of belief systems and to explore the teachers' beliefs in a variety of ways as suggested by Pajares (1992) and Richardson (1996).

Development of the TBI

Luft and Roehrig (In review) described the process of developing the TBI as an iterative process of testing, reflection, and revision of the initially proposed set of eight questions that were drawn from a review of teacher beliefs, research, and the comments from experts in the field. The seven questions that emerged were field-tested using over 100 preservice and induction teachers, and were revised to best capture the beliefs of the teachers. These questions are listed below in Table 3.3.

Table 3.3: Questions used for teacher beliefs interview (from Luft & Roehrig, In review).

Question	Question format	Area addressed
1	How do you maximize student learning in your classroom?	Environment
2	How do you describe your role as teacher?	Student knowledge
3	How do you know when your students understand?	Understanding
4	How do you decide what to teach and what not to teach?	Students and standards
5	How do you decide when to move on to a new topic in your classroom?	Assessment
6	How do students learn science best?	Learning
7	How do you know when learning is occurring in your classroom?	Student response

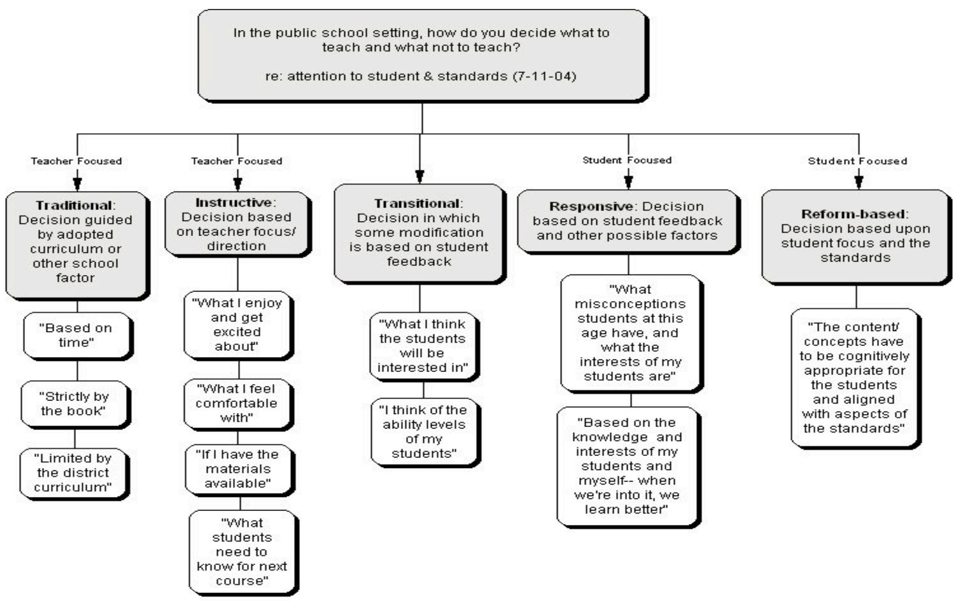
Additionally, the questions were sent to experts in teacher beliefs research for comments and further revision. After this, 75 sets of responses from the questions were analyzed and grouped into themes, concepts, or categories in a constant comparative method (Glaser & Strauss, 1967). Each question, along with categories that emerged from the previous analysis, was then placed in a clustered summary display (Miles & Huberman, 1994), which created a visual map for the varying responses to the question. The categories that emerged from the initial analyses were labeled in the following way: Teacher-Centered responses were identified as “traditional” or “instructive” beliefs. “Responsive” and “reform-based” answers were identified as student-centered beliefs, and responses that indicated primarily behaviorist and affective student attributes were characterized as "transitional" (Luft & Roehrig, in review). The categories and examples are presented in Table 3.4.

Table 3.4: TBI categories with examples.

Category	Example	View of Science
Traditional: Focus on information, transmission, structure, or sources.	I am an all-knowing sage. My role is to deliver information.	Science as rule or fact.
Instructive: Focus on providing experiences, teacher-focus, or teacher decision.	I want to maintain a student focus to minimize disruptions. I want to provide students with experiences in laboratory science (no elaboration).	
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. I am responsible for guiding 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 allows 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.

The resulting interview maps were then used with over 50 conducted interviews by multiple researchers, and the maps and questions were revised again after the coding of these interviews. A sample interview map for Question 1 is included below in Figure 3.4. The remaining maps can be found in the appendix.

Figure 3.4: Sample Interview Map (Luft & Roehrig, in review).



Using the TBI

The process for conducting the interview process was as follows: The average meeting took between 45 and 60 minutes and included the TBI and a series of questions designed to update the researcher on any new or different information from the participant. Each interview was audiotaped using a digital voice recorder or analog tape recorder by the researcher. Field notes were also compiled during the interview. During the initial and ending interviews, the participant would also complete a written questionnaire on their views of the Nature of Science (VNOS-C).

The sequence of events at each meeting follows. When the participant was settled, the interviewer turned on the digital voice recorder (Olympus DSS-466) to record the conversation and began by asking about any artifacts that the participant had brought to the interview. These artifacts were usually lesson plans, class assignments, or CD copies of teaching experiences that the student thought were important to share concerning their growth as teachers, and were photocopied by the researcher (with permission) for the participant's file.

After sharing the relevant artifacts, the researcher then asked a series of questions designed to gather demographics and current general information from the teacher. These questions are listed in Appendix A and included general queries about the status of the student regarding the program, classes that the participant found useful or not useful with regard to their professional growth, and other general questions that elicited information about the participant's development as a science teacher. The interview was open-ended, and general questions like "What was important to you last semester in terms of learning to teach science?" were framed to capture the perspectives of the teacher. Based on the responses to these general questions, follow-up queries were asked to probe more deeply into the participant's views about his or her own progression or feelings about the program. These responses ultimately helped to categorize and frame the teacher's experience longitudinally throughout the study.

Nature of Science Interview

To document students' understanding of the Nature of Science, the "View of Nature of Science — Form C" (VNOS-C) instrument developed by Abd-El-Khalick, Bell, and Lederman (1998) was used (see Appendix). This form was given to students at the beginning and end of the study to summarize the participants' perspectives on the nature of science and whether this perspective changed over time. Questions in the VNOS-C are designed to elicit views about the tentative and subjective nature of science, the role of society and culture in science, the difference between observation and inference, the role of theories and laws in science, and the role of creativity and imagination in science. The VNOS-C responses were coded to depict the participating students' views of the nature of science as contemporary (i.e., science as tentative and a human construct), traditional (i.e., science as procedure that accurately depicts the natural world), or naïve, which means that the views of students straddle both or neither domains. Details about the coding process for contemporary and traditional views of science can be found in Abd-El-Khalick, Bell, and Lederman.

Artifacts

Throughout the study, a series of artifacts were collected from participants to understand their developing beliefs and practices about science teaching and learning. These sources included lesson/unit plans developed by students, student work from education, and subject matter courses, including rationales for teaching; field experience reflections; student-teaching evaluations and reflections; lab reports and papers; final teaching portfolios; and lessons, assessments, and other pupil work from the participants' first year as classroom teachers. The artifacts were collected at the time of the interview, placed in the participants' folders after being labeled with the appropriate time and date, and then analyzed later by looking for themes or issues that emerged as the cases developed. Field notes from the interview along with the collected documents were examined together (Stake, 2005).

Practice

To understand the development of the participants' practice and the relationship of these practices to inquiry-based teaching, observations were conducted during both preservice and in-service teaching of participants. In some instances, I served as the university supervisor for the participants' student-teaching experience, and in others as the teaching assistant for preservice classes. I observed all teachers during their first year in the classroom. A number of different observation protocol were used during the observations. For the early field experiences of some of the participants, a class-designed observation rubric was utilized that focused on the students' development of inquiry-based practices. For other students, the Reform-Based Teaching Protocol (RTOP) developed by Piburn et al. (2003) was used to provide a standardized means for detecting the degree to which classroom instruction in science was reform-based (see Adamson et al. (2003) or Sawada et al. (2002) for detailed information on this instrument). During the student-teaching phase, participants that I worked with were evaluated weekly using Focused Proficiency Observation rubrics prepared by the teacher preparation program. These rubrics were conceived and developed by a team of science educators and master teachers to encompass important science-teaching and general pedagogical attributes. For example, one week's observation might entail a focus on how well the classroom was prepared, while another focused on inquiry-based practices.

The variety of observations led to a view of the classroom practices of the participants from different perspectives, as suggested by Pajares (1992) and Richardson (1996), for harvesting data on the beliefs and practices of teachers.

DATA ANALYSIS

In her introduction to analytic techniques for data management, Merriam (1998) remarked that data analysis in qualitative research has historically been characterized as a "mysterious metamorphosis" (p.155) in which the researcher presents findings without a clear description of the strategies used in the investigative process. Yin (1994) called case study data analysis "one of the least developed and most difficult aspects of doing case studies" (p. 109). Both authors called for a defined analytical strategy to help readers and the researcher alike understand the processes used when presenting the findings from the study (Merriam, 2003; Yin, 1994). Creswell (2003) described the process of data analysis as "making sense out of text and image data" (p. 190). This analysis includes ongoing reflection about the nature of the data being collected as well as writing and asking analytical questions about the study and the data collected. It is an open-ended process, with generative themes and categories that emerge from information provided by participants, and it needs to be contextually tailored to the methodology chosen by the researcher (Creswell, 2003).

In an effort to create a robust, accurate and credible study, factors contributing to the validity of the data collection and analysis have also been addressed. Unlike reliability and generalizability, terms more common with quantitative research and which play a minor role in qualitative research (Creswell, 2003), establishing validity is a crucial component of case study research. Creswell chooses to employ the term "verification" rather than "validity" when describing the procedures and objectives necessary in qualitative research for quality work. He does this to establish the verification elements as a legitimate mode of inquiry distinct from quantitative research

(Creswell, 1998). Table 3.5 shows the recommended verification strategies suggested by Creswell and the resulting ways that this study has met them.

Table 3.5: How this study meets verification standards for quality.

Objectives to ensure quality of study (Creswell, 1998; 2003).	**Strategies employed by this study to meet objectives**
Triangulation of different data sources to build coherent justification of themes (Merriam, 1998, Miles & Huberman, 1994)	Semi-structured interviews TBI interview Observations in field Artifact collection
Member-checking for accuracy of findings with participants (Lincoln & Guba, 1985)	Cases sent to participants for feedback followed by final interview to collect feedback verbally or in written form
Rich, think descriptions of findings to place the reader in the experience and allow the reader to make decisions regarding study transferability (Lincoln & Guba, 1985, Merriam, 1998)	Variety of data sources and artifacts lead to think descriptions of sub-cases
Clarification of researcher bias to provide an open and honest communication with the reader (Merriam, 1998).	Added to Ch. 3
Discussion of data that runs contrary to themes to show the complexity of the data collected (Creswell, 2003)	Added to Ch 4. In discussion section for each sub-case.
Spending prolonged time in the field to collect in-depth understanding of phenomenon under study (Lincoln & Guba, 1985; Merriam, 1998)	Longitudinal study: researcher served as teaching assistant, student teaching supervisor and/or research observer for participants in study.

Procedures

The first step taken when compiling the data for analysis in this study was to organize and prepare the data. This process occurred simultaneously with data collection (Merriam, 1998), and initial categories and themes that emerged from researchers' first examination of the data stimulated the subsequent preliminary studies (reviewed in Chapter 2) that examined the recruitment strategies and the impact of early field experiences on the reflective capacity of students in the program. It was important to examine the data analytically while collecting it throughout the study to enhance the focus and to develop further the questions being asked in the study (Bodkin & Biklin, 1992; Merriam, 1998).

The organization of data included transcribing semi-structured beliefs interviews using a modified verbatim transcription process. This process of transcription included both verbatim and semi-verbatim transcription, based on the topic of conversation. For general demographic information, semi-verbatim transcription was employed to capture both factual information and a general overview of the subject's mood, attitudes, motivation, and other affective factors that are difficult to capture when typing interview data verbatim (Halcomb & Davidson, 2006).

Researcher field notes were inserted and highlighted during the semi-transcription of these interviews when questions arose or potential themes seemed to emerge. During the beliefs interviews, verbatim transcription was employed to capture the text as spoken. Field notes and comments were also added and highlighted to capture themes or questions for further probing. In addition to the audiotaped interviews, additional data was organized by typing and transcribing written and audiotaped field notes, scanning artifacts when necessary, and sorting the resulting data chronologically and by type per participant in different-colored file folders.

As this process evolved, regular meetings were convened with the research staff involved in study to explore and follow up on promising leads and trends that emerged from previous interviews and observations. This method of integrated data collection and analysis is aligned with the constant-comparative method (Glaser & Strauss, 1967), which seeks to link categories and properties conceptually between studied phenomena through ongoing and constant comparison. By aligning incidents chronologically (for example, recruitment course experiences for each participant) and then comparing them against each other, tentative categories emerge that can lead to a clearer understanding of the case.

The initial coding categories that emerged after the first reading of the data included "Beliefs about Teaching," "Beliefs about Learning," "Field Experiences," "Program Impacts," and "Development of Practice." After the second reading, the initial coding categories were collapsed to "Beliefs about Teaching and Learning," "Development of Practice," and "Impact of Program." The development of these categories occurred from a combination of factors including the direct meaning derived from the comments of the participants, as well as my own orientation and knowledge of the program. Category generation is a process that Merriam (1998) calls both intuitive and systematic, and is also informed from the purpose of the study (p. 179). The development of these initial categories then led to looking for regularities between units of information between the embedded sub-cases (the individual case studies for each participant). These within-case themes could then be compared across the sub-cases to inform the categories and themes for the overall case (Yin, 2002; Miles & Huberman, 1994).

For the teacher beliefs interview, coding categories were developed as the questions and subsequent interview maps evolved, and were field-tested with previous groups of teachers (Luft & Roehrig, In review). The categories were then labeled as traditional, instructive, transitional, responsive, and reform-based. For coding purposes, the categories are arranged on a continuum from a more traditional or teacher-centered approach (traditional and instructive categories) to a student-centered or reform-based orientation (instructive or reform-based). The transitional category refers to responses from teachers that include students but on a superficial level.

To orient the practices of the participants, a written summary of each observation was compiled from artifacts, field notes, evaluative documents, and videotaped evidence (when available). These written summaries were then coded using categories that describe the students' level of inquiry-based practice.

The categories that emerged from an initial examination of the data were "beginning," "limited," "proficient," and "experienced." A beginning level of practice about science as inquiry describes a teacher who does not have a background with the literature beyond typical catchphrases like "hands-on" or "inquiry learning," and has not attempted to develop lessons based on inquiry principles. The student may say that inquiry in science is "hands-on" and that students learn best through discovery, without understanding the complexities of this process or the role of the teacher. During observations, the teacher primarily uses teacher-centered strategies to convey concepts. Students are passive observers.

At the limited level, the student may have experience or coursework with a partial focus on inquiry and may have taught one or two lessons from a science kit, but does not yet have the experience to integrate all of the elements of a successful inquiry-based class. For example, they may recognize the importance of an engagement activity that captures the pupil's interest, but may not know how to facilitate their learning beyond this point. When observed, the student may attempt to utilize elements of an inquiry-based lesson without creating a conceptually cohesive class session.

A student with a proficient level of knowledge about inquiry can articulate, plan, and carry out a science-as-inquiry lesson successfully, and is able to facilitate the pupils' understanding of the topic through student-centered activities. For example, in order to guide students to an understanding of scientifically oriented questions, the teacher might give students a number of questions to choose from in an investigation, or ask students to create their own question that relates to the topic being explored.

The experienced category is demonstrated by teachers who consistently articulate and demonstrate a science-as-inquiry perspective in their practice and reflections.

After the categories were created, they were compared to two documents used to measure inquiry-based practices in the field. These instruments are the Essential Features of Classroom Inquiry matrix (NRC, 2000, p.29; see Table 3.6) and the Extended Inquiry Observation Rubric (EIOR) developed by Luft (1999; see Appendix).

Table 3.6: Essential Features of Classroom Inquiry (NRC, 2000, p.29).

Essential Feature	Variations			
1. Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in question provided by teacher, materials, or other source
2. Learner gives priority to **evidence** in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
3. Learner formulate **explanations** from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence and how to use evidence to formulate explanation
4. Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
5. Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use sharpen communication	Learner given steps and procedures for communication

More ——— Amount of Learner Self-Direction ——— Less
Less ——— Amount of Direction from Teacher or Material ——— More

After coding, individual time-ordered displays were created (Miles & Huberman, 1994) for each participant to organize and describe the progression of beliefs and practices throughout the duration of the program. The graphical-display format suggested by Miles and Huberman focuses extended and unreduced text that may be weak, cumbersome, and dispersed over many pages without refinement by the researcher into manageable and coherent chunks. When arranged according to themes that relate to the research question and have been derived from initial coding of the data, data displays can help the researcher see differences, compare sets of data, and note patterns and trends that may evolve (p. 92).

These individual displays were then synthesized into a rich narrative account of each individual's growth through the program. Salient areas of this narrative included the participants' personal and professional backgrounds, evolution of beliefs about both teaching and learning over time, development of an inquiry-based practice in the field, and influence of outside factors (school, personal, and university-related) on professional growth throughout the program and in the classroom.

A discussion of the themes that emerged for the individual followed the narrative. The final step was to compare the individual development of beliefs and practices that emerged in order to create general trends that related to the program. This analysis was performed using meta-matrices as defined by Miles and Huberman (1994).

To clarify some of the terms and representations of the data in the findings (Chapter 4), the following notes have been added for clarity. First, when discussing the findings of each participant as they progress through the teacher preparation program, three terms are used to define the phase of the program—"Recruitment phase," "coursework phase," and "teaching phase"—and are outlined in Table 3.8.

The second note pertains to the viewing of the teaching and learning beliefs matrices (see Figure 4.1 as an example). The values reported in the cells are the numbers assigned to the TBI questions and are not ordered in any way. In other words, the number "1" is a placeholder for Question 1 (How do you maximize student learning?). For example, in the above matrix, Janet's response to Question 5 (When do you move on to a new topic?) was categorized by researchers as "traditional" for Interview 1, "instructive" for Interviews 2 and 3, and "traditional" again for Interviews 4 and 5.

Table 3.8: Description of phases of study.

Phase	**Study Timeframe**	**Description of Phase**	**Data Sources**
Recruitment	Early	Refers to the first year in the program and includes the initial views of the teacher	General interview 1 TBI interview 1 NOS interview 1 Observations Field notes Artifacts from coursework/EFE's
Coursework	Middle	Refers to the time when the teacher is taking the majority of teacher preparation courses and are engaged in early field experiences	General interview 2,3 TBI interview 2,3 EFE Observations Field notes Artifacts from coursework/EFE's
Teaching	Late	Refers to the time when the teacher is student teaching or is employed as a first year teacher	General interview 4,5 TBI interview 4,5 NOS interview 2 Classroom observations Field notes Artifacts from teaching

The third note concerns stable and variable beliefs. Beliefs are characterized as "stable" if the responses of the participant to the TBI remain consistent over the length of the study. For example, Janet's response to Question 2 was coded as transitional for all five of the interviews (see Figure 4.1). For this study, the parameters for labeling a belief as “stable” are that the participants’ responses must fall within at least one category for four out of the five interviews. In other words, the responses must align (80% of the time) within one category throughout the study to be labeled as stable. An example of another stable belief for Janet is demonstrated with her replies to Question 6. The researchers coded her answers to the question “How do your students learn science best?” as “transitional” for Interviews 1 and 2, “instructive” for Interview 3, and back to “transitional” for Interviews 4 and 5. On the other hand, beliefs are labeled as “variable” if they fluctuate during the study. For example, Janet’s response to Question 1 (How do you maximize student learning?) evoked responses that ranged from traditional to responsive (see Figure 4.1). Table A.4 summarizes the stable and variable beliefs of the participants and also clarifies variable beliefs that fluctuate over the study but return to the original category by the end, versus those variable beliefs that show an overall trend toward either student- or teacher-centered ends of the spectrum.

CHAPTER 4: FINDINGS

This chapter is dedicated to reporting the findings from the study and will be divided in the following way: First, the individual evolution of the beliefs and practices of the teachers in the study will be presented through case studies. These will be followed by a cross-case comparison.

Sub-Cases

JAN

Jan is currently teaching Pre-AP Biology and AP Environmental Science courses in a small local school district with a predominantly white, upper-middle-class constituency. The student population is 86% Anglo, 12% Hispanic, 1% Asian-American and 1% African-American. The school reports that 9% of the students are economically disadvantaged, compared with a 55% state value for the same characteristic.

Jan attended and graduated from the same high school where she now teaches. Her younger sister is currently a senior at the same school and her father is an active school board member. Jan's path to a career in teaching started after a re-evaluation of her childhood goal to become a dentist. Jan realized that she had been driving herself to establish the same level of financial comfort that her parents had provided, but came to understand that this wasn't what should drive her decisions. After consulting with family and friends who were already in the teacher preparation program, Jan decided to switch her focus to teaching.

She was happy to be in a program that included friends and a sense of community. Jan chose science teaching not because of her previous teachers (her own high-school biology experience was very negative, based on the teacher) but because she had traditionally done well in science and her friends were in the program.

Interview data shows that Jan started the program feeling like she left behind one vision for herself, but was supported and happy with her decision to become a teacher. She said, “ I feel like I had to drop one dream for another, but I’ve always said since I was a kid that I wanted to teach too [as well as be a dentist]” (Interview 1, 7.46). Jan began the program excited to be with friends and to work with children.

Profile of Jan’s Beliefs about Teaching and Learning

Jan’s Beliefs about Teaching

Early in the program, Jan’s answers indicated a mixture of beliefs about teaching that were distributed fairly equally from the traditional to transitional categories (see Figure 4.1). The following example demonstrates that Jan held traditional ideas about what drives the curriculum:

> I. How will you decide to move on to a new topic in your classroom?
>
> J. Probably by the textbook chapters. When I learned well was when we finished a chapter in the textbook and then did a few explorations at the end. (Interview 1, 29.57)

The above example also shows Jan’s reference to her own learning as an orientation for her belief systems about teaching. This orientation occurs frequently during her early interviews. For example, when asked about her role as teacher, the following exchange with the researcher occurred:

> I. How do you envision your role as teacher?
>
> J. I want to be cool [*laughs*].
>
> I. [*Laughs*] You want to be cool?

> J. I mean, those are the teachers I learned best from, the teachers I felt I could talk to about my normal life. The teachers you could joke around with and felt more like friends were the ones I felt I learned more from. (Interview 1, 36.01)

As Jan progressed through the program, her coded responses concerning beliefs about teaching clustered primarily in the transitional category. Jan's orientation toward her beliefs continued to align with her own experiences as a student but included a greater focus on respect as a foundation of the classroom. This additional focus shifted her answers to a more transitional perspective that included the ideas and perspectives of the student. This is typified by the following passage:

> I. How do you know when to move on to the next topic?
>
> J. I change my mind a lot. I used to say—spend two weeks and then we will move on. But you have students that learn faster or slower so you have to assess your students before moving on, and know when they know what they know. When they get it.
>
> I. What does it mean for them to know or get it?
>
> J. If they can explain it to me orally, written. If you know it well enough to teach it then you know it. You can see it in their face when they get it. You can tell. (Interview 3, 26.00)

Jan's earlier wish to be a friend to her students evolved by the instruction phase of the program. She began to identify her role as "respected friend":

> I. How do you envision your role as teacher?
>
> J. A respected friend. If you have too many rules, there's more for them to break. My main rule will be respect. If you treat them as people, not as students, you'll get a lot more out of them. It's going to be hard for me to separate myself from them as friends, but I know I'll have to do that. (Interview 3, 29.54)

As Jan entered the classroom, her beliefs about teaching diverged and became either traditional or transitional/responsive. For example, when asked about maximizing student learning, she expressed beliefs more aligned with contemporary standards. She mentioned the following when asked about maximizing instruction in the classroom:

> J. I'll try to make everyone involved. Use whiteboards for chemistry where they write answers. Use real-life examples and demonstrations, Don't make them take notes, post those on a Web page, so they can listen in class. Make the class interactive, have them come up to board to do problems. (Interview 4, 14.09)

But when responding to how she decides what to teach, Jan's response reflected a traditional perspective, as evidenced below:

> I. How do you decide what to teach?
>
> J. The district calendar is right behind you and was made by the department over the summer. It's in the same order as I would have chosen. (Interview 4, 20.40)

Jan's Beliefs about Learning

Jan's initial beliefs about learning were grouped during the recruitment phase in both instructive and transitional categories, as shown in Figure 4.2. Interview responses from Jan indicated that she began the program with an incomplete understanding of how children learn or understand. Her answers were limited in length and did not reflect the same personal examples and experiences as her ideas about teaching. The following question about student understanding illustrates this:

> I. So how will you know when students have understood in your class?
>
> J. Some form of assessment, when they can complete a project, or just making sure everyone can answer a question. It…it depends on how big the problem is.
>
> I. Yeah, some form of assessment… At the end?
>
> J. Well, in Classroom Interactions, we learned that to do it right you have to do it at the beginning and the end. Maybe in the middle and evaluate it once you're done. I'm really not sure.
>
> I. Ok, so it's still something you're thinking about.
>
> J. Yeah, well, I don't have that much experience. (Interview 1, 32.23)

As Jan progressed through the program into the coursework phase, her beliefs about student learning and understanding in science were coded with the majority of the responses in the instructive category and one transitional response. As in the first example, she also continued to use examples from her teaching preparation coursework to explain her answers to the interview questions. After an early field experience in Classroom Interactions, for example, she began to see the value of an inquiry-based framework for student learning:

> When we were in Classroom Interactions, during our teach, we did a lecture on photosynthesis before the lab, and when we gave the homework, no one got it. But then for the re-teach, we did a lab and after that, they were able to explain it. So I think doing the labs first is the best way. (Interview 2, 45.56)

By the teaching phase of her program, Jan had a clustered set of beliefs about learning that shifted toward transitional. For example, Jan clarified her earlier perspective of how students understand in science to reflect a more student-centered response:

> I. How do you know your students understand in science?
>
> J. They understand when they can explain it to someone else. For example, I have a student who feels like she doesn't really know the material until she teaches it to her friends or to me. (Interview 5, 24.30)

In summary, Jan's beliefs about teaching and learning are primarily clustered from the transitional level to the more teacher-centered side of Figure 4.2. Some of the beliefs are stable in nature, while other beliefs fluctuate as she evolves. The trend for Jan's beliefs about teaching and learning was a shift toward either a traditional orientation or to a transitional orientation by the end of the study.

Figure 4.1: Profile of Jan's beliefs about teaching and learning.

Jan's beliefs about teaching

1. How do you maximize student learning?
2. What is your role as teacher?
4. How do you decide what to teach?
5. When do you move on to a new topic?

Teacher-centered-----------------Student-centered

	Trad	Inst	Trans	Resp	R-Based
Interview 1	**5**	**1,4**	**2**		
Interview 2	**1**	**4,5**	**2**		
Interview 3		**5**	**1,2,4**		
Interview 4	**4,5**		**1,2**		
Interview 5	**4,5**		**1,2**		

Jan's beliefs about learning

3. How do you know when students understand?
6. How do students learn science best?
7. How do you know learning is occurring in the classroom?

Teacher-centered------------------Student-centered

	Trad	Inst	Trans	Resp	R-Based
Interview 1		**3,7**	**6**		
Interview 2		**7**	**3,6**		
Interview 3		**3,6**	**7**		
Interview 4	**7**		**3,6**		
Interview 5			**3,6,7**		

Profile of Jan's Practice

When initially developing her practice as a science teacher, Jan drew on her past experiences as a student with both positive and negative examples of how a teacher should practice science. Initial positive and negative experiences in high school revolved around both personal relationships and the teaching styles of the teachers that Jan had. For example, when asked to reflect on the impact of an initial recruitment class on her ideas about teaching, Jan said,

> J. Umm, I like thinking about the different ways of teaching. I went through that in high school. We had young teachers and old teachers so there was a mix of teaching techniques. The young teachers, they were starting to use inquiry-based teaching, but they really didn't grasp it. I used to get so frustrated with them. I'd go and ask a question and they'd say "What do you think?" instead of answering it.
>
> I. Yeah…

> J. So that would frustrate me. Now I'm learning about inquiry-based teaching and I realize that that's what they were trying to do. So remembering what frustrated me is making me want to learn how to do it better than I experienced it. (Interview 1, 25.19)

Jan described the focus of her current learning through the preparation program in the following way:

> I. How is what you are learning now different from the way you experienced it back in high school?
>
> J. It's more like teaching with questions rather than the student coming up with questions that the teacher doesn't answer. The teacher doesn't frustrate students by not giving them the answers, but uses questions to guide the class more. (Interview 1, 25.30)

Responses to interview questions show that establishing respectful and friendly personal relationships is important for Jan and may be her primary focus when in the classroom. Interview notes from Jan's initial teaching experiences in the classroom (elementary school) indicate that Jan is at the beginning level of inquiry-based practice. Table A.5 shows the progression of Jan's practice through the program. Her focus on positive interaction with the students seems to be the most important lesson that she expressed from the experience. Jan remarks about this teaching experience at length in her first interviews. She was impressed with the interest that one child demonstrated about the interaction of water drops on wax paper and was touched by the handmade cards from the pupils that she received:

> J. The kids loved the wax paper. It was a bilingual classroom and one of the girls came up and said, "Could I have a piece of that paper so I can show my mom?" And that made me feel really good, that they had such a good time. (Interview 2, 4.54)

The classroom teacher was asked to provide feedback on the lesson, and her comments reflect Jan's teacher-directed demonstration as well as her friendliness with the students:

> Students responded well to Jan and her [partner]'s demonstration of the water drop. When the lesson on surface tension began, they followed well and reflected on the comments and experiments shown. They really started bonding with [partner] and Jan. (Observation JGS04ART01, p. 1)

By the midpoint of her time in the program, Jan had completed a number of early field experiences to develop her practice with inquiry-based experiences. These field experiences were clearly important to her, based on her interview responses:

> I. What has been the most powerful experience for you through this program?
>
> J. Probably the classroom experience. You can write a hundred lesson plans or write a philosophy of teaching but until you teach them, they don't mean much. I wish that [the program] had more field experiences, actually. (Interview 3, 6:12)

By the time Jan reached her first year in the classroom, observation notes indicated that she created a safe and friendly environment in the classroom and was attempting to generate a variety of ways for pupils to learn the content. Fostering the role of friendship and respect was still an important part of her practice, as demonstrated by the following interview exchange:

> I. So how are your classes going?
>
> J. For the Juniors in Chemistry, they are fighting each other like brothers and sisters. They have all been together since elementary school. I got so tired of it the other day that I had them sit and write down compliments to each other. They thought that was the best thing ever. I had one student come up after class and say, "Chemistry isn't supposed to be fun. How come this class is so fun?" (Interview 4, 05.00)

Jan's use of inquiry, however, was underdeveloped. Field notes from a class visit demonstrate this:

> Students were milling around in class after the bell rang. A few came in late and sat down. Jan spent a few minutes talking about her weekend and the kids asked her questions about her new dog. The atmosphere is friendly and respectful, and the students seem very social. A few students quietly check their cell phones while Jan leads the discussion on acid/base reactions, and use the white boards that she hands out to write notes to each other. Discipline seems quite lax. As for

> content, Jan really led the students through the work in class today. She explained how to work the problems without giving them time to try first themselves, and gave them a few practice quiz questions with the answers before giving the actual quiz. I'm not sure the kids had to struggle enough conceptually with the content or the quiz she gave. Seemed more cookbook/rote. Jan did spend time with students individually to try to get the content across. She told me that she uses the quizzes as a tool to have students practice the concepts. She is definitely supportive of them. (Observation JGS05RTOP, p. 5)

For Jan, then, the relationships and classroom environment were the most important factors in her practice. Teaching the content by following the department-created lesson plans and textbook chapters made planning easier for Jan and allowed her more time to build relationships with students and in the school community.

During the final interview, Jan's perspective on inquiry-based practice came clear with this response to a question about how she implemented inquiry-based science in the classroom:

> I. Are you doing any inquiry labs?
>
> J. They are guided labs. I felt like inquiry was fluffy when I learned it. I don't know that it applies that well to my teaching method. It may work for others, but I'm not so sure for me. I think inquiry is a good theory, but not practical.
>
> I. What are the constraints to inquiry for you?
>
> J. Time. You have to cover so much and inquiry takes so long. You only have so many days and you have to cover everything for the TEKS and TAKS world. Test-taking is a hard thing to overcome and inquiry doesn't prepare you for that.
>
> I. Inquiry was kind of a push from [the program], wasn't it?
>
> J. Yes, and I haven't written a 5E lesson plan since then. In student teaching I just wrote outlines and went with it. Now, with my Pre-AP kids, it's just, "OK, here's what we are going to learn today. We have 30 minutes to get through this." We can't stop and talk about it because they'll lose focus. (Interview 5, 46.29)

The Impact of the Preparation Program on Jan

During the recruitment phase of the study, impacts of the program for Jan revolved around her friends and the supportive atmosphere of the program. General interview notes indicated that Jan felt especially supported in her growth as a teacher when compared to the pre-dental program at the university.

> I. Based on what you know, how is the program helping you to become a teacher?
>
> J. Everyone here is helping me become a teacher. You need to have experience, background knowledge and all these people helping you. The program is small and close-knit. I like that. They have tutors for you for free and you feel taken care of. (Interview 1, 21.34, 28.12)

Data also suggested that Jan found classes with field components to be the most useful. Being in the classroom was the highlight of her first few semesters in the program because it helped her strengthen her vision of becoming a teacher, even though the elementary and middle-school levels were not her chosen level:

> I. How did you like the program?
>
> J. I loved the program. A lot of my friends were in it and I really appreciated Step 1 and Step 2, even though I wasn't interested in elementary or middle school. Those classes helped me make up my mind that I wanted to teach. I worked really hard for my degree in Biology and I don't want to spend it on 4th graders. Plus in high school I can have real conversations with my students. I have seniors in here where I talk to them like friends. I mean, it is at an appropriate level, but we have a real laid-back attitude. (Interview 5, 10.23)

WALT

After graduating from the preparation program with a degree in chemistry and a comprehensive secondary science-teaching certificate, Walt is in his first year of teaching Integrated Physics and Chemistry (IPC) at a suburban, middle-class high school that accepts only 9th grade students. The student population at Walt's school is mixed, with 50% Anglo, 30% Hispanic, and 20% African-American students. Teachers are split into teams with a core group that works together to monitor and ensure students' progress. Walt took a core-group position mid-year from a teacher who "let the kids walk all over him," and hopes that next year will be easier for him.

Walt started his undergraduate degree after many years in the business sector as an electronics technician and service in the military. Following an initial few semesters at a local community college to garner needed science course credits, Walt enrolled in the university preparation program. He became interested in teaching science after a back injury and work layoff gave him the opportunity to change careers. Data from the initial demographics interview indicated that Walt wanted a job that "makes a difference" and matched this interest with previous positive experiences as a trainer in the military and private sectors. Interview data suggests that Walt began the preparation program self-confident and excited to teach and make a difference in the world.

Profile of Walt's Beliefs about Teaching and Learning

Walt's Beliefs about Teaching

Walt's initial responses to the questions that concerned his beliefs about teaching were primarily instructional, with one transitional response as shown in Figure 4.2.
Data from the first interview suggested that Walt struggled with his perceived notion of how teaching should ideally take place and with his notions of the realities of the

classroom. His responses indicated a tension in beliefs between teaching as a teacher-directed activity and current theories that include student ideas and perspectives. This exchange was indicative of Walt's responses throughout the initial portion of the study:

> I. How do you see your role as teacher in the science classroom?
>
> W. I've heard it in a number of ways. I've heard facilitator, and that's part of it because in science you want them to make their own connections if possible. But at some level you have to be the big talking head up in the front, giving them the information. (Interview 1, 11.48)

By the coursework phase of the study, Figure 4.3 showed that Walt's beliefs about teaching had spread to include one transitional and one responsive answer, along with two instructive responses. At this time, Walt had numerous experiences in the classroom and began to relate his responses to these practical experiences. For example, Walt's response about his role as teacher was more assured than in the first interview:

> I. How do you see you role as a science teacher?
>
> W. I'm a guide. Not the guy with the answers, but the guy that can lead you down the path to the answers. That's one I see with the 5th graders right now. They have to construct the knowledge for themselves—me telling them the answers really doesn't work—although the teacher still needs to direct the students. If the students are constructing everything for themselves, they may still miss big chunks of what is important. (Interview 3, 30.05)

By the time Walt entered the classroom as teacher, his interview responses demonstrated that his beliefs about teaching had moved back toward a more traditional perspective with two traditional, one instructive, and one transitional response. Walt's comments indicated that he was frustrated and confused about how to enact the constructivist theories of teaching that he learned in the program. The following conversation about his role as teacher in the classroom demonstrated this:

> I. How do you see your role as science teacher in the classroom?

> J. Lion-tamer [*laughs*]. It's probably not what I want it to be. Right now, it's more director than I want it to be. I find I'm having to direct their actions pretty tightly. I tell them what to do. I show them what to do. I guess I'd rather be more facilitator or stand back and guide a little more, but we're not there. Either we're not there, I'm not there or they're not there; one of those.
>
> I. So you're more like the director right now?
>
> W. Yeah, I end up having to really point them around and tell them what I want them to do, and then point out to them after the fact, "OK, here's what you just did." (Interview 5, 32.32)

Walt's Beliefs about Learning

Walt's initial beliefs about learning were predominantly transitional with one instructional response. His initial responses reflected a naïve and unformed orientation toward how students learn science. As Walt spent more time in the classroom as an intern and took more core classes for the program, his responses shifted toward a predominantly responsive and reform-based perspective. For example, when first asked about how students learn science best, Walt responded:

> W. Well, I haven't had any students yet so it's hard to say. Hands-on is good, tends to sink in well, but it's hard to always do that, though. Hands-on isn't always practical, but it's good. (Interview 13:30)

By the midpoint of Walt's coursework, however, his response to this question reflected a deeper understanding of reform-based perspectives:

> I. How do your students learn best?
>
> W. I think they learn best when they are given a problem and led to approach it like a scientist. Here is a phenomena, figure out how it works. I think that's how they learn best. That's the stuff that sticks, when they have to struggle through it.
>
> I. What does it mean for them to approach it like a scientist? What does that look like?
>
> W. When they are making educated guesses about how things work and then planning a way to test it, along with revisions to the testing. I think inquiry is the way to do it. (Interview 3, 49.05)

By the time Walt reached the classroom, however, his views about student understanding had stabilized to a transitional perspective that reflected his continuing interest in working with students on their application of science concepts to other questions and areas.

Figure 4.2: Profile of Walt's beliefs about teaching and learning.

Walt's beliefs about teaching	Walt's beliefs about learning
1. How do you maximize student learning? 2. What is your role as teacher? 4. How do you decide what to teach? 5. When do you move on to a new topic?	3. How do you know when students understand? 6. How do students learn science best? 7. How do you know learning is occurring in the classroom?

Walt's beliefs about teaching: Teacher-centered-----------------Student-centered

	Trad	**Inst**	**Trans**	**Resp**	**R-Based**
Interview 1		**2,4,5**	**1**		
Interview 2		**2,4,5**	**1**		
Interview 3		**4,5**	**2**	**1**	
Interview 4	**2,4,5**	**1**			
Interview 5	**2,4**	**5**	**1**		

Walt's beliefs about learning: Teacher-centered------------------Student-centered

	Trad	**Inst**	**Trans**	**Resp**	**R-Based**
Interview 1		**3**	**6,7**		
Interview 2			**6**	**3,7**	
Interview 3				**6,7**	**3**
Interview 4			**3,6**	**7**	
Interview 5			**3,6,7**		

Profile of Walt's Practice

Walt entered the preparation program as an older student with extensive work and life experience. Data from artifacts and interviews suggested that Walt's initial ideas about science-teaching practice may have been shaped by traditional teacher-centered school memories. However, Walt was eager to learn and implement more contemporary ideas about science teaching. For example, when asked to compare a beginning and end-of-semester self-drawn concept map of what it means to be a science teacher, Walt wrote:

> The main difference that I note is that I have now split functions between categories of "model" and "source." The source side contains those items I think of as more lecture- or demonstration-based. These are the things I remember from my high-school education long ago. I still see a need for these, but they now feed

> into inquiry as a source for researchable questions and methods for collecting and analyzing data. (WGF04ART01, p. 1)

In a written reflection on his first experiences working with young children, Walt began to grasp the complexities of teaching in an inquiry-based way. In the middle of a three-lesson cycle (one elementary science lesson co-taught every two weeks in a fourth-grade classroom), Walt was asked to rate his confidence as a teacher from 1–5 (1=less confident). His response indicated a drop in confidence:

> I'm going to drop to a 3 for now. This wasn't my lesson and my partner took the lead in teaching it, but I can see some new things I need to keep in mind. The first lesson, I tried not to control things too tightly and many of the students got completely wrong results. This time lab was pretty cookie-cutter in its approach and the next one looks like it will be as well. I'm just not sure how to create a lab where the kids REALLY discover something for themselves while ensuring that they either get the right results or they can understand why they didn't. There is a happy medium in here somewhere, but I haven't found it yet. (WGFO3ART04, p.2)

By the middle of his coursework, Walt initiated a number of extra middle-school-classroom teaching and mentoring experiences outside of the required coursework to give himself a "head start on student teaching" (Interview 2, 25.38). Observations and field notes from early field experiences indicated that Walt continued to try inquiry-based lessons and was observed using strategies that follow an inquiry framework. For his extended field experience in Classroom Interactions, Walt and his partner designed a three-day lesson that actively involved students in building simple circuits, creating simple schematic representations of the parts of a circuit, and then modifying their own models to match standard schematics in the electronics industry (WGF04RTOP, p.2), but Walt still struggled with finding the balance between student-centered learning and the role of the teacher.

Walt's student-teaching experience was a semester-long teaching placement at an upper-middle-class urban high school teaching Honors IPC. During this stage, observation notes indicated that Walt was challenged by both the daily logistical tasks of teaching and the enculturation into the regimented science curriculum enforced by the district. In general, Walt attempted to challenge students cognitively for bell work problems and showed a limited level of inquiry-based practice, but failed to create opportunities during laboratory time for student-led work. As an example, these comments from the student-teaching university supervisor indicate the lack of student input in the laboratory sessions of the class:

> For the lab, I am wondering if you thought to adapt this and make it more aligned with inquiry-based practices. So what can you have the students do that you provided for them? For example, do you think they could have come up with a procedure if you had given them the problem, "How much power do you use when you go up a flight of stairs?" This is where we want to head, lesson-wise. You could lead them in a discussion of the things they'd need to know for this: weight, work, height of rise, time it took, etc., and then ask them to figure out a way to do it. (WGF05OBS04)

Walt entered the classroom as a teacher in mid-year and found students unmotivated and bored with science. He teaches regular IPC classes in 1.5-hour block classes and was observed using a variety of instructional methods to teach Newton's laws. His use of a variety of strategies and his willingness to start lessons with active exploration indicated a proficient level of inquiry-practice. For example, during one observation, Walt pre-assessed student knowledge with bell work, showed a 30-minute video on myths surrounding the velocity that pennies reach if thrown from the Empire State building, and asked students to complete a series of lab station investigations on Newton's laws. Despite the variety of activities, only 25% of the students were observed to complete the bell work; most students seemed bored with the class and some were openly rebellious toward Walt as he attempted to manage them (WGS06OBS). This disconnect between student and teacher dropped Walt's observed level of inquiry to a beginning level. When asked about this after class, Walt remarked that getting the students to care had been one of the biggest hurdles for him, along with structuring cooperative learning activities for success.

In summary, Walt felt like he was "treading water at the moment" but was still committed to teaching. When asked if he thought this would be a long career for him, Walt replied:

> I think so. I've invested a lot of time into it. I came to school because I wanted to be a science teacher. I know it will get better, and I'll be more organized, my pacing will be better. Things are going to get better when I will be their teacher from day one. The previous teacher let the kids walk all over him, but I will never allow that. I am way to stubborn to be worn down by them like that. (Interview 5, 1:03:30)

The Impact of the Preparation Program on Walt

Interview data indicated that Walt found the preparation program useful when it provided practical field experiences, and did not see the connection or usefulness of taking advanced science classes while in the program. When asked about important events or activities that contributed to his growth as a teacher, Walt remarked, "Any classes with field components are good" (Interview 3, 18.00). He appeared to act on this belief by spending as much time as possible in the classrooms of middle-school teachers before student teaching. Walt enrolled as an intern at a local middle school and helped create and teach chemistry lessons for students. This experience led to a summer appointment teaching elementary-school teachers chemistry content and aiding in a large curriculum effort by a local school district. Even as a student teacher, Walt spent a few mornings a week at local middle schools, helping teachers prepare for labs and guest-teaching classes when asked.

As Walt has traversed the continuum of development, his original enthusiasm and confidence that providing a set of structured lessons will challenge students and allow them to have fun and learn seems shaken by the complexity and context of the teaching position he is in.

CHRIS

Chris is currently teaching chemistry as a first-year teacher at a rural high school about 30 miles from the university where he completed the preparation program. Chris's school and district are rapidly changing from a predominantly Anglo farming community to a diverse group that includes the children of migrant workers and city dwellers looking for reasonable home values and a rural setting. The student population is comprised of 44% Hispanic, 40% Anglo, 15% African-American and 1% Asian-American students.

The initial demographics interview indicates that Chris's path to teaching was influenced by two dedicated and very firm science and mathematics teachers he had in high school who demanded the best from students and supported this with hours of tutoring and other support to those that needed it. Chris was also impressed that they kept current with advances in their fields. Data shows that Chris came to the teaching preparation program circuitously. After a few years in the military and some time preparing for a chemical engineering degree, he switched to the teacher preparation program, citing his high-school teachers as influences along with a desire to live for more than financial success (his stated reason for choosing chemical engineering). As Chris entered the program, he was ready to learn about and model the characteristics he admired in his teachers from high school.

Profile of Chris's Beliefs about Teaching and Learning

Chris's Beliefs about Teaching

Chris's initial beliefs about teaching were primarily in the transitional category, with one each in the instructive and responsive groups, as seen in Figure 4.3. Interview data from Chris showed that he believed student engagement in the topics presented is essential for maximizing student learning. When asked about what topics he would choose to teach, Chris's initial answer was consistent with a constructivist orientation. For example, he mentioned relevance, prior knowledge, and scaffolding in the following excerpt:

> I. What would you decide to teach in your classroom?
>
> C. Ideally, each kid would be taught on their own based on their prior experience. Curriculum is set to each student. Basics are important because you can't make connections to the more complicated things without them. Flexibility is key also. Real-life concepts are always good to use. (Interview 1, 57.39)

By the midpoint in the program, however, Chris responded to questions about teaching in a instructive way. Interview data showed that Chris was interested in providing students with experiences that would help them stay interested in science. He saw his role as that of a mentor, someone who would provide students with a model for success in science and in life. Chris's experience in the military may have helped shape this perspective. He also mentioned that discipline and order are an important part of effective teaching:

> I. What are your ideas about discipline in the classroom?
>
> C. Discipline and order are key. Order needs to be kept. Kids need to listen. When a teacher is trying to convey meaning, the kids need to listen. You can be strict and stern, but can also be a mentor. From the military, you need to be a hard-ass but be open to suggestions and ideas. What I really remember from 1st grade was that you didn't get up unless you were told to. Things are different than that now. For me, maintaining order and respect are important. These are things I learned in the military. (Interview 1, 33.11)

When Chris entered the classroom, 100% of his beliefs about teaching were coded as traditional. His responses indicated that the transition to teaching left him feeling frustrated by the lack of student motivation to learn. The following example demonstrates this:

> I. When do you move on to new topics in the classroom?

> C. Sometimes you just have to go. It’s time to move on. If the students are behind and they don’t come in for extra help, we just need to move on. (Interview 4, 56.21)

Chris also instituted accountability in his classes by mandating tutoring for low-performing students and firmly enforcing homework and late-work policies. This caused some turmoil for Chris as the students and parents adjusted to his no-nonsense style of teaching. He said:

> I don’t coddle my kids. I tell them the first day they walk in, “This is going to be the toughest class you’ve ever taken.” I don’t accept late work and the pre-AP class is much harder than they are used to. (Interview 5, 22.30)

This perspective is reminiscent of the memories Chris shared about his own favorite teachers in high school as well as the military instructors that he excelled under while in language school: tough but fair.

Figure 4.3: Profile of Chris’s beliefs about teaching and learning.

Chris’s beliefs about teaching	Chris’s beliefs about learning
1. How do you maximize student learning? 2. What is your role as teacher? 4. How do you decide what to teach? 5. When do you move on to a new topic?	3. How do you know when students understand? 6. How do students learn science best? 7. How do you know learning is occurring in the classroom?

Chris’s beliefs about teaching: Teacher-centered-----------------Student-centered

	Trad	**Inst**	**Trans**	**Resp**	**R-Based**
Interview 1	**5**	**1,2**	**4**		
Interview 2		**2,5**	**1,4**		
Interview 3		**1,2,4 5**			
Interview 4	**5**	**2**	**1,4**		
Interview 5	**1,2,4 5**				

Chris’s beliefs about learning: Teacher-centered------------------Student-centered

	Trad	**Inst**	**Trans**	**Resp**	**R-Based**
Interview 1			**3,6,7**		
Interview 2			**3,6,7**		
Interview 3		**3,7**	**6**		
Interview 4	**6**	**3,7**			
Interview 5	**7**	**3,6**			

Chris's Beliefs about Learning

In the recruitment phase, Chris's beliefs about student learning were transitional in nature. Interview data showed that he recognized the importance of having student input but still indicated that the lessons were derived from the teacher. Chris seemed to value student responses to teacher-directed questions and experiences. The following exchange highlights this:

> I. How will your students learn best?
>
> C. Definitely by keeping them actively involved. Not actually drilling them, but prompting them for suggestions, prompting them for answers, for things like that. It will keep them awake at least [*laughs*].

By the middle of the coursework portion of the program, Chris's responses were mixed with both instructive and transitional answers. He was a strong proponent of listening to how students can apply content to their lives, and found assessment choices that included listening to student-questioning techniques as an important part of understanding.

By the time Chris entered the classroom as a first-year chemistry teacher, his beliefs about learning moved further toward a traditional perspective with a mixture of instructive and traditional responses. Chris struggled with the tension between constructivist-preparation program goals and his own experience with students in the classroom. When asked how students learn science best, Chris replied:

> They like lecture. They like being told, "This is what you need to know." When I ask the students what helps them learn the best, they say, "Do more PowerPoints." They just really like to listen to me talk and take notes. (Interview 4, 1:00:52)

For Chris, then, listening to his students' responses to what helped them learn appeared to guide his instruction rather than the extended training from the science teacher preparation program.

Profile of Chris's Practice

A graphical summary of Chris's level of practice throughout the study can be found in Table A.5. Chris was introduced to constructivist theory early in the program through Knowing and Learning. At the same time, Chris was also taking the preliminary EFEs that introduced him to inquiry-based practices. Artifacts from the Knowing and Learning class demonstrated that Chris had a good grasp of social-constructivist principles. Researcher notes from one artifact indicated that he was able to articulate a thoughtful critique of a teaching case study with a social-constructivist perspective. Other documents from this time suggest that Chris was "trying on" the ideas of inquiry-based practice and that this way of knowing and learning was not firmly rooted. This assortment of data reflected a limited level of inquiry-based practice from Chris's expressed views and a beginning level from early observations of his practice. Researcher summary notes remarked:

> C's rationale covers the basics of Inquiry-Based learning (CSS03ART06). He starts with a description of his role (as mentor and facilitator) but his other documents don't necessarily show the facilitator role as a firm belief. He tried that one on… (Summary Note for Spring 2003 artifacts)

By the coursework phase, Chris's practice began to change to a teacher-centered orientation. His level of observed practice remained at a beginning level. Observation field notes from this time supported this teacher-centered focus during an early field experience for Classroom Interactions. The field notes for one observation began:

> C was eager to teach this lesson and his attitude toward the students vacillated between military gruffness and enthusiasm for the complexity of the naming of chemical compounds. He joked around a little but the atmosphere in the class was focused on the lesson at all times. C attempted to bring students' ideas into the lesson by asking questions like, "So how would you name these objects?"—but the overall thrust was very much teacher-driven. C had the ideas; he had preconceived answers that he fished for with the students by asking leading questions or only commenting on answers that fit the correct response. The

> questioning strategy did not give students time to pursue divergent modes of thinking. This felt like a lesson that had good intentions, but not enough thought with regard to inquiry-based instruction. The students were observers and C did all the work on the overhead. This is teacher as explainer, with lip service to inquiry. (CSF03TRTFN, p. 4)

In the classroom as a teacher, Chris clearly relished the content and working with students. He was engaged and friendly with his students but was clearly cautious about using inquiry as a model for teaching on a daily basis. This exchange during an interview captures Chris's perspective as he reflected on inquiry and the program with the researcher:

> I. So are you ready for inquiry in the classroom?
>
> C. As a first-year teacher, I don't think so. I read a book for PBI that talks about a teacher who tries inquiry and says the first year is hell, but it gets easier after a few years. What I've learned from Knowing and Learning I wouldn't be able to apply, but several years down the road I'd be able to be a lot more involved in it.
>
> I. That's interesting, because I'd think if I were a first-year teacher and I taught in a traditional way…don't you think that would be hell?
>
> C. Yeah… I…Yeah.
>
> I. Yeah. So now it's just what style are you going to fall into.
>
> C. Exactly, and I really think it's the kids who you have to gauge it by. I'll use my kids as an example. They are not groomed for inquiry-based learning at all.
>
> I. So when do they learn?
>
> C. I think you have to start out with baby steps. It would take a good half-year to do it. In chemistry class you have to do cookbook labs for safety reasons.
>
> I. So what would convince you to do inquiry in your very first week of chemistry class?
>
> C. Oh my gosh! Um, if you offered to pay me 18,000 dollars [*laughs*]. I don't think anything could compel me to start day one with inquiry because I really want to know my kids before I would do it. I wouldn't want to set them up for failure. But at the same point, I think traditional teaching is boring, and I think you need to have some inquiry thrown in there.

I. How much inquiry did you use in student teaching?

C. I'd say 30%. You know, I can't even give you a number. Not very much, I'd say.

I. Well, considering that inquiry is the focus of the program, what does that tell you?

C. I know…I'm a failure. [*laughs*] I think the program gears me up for it, but I just don't feel ready to teach with inquiry. To be honest, I don't feel that I got enough inquiry-based experience [through the preparation program] for high-school chemistry. The examples we saw and used were for grade school. I've never really seen a good inquiry lesson for high-school chemistry. (Interview 4, 17.15)

Chris felt unprepared by the program to teach within the framework of an inquiry-based practice, and his final levels of inquiry practice remained at the beginning level.

The Impact of the Preparation Program on Chris

Interview data indicated that Chris seemed to enjoy the field-based portions of the program because these experiences offered practice with students. He mentioned that the student-teaching experience would be more realistic if students taught for the entire day rather than four hours. Chris did not see the recruitment-course field experiences as useful in the program. He preferred the multi-day and student-teaching fieldwork. Chris also did not see the connection between content courses in chemistry and teaching because "[w]e will never use the stuff I'm learning. Maybe having to sit in all these lectures is important for me to know how not to teach" (Interview 2, 24.36). Finally, Chris enjoyed the theory-based portion of the program and saw it as a necessary part of his preparation:

I. So why do you need a theory class—why not just go teach at Crockett for a year?

C. I think you still need a theory class.

I. But you are telling me it's not going to be useful for ten years down the road.

C. But you still need the background in it. (Interview 4, 29.45)

NOELLE

Noelle is currently teaching high-school Pre-AP Chemistry in an affluent school district 20 miles from the university preparation program site. The student population includes 66% Anglo, 21% Hispanic, 8% African-American, and 5% Asian-American students, and the district boasts of average student SAT and other test scores above state and national levels. Noelle's interest in teaching science was piqued after experiences tutoring friends in high-school science classes and working as an undergraduate teaching assistant at her first university. In fact, the experience of teaching at the university level was a powerful one for Noelle, according to interview data, because her interactions with learners at the same age who appreciated her talents empowered her to continue on as a teacher. Noelle's talents may stem from a natural interest and passion for chemistry and a desire to share this with others:

> When I was thinking of majoring in chemistry, people would say, "Ewww, gross!" and I wanted to say, "NO! It's not yuck." I want to help show people that it's all about daily life. Science is everywhere, and I just hate it when people say they hate science or that they suck at chemistry. I want to inspire other people about science. I want to motivate them. (Interview 2, 09.00)

Noelle started her path toward teaching directly from high school at another university and was one semester from finishing that degree when she made the decision to transfer to the preparation program in this study. She has taken a number of education courses prior to her acceptance to the preparation program but is excited to be a part of it after doing research on the reputation of the program and the university in general.

Profile of Noelle's Beliefs about Teaching and Learning

Noelle's Beliefs about Teaching

Noelle's beliefs about teaching were generally teacher-centered during the recruitment phase of the program, with one traditional response, two instructive responses and one transitional response, as seen in Figure 4.5. Noelle's beliefs about what to teach during this phase were based on the standards and textbook contents, and reflected an awareness of her novice status when thinking about these questions:

> I. How will you decide what to teach?
>
> N. You mean the topics? Doesn't the district have those IPGs? So I'd pretty much follow those. I mean, of course I would want to teach what is relevant. But, I…I haven't really learned this yet. That's kind of scary. I took all those classes at NMSU and I really didn't learn what to teach.
>
> I. How about in an ideal situation?
>
> N. [*Laughs*] I don't know. It's bad, but I'd follow the textbook guidelines and then modify that to make it more interesting. [*Laughs*] I don't know, (Interview 1, 17.08)

Data from interviews indicate that Noelle saw her role as that of an "exciter" or motivator for students as well as a trainer for science classes in the future. As figure 4.5 shows, this belief was stable throughout her preparation and clearly was an important part of what drove her as a teacher.

By the coursework phase, Noelle's beliefs about teaching had shifted to a student-centered orientation, with three responsive and one transitional category represented. At this stage, interview data and artifacts show that Noelle expressed ideas about teaching that reflected attention to student ideas and student cognition, structured lessons that promoted student thinking, and modeled the discipline of science.

As Noelle entered the classroom, her beliefs about teaching split into two distinct modes, with two traditional responses and two transitional ones. Noelle's ideas about what to teach and when to move on in the classroom were related to department and school curriculum standards and reflected a traditional orientation. Her beliefs about her role and how to maximize student learning were transitional in nature and reflected a stable belief that her job was to motivate and interest students in chemistry:

> I. What is your role as the teacher?
>
> N. My role is to expose them to science and technology and help them see that they can do it. A lot of them seem close to giving up and I want to encourage them to succeed. I want them to see me as a positive role model and as someone who is dedicated and successful. (Interview 5, 20.36)

Figure 4.5. Profile of Noelle's beliefs about teaching and learning.

Noelle's beliefs about teaching

1. How do you maximize student learning?
2. What is your role as teacher?
4. How do you decide what to teach?
5. When do you move on to a new topic?

Teacher-centered----------------Student-centered

	Trad	Inst	Trans	Resp	R-Based
Interview 1	**4**	**1,5**	**2**		
Interview 2			**1,2,4 5**		
Interview 3			**2**	**1,4,5**	
Interview 4	**4,5**		**1,2**		
Interview 5	**4,5**		**1,2**		

Noelle's beliefs about learning

3. How do you know when students understand?
6. How do students learn science best?
7. How do you know learning is occurring in the classroom?

Teacher-centered-----------------Student-centered

	Trad	Inst	Trans	Resp	R-Based
Interview 1			**3,6,7**		
Interview 2			**6,7**	**3**	
Interview 3				**3,6,7**	
Interview 4		**7**	**6**	**3**	
Interview 5	**7**	**6**		**3**	

Noelle's Beliefs about Learning

Initially, Noelle had transitional beliefs about learning. Notes from the first interview indicate that Noelle had a strong belief that students learn best by a combination of lecture and active experiences with phenomena, and that learning in the classroom was best evaluated by watching students in the classroom over time. Noelle related her own experience taking an inquiry-based physics class at the university level to the students' ability and motivation:

> I. How do students learn science best?
>
> N. Hands-on, through experience. I mean, I think you have to lecture at times. I took a physics-by-inquiry class that was incredible. We learned it ourselves. I really felt like I learned it and knew it. It took so much time, but it was great. You learn about the subject, you learn about yourself, you learn about your teaching, I just really liked it. I think that's one of the best ways to learn.
>
> I. Was that course critical for you in understanding how students learn? Or did you already know that?
>
> N. I always knew that learning in that way was good, but I had never actually experienced it in such depth, especially in college.
>
> I. So is hands-on good for people who aren't motivated to learn?
>
> N. No. That inquiry was hard. There were times when we wanted to give up, so I don't know if that is good. But it was exciting, interesting and extremely relevant, so I think it is better than just lecturing for someone who is not motivated. (Interview 1, 23.37)

By the coursework phase, Noelle expressed beliefs that were fully responsive and student-centered in nature. Noelle saw student understanding as the ability for them to predict, apply, and create links to the real world with the knowledge that they were gaining. She strongly supported students' making reflections and asking students to think historically when expressing scientific ideas, and saw history as an avenue for motivating student learning. Noelle also believed that tests and subjective measures were not enough to know if the students were learning. She said:

> It's not necessarily if they are all looking quiet and taking notes, and it's not if they do well on the test. Although they may be learning, it's not for sure, and you can't make that assumption. Grades don't necessarily mean they are learning. If they are in small groups and are asking questions, talking about it, you have a

> better idea. You have to listen, walk around, see their work, interact with them, hear their questions… (Interview 3, 43.17)

By the teaching portion of the study, Noelle had split her answers into traditional, instructive, and responsive categories, as seen in Figure 4.5. The practical nature of the classroom had influenced some of her responses, according to interview data. Most notably, Noelle adjusted her former beliefs about how students learn through the realities of the classroom:

> I. How do your students learn science best?
>
> N. I think by doing it and experiencing it and thinking about it themselves… [*sighs*]. Ahhh, this is so much theory [*laughs*]. I can say it and I know it but it's so hard to do, and given the time. To get them to actually think about it and do it and talk about it takes time… But I think it's probably the best, just to experience it and then wonder what they are doing, not just reading about it and not having a clue. (Interview 5, 37.56)

Profile of Noelle's Practice

During the recruitment phase of the program, Noelle demonstrated a limited proficiency with the ideas behind an inquiry-based practice as she discussed how her teaching would represent the discipline of science. Noelle mentioned the importance of working in cooperative teams, the role of questioning and defending ideas, and the importance of learning the process skills of science through laboratory exercises and safety lessons, but still held incomplete ideas of how to negotiate these practices in the classroom. During an observation of an early videotaped three-day lesson, the researcher noted that Noelle had a grasp of inquiry-based practices and that she attempted to engage the students with a real-world problem of designing a "cold pack" for sports medicine. The observation summary reported:

> The overall idea was great and once the students were working on the measurements and using the computers/probes, they were engaged. The first and last day seemed to drag a bit and the students spent a lot of the class period sitting

> and waiting for one or two in the group to finish the work (writing hypothetical lab procedures for the investigation and creating a poster describing the lab). The concept was very student-centered but the practice ended up more teacher-driven because they gave the kids detailed directions and set up the equipment for them. Great promise though. (NWS04OBS01, p.3)

Noelle came to the program with mixed views on the nature of science as a discipline, as seen in Table A.6. She carried both traditional and contemporary perspectives as well as a number of unformed or contradictory perspectives that are labeled as naïve.

By the coursework phase, Noelle had more experience with both the theories and practice of inquiry, and moved to a proficient expressed level and a limited observed level of practice. Her observed lessons in a high-school IPC classroom demonstrated tension between understanding and attempting to apply constructivist theories of learning into practice with the dynamics of working with a teacher-centered mentor teacher and students who had not been successful in science (NWF05OBS06).

By the classroom phase, Noelle was teaching Pre-AP and regular chemistry classes. Her observed practice demonstrated a beginning level of inquiry. The observation summary noted:

> The lab is "cookbook." She calls it a "formal" lab. This must mean it will be handed in. This seems like a very traditional lab-verification type. N has great control of the class, has got procedures down, seems well-organized, etc., but I am not seeing the inquiry piece at all. Posters on wall speak to trustworthiness, responsibility, fairness, etc.; nothing about content. (NWS06OBS, p.2)

When asked about this investigation during the follow-up interview, Noelle mentioned that her supervisor had asked her to follow the labs' setup in the textbook in order to keep all students at the same place for testing purposes. She also mentioned the culture of the students in her classroom:

> For the Pre-AP students, I'll do a fun engagement and they'll look at me like, "What do you want us to learn?" The regular kids love the engagements, but the

> Pre-AP kids have stopped thinking. They do labs but they don't know why they are doing what they are doing. The AP teacher is good though. The kids like her because she is very traditional—straight lecture. This semester has been crazy for me, following her lead. I pretty much have to do the labs she sets out for her classes and have to stick to her time schedule. (Interview 5, 5.47)

With the traditional nature of the observed class, Noelle expressed limited views of inquiry-based practice. Her description of how her teaching practice modeled science reflected an orientation that put the teacher back in the center of the instruction:

> I. How does your teaching model the discipline of science?
>
> N. I try to make them question. I think that's what drives science. It's observing and questioning and wondering why, and then doing an experiment and analyzing data. That's all I can do right now. I also try to model good safety and lab techniques. (Interview 5, 42.30)

Noelle's responses were centered on her own actions and how she directed the students, not on the students' construction of their own understanding from topics studied. Despite this limited view, Noelle's responses to the NOS questions reflected a distinct shift toward contemporary views about the nature of science. This dichotomy between practice and knowledge of current ideas about the discipline of science characterized Noelle's transition into the classroom.

The Impact of the Preparation Program on Noelle

Interview data shows that Noelle began the program excited to be challenged by both the teacher preparation program and the rigorous content preparation necessary for graduation. She strongly supported the tough science content coursework requirements for science teachers. When asked if the change from her previous school in New Mexico was a good one, Noelle replied:

> I'm so glad, academically. I've learned so much about myself since coming to this university. This school is hard. I try my best and still don't get A's. It's helped me

> understand that my students may try really hard and still not get A's. I've learned a lot by looking at myself. It's going to help me be more understanding of my students. (Interview 2, 24.24)

As Noelle completed her coursework, she continued to reflect on the program and her own learning during the interview sessions. Her general feedback consistently stated that structure and practical courses were the most valuable for her. The recruitment courses felt like "a waste of time," and she did not see the connection between upper-level science and mathematics content courses and her preparation to teach high-school chemistry. As she entered the classroom, interview transcripts showed Noelle as a frustrated beginning teacher:

> I. How has your view of teaching changed throughout the program?
>
> N. Well, it's a lot of work. I've definitely thought about doing Chemistry, 'cause who knows how long I'm going to be teaching. I don't think it's the program's fault. I think the program has big ideas and…I mean, I know they are trying to change the nation and the thinking, but I mean, just changing one little school, I mean… I don't know. I think it's frustrating. You put a lot of work into it and it doesn't end up working.
>
> I. You mean when you plan a good lesson and it doesn't work? N. Yeah, when it doesn't work. Maybe when you look deep inside and see the kids getting something out of it, but then you look down the hall at the teachers and the administrators. A lot of administrators and teachers don't understand inquiry and they just want to see kids doing well on exams, which doesn't really mean very much for their learning and understanding of science. But that's the way the world works sometimes. (Interview 5, 44.20)

HAL

Hal currently teaches Biology and Integrated Physics and Chemistry in the sole high school of a rural school district near the urban area where he was prepared to teach. The student population is 45% Hispanic, 26% African-American, 27% Anglo and 2% Asian-American. Interview notes indicate that the position has been a challenge for Hal due to personal issues with certain staff at the school as well as the number and type of courses he was given at the beginning of the semester. Additionally, the school's "academically unacceptable" rating by the state has put pressure on the school to "teach to the test." The personal climate, course load and pressure to teach to the test have left Hal feeling uncertain and anxious about his future at the school. Hal came to teaching from a general interest in science, after a number of years exploring different career options. He has taken coursework as an Electrical Engineer, Pharmacy, Chemistry, and finally Biology major with a teaching emphasis. He decided to stop making teaching his secondary choice and focus on it as a career:

> I. Why did you switch majors?
>
> H. I decided I didn't really like those [other subjects] and I wanted to spend my life doing something I was happy with. In the back of my head has always been the thought of teaching as a backup—even in high school—so I decided to stop making it the backup. (Interview 1, 01.42)

Interview transcripts indicate that Hal chose to teach science because it "makes just a little more sense" than the other subjects he's taken. Hal wasn't unduly influenced by anyone in his past but enjoys the subject matter. His interest in science seems driven by field-based experiences where he can see and handle organisms and apply theories to practice, and he entered the preparation program determined to learn all he could about teaching science and sharing his own enthusiasm for ecology and biology with students.

Profile of Hal's Beliefs about Teaching and Learning

Hal's Beliefs about Teaching

Hal entered the preparation program with beliefs about teaching that were instructive and traditional, according to interview data summarized in Table 4.4. For instance, Hal had a belief about his role as teacher that included being an encyclopedia for the students and a "library of information who will teach the student what he knows" (Interview 1, 30.31). Hal had a procedural orientation toward teaching that did not take into account student ideas or prior understandings:

> I. When do you move on in the class?
>
> H. When students understand what they've been taught. You teach, ask questions, give homework and then test them. When the majority of the class gets it, then you move on. (Interview 1, 29.08)

By the coursework phase of the program, Hal's beliefs about teaching were primarily instructive with one transitional response. He continued to see himself as the source of ideas in the class, as evidenced by the following remarks:

> I. What would it look like if I came into your room and you were teaching? How would you maximize learning in the class?
>
> H. You would see students sitting at tables with an experiment in front of them and me walking around and planting ideas in their heads. They would have a bunch of pieces and would be told to get to this end from these pieces, and I'm not going to tell them how to get there. (Interview 3, 1:04.19)

For Hal at this stage, an effective science teacher was someone who gave students the beginning and end of a problem and expected them to figure out the steps in between. As Hal entered the classroom, his beliefs about teaching became more traditional. His evident frustration with student interest in the topics he chose is shown by the following exchange:

> I. What is your role as teacher?

> H. Sometimes I feel like a record player. I sit there and spout things off and if they want to listen they do, and if they don't, they don't. I'm there like the textbook, as a resource. I'm there facilitating their needs. We all have frustrating days where you get up there and teach your heart out and the kids just give you blank stares. (Interview 5, 03.30)

Hal's comments from the final interview indicated that he was struggling with his role and with issues concerning when to move on to new topics in the classroom as well as how to balance the ideas of inquiry from the program with the pressures from the state and district to cover more topics.

Figure 4.4: Profile of Hal's beliefs about teaching and learning.

Hal's beliefs about teaching

1. How do you maximize student learning?
2. What is your role as teacher?
4. How do you decide what to teach?
5. When do you move on to a new topic?

Teacher-centered----------------Student-centered

	Trad.	Inst.	Trans.	Resp.	R-Based
Interview 1*	**2**	**4.5**			
Interview 2	**2**	**5**	**1,4**		
Interview 3		**2,4,5**	**1**		
Interview 4		**4,5**	**1,2**		
Interview 5	**2,4**	**5**	**1**		

* Question One not asked

Hal's beliefs about learning

3. How do you know when students understand?
6. How do students learn science best?
7. How do you know learning is occurring in the classroom?

Teacher-centered-----------------Student-centered

	Trad.	Inst.	Trans.	Resp.	R-Based
Interview 1		**3**	**7**	**6**	
Interview 2			**3,6,7**		
Interview 3			**3,6,7**		
Interview 4			**3,6**	**7**	
Interview 5		**3**	**7**	**6**	

Hal's Beliefs about Learning

Initially, Hal's beliefs about learning were spread from instructional to responsive, as seen in Figure 4.4. Interview data shows that Hal had well-formed ideas about student learning and understanding in science, and recognized that learning was occurring when students could apply the concepts to new ideas and expand the questions to deeper levels of understanding. Hal imagined the students taking the science content that he presented during lecture and then applying it to “big concepts in the discipline”:

> I. How do your students learn science best?
>
> H. To learn science best, students need to learn the principles and basics of science and how to apply them in thousands of different ways. Take the basics and apply them.
>
> I. Can you give me an example?
>
> H. You might be given a periodic table of the elements, and they teach you, “OK, these different elements come in different forms. OK, make something. Make me a molecule.” (Interview 1, 32.50)

By the coursework phase, Hal’s beliefs about learning had stabilized in the transitional category. His decisions about when students were learning in the classroom and when they had understood something in science were based on subjective feedback from discussions with the students and on observing them in the classroom:

> I. How do you know the students understand?
>
> H. I have a picture in my head of my classroom on test day, and rather than silently taking a test we are having a discussion about the material. We are having an in-depth conversation like, “Tell me what you know, why it’s important and how you learned it.”
>
> I. OK, any other ways?
>
> H. You can watch them and see the light bulb come on. You can stand back watching them and see them learning. (Interview 3, 25.03)

By the teaching phase, Hal’s beliefs about learning had spread again to include instructive and responsive answers. His experience working with students seemed to have left him more tentative with his responses in relation to the coursework phase. For example, his response to knowing when learning was occurring had a similar theme from the previous phase, but he acknowledged the difficulty of evaluating whether learning was actually occurring:

> I. How do you know when learning is occurring in the classroom?
>
> H. I don't think you always do know. Sometimes my students look at me blankly and they still have a deep understanding of the topic. Sometimes it just clicks for them. You have to look around and feel for it. (Interview 5, 17.35)

Profile of Hal's Practice

Hal began the program with a beginning/limited level of inquiry practice, as seen in Table A.5. Observation notes from Hal's first attempts at inquiry and lesson plans submitted as early artifacts showed a beginning level of understanding, but his verbal descriptions of what it meant to do science within an inquiry framework showed a limited understanding of how inquiry-based instruction works. For example, Hal was asked how his teaching represented science during the first interview:

> I. So how will you make your teaching like science?
>
> H. To represent science, you can't start with lecture. You can't lecture until you have an experience or application. You have to have some hands-on application. That way you can actually see the concepts you are learning—see how they apply—and then move on. I like an inquiry style of teaching where you are putting information out there, letting them understand it, learn it, and draw conclusions about it. That is the most representative of science to me.
>
> I. Can you give me an example of that? What would that look like?
>
> H. When we taught surface tension, we didn't introduce the term "surface tension." We didn't introduce the concept. We went in and said, "OK, what we are going to do is see how many drops of water you can fit on this penny. As you do this, I want you to see what shape the water makes. Why do you think it made that shape?" And then they'd give you basically a description of water tension, what it is and how it works, and then later you'd give them the terms for everything. Basically you let them discover the concept before giving them the terms. (Interview 1, 39.36)

As Hal advances through the program, his proficiency with describing the steps and ideas of inquiry-based practice remained at the limited level while his observed practice remained at a beginning level. Hal wrote detailed lesson plans that followed the program format (5E instructional model) and had clearly defined engagement and exploration phases that allowed students direct experience with the concepts, but his overall grasp of inquiry remained at a fairly low level. Hal's vision of inquiry-based practice included an initial time when he "throws out a concept" or "plants ideas" in the students' heads, and then a vague time in which they "explore the concept" before the "light bulb goes on" (Interview 2, 27.20). Observed teaching moments indicated that Hal was still at a beginning level when in front of students. Classroom observation summaries seemed to focus on classroom management issues, and Hal was observed embarrassing one student at the beginning of one classroom session:

> The bell rings and the students are introduced to H and the other intern teachers by the classroom teacher. The students are 95% Hispanic and there are a fair number of ESL students in the class. H and the other students introduce themselves and H immediately begins the class by asking a series of questions like, "So do we know what cancer has to do with Mitosis?" And after silence, "So anybody remember what Mitosis is?… Come on…" H. seems impatient that the class is unresponsive. One student shyly tries an incorrect answer and H responds, "No, mitosis is part of the cell cycle." The student who volunteered puts his head down in embarrassment. Not a good start to a three-day lesson. Not sure if this is nervousness or just irritation from H. (HWF03OBS01, p.3)

By the teaching phase, Hal had had experience in and out of the classroom working with students. However, his student-teaching/first-year-teaching observations continued to reflect a beginning level of inquiry practice. During student teaching, notes from observers reflect that Hal spent most of his time with management and procedural classroom issues. He also seemed to face constraints from his first teaching job, based on summaries from observation and interview data. At the time of the observation, low district test scores (5% passing) from all students in science effectively stopped normal science instruction, and all science teachers were requested to teach state-standardized test review material for the five weeks up to the state assessment. The summary from the last observation painted a bleak picture for Hal:

> H seems really burned out by this class and this teaching assignment. He is bitter about the testing taking over his own curriculum and seems resigned to doing the reviews, but the atmosphere in the class is not good. Students seem to be in control. They decide when to work and when to gossip, and his reprimands and pleas for quiet and work lack conviction. He seems to have given up and they seem to never have had any motivation to start. I don't sense interest in inquiry or passion about biology and field studies as in earlier observations, etc. The climate of the school, TAKS, etc. seems to have deadened his interest and will. (HWS06OBS, p.2)

Hal's expressed understanding of science practice was characterized at the proficient level despite his observed practice. In the final interview, for example, Hal responded to the question of how his practice reflected science by stating:

> You can't present science as cold, hard facts. Science is always rebuilding itself. You have to present things that show that things aren't always the way they were before, and offer students the opportunity to propose their own ideas. Give them a chance to test those ideas. (Interview 5, 19.14)

This response contrasts sharply with the observed practice of Hal.

The Impact of the Preparation Program on Hal

Hal's beliefs about teaching and learning along with his practice with inquiry remained fairly stable throughout the preparation program, as evidenced by Figure 4.4 and Table A.5. When asked what courses were important for his growth as a teacher, Hal typically mentioned the personal relationships with instructors of science content courses as being instrumental in his development as a science teacher, especially those courses that include field-based components. He was not focused on the content as being important during these discussions, but he was struck by the personalities and teaching methods of the instructors. Hal also came to the program with his own firm beliefs of what inquiry-based practice looked like:

> I liked AP biology in high school. It challenged me to think. It was more inquiry-style teaching. She would give us the facts and we'd have to draw out the conclusions. (Interview 1, 4.00)

The program doesn't change this basic view that Hal carried about inquiry-based teaching as a process in which students solve teacher-driven questions when the teacher provides the puzzle pieces and the students are asked to put it together. When asked about courses and the impact of the program on his growth, Hal said:

> From start to finish, I don't think I really changed that much. I knew when I came in that I wanted to teach science and at what level. (Interview 5, 05.51)

Hal's comments also centered on the courses that provided field experiences as being key for his growth, with student teaching being the best course of the sequence due to the practical experience of teaching in the secondary setting.

Cross-Case Analysis

The previous section focused on ways to explain, describe, and explore what occurred to the individual units of analysis or sub-cases in the study. The narrative for each sub-case was written from time-ordered displays that had been created for each participant. As the process of writing and reflecting on the individual sub-cases evolved, themes emerged from the analysis that were categorized and placed in a grid that allowed for comparison of participants from their initial recruitment into the program through their first year in the classroom. Themes that had guided the within-case findings for each sub-case provided a useful framework for comparing across the sub-cases.

Tables A.1 and A.2 summarize the trends that came from the initial writing of the cases. For each grouping (beliefs about teaching, developing practice, etc.), supporting meta-matrices were created that reduced the data for clarity and identification of important developments. These tables are located in appendix A. As the cases were compared, comments set out by Miles and Huberman (1994) were recognized to avoid a superficial reading across the individual cases. Perhaps the most important of these suggestions is the admonition to respect the complex and contextual nature of each case while still finding a way to reduce the data to examine any important developments that may have emerged. In other words, it is important to examine both the forest and the trees, by both honoring the diversity and multitude of factors peculiar to each case while also seeing the whole picture. With these cautions, a general explanation of the emergent trends ensues.

BELIEFS ABOUT TEACHING AND LEARNING: PATTERNS NOTED

Table A.3 shows the distribution of beliefs about teaching and learning for all participants throughout the study. There are a number of patterns that emerge from examining the beliefs about teaching and learning science:

- The overall pattern for the participants' beliefs about teaching start with a teacher-centered orientation, then shift toward a more student-centered perspective by the coursework phase, and finally, sharply return toward a traditional teacher-centered status by the teaching phase. Within this pattern, the response to Question 4 stands out. By the teaching phase, every participant shows a strong trend toward a traditional teacher-centered perspective when asked how they decide what to teach in the classroom. Table A.4 shows the stable and variable beliefs held by teachers and illustrates the trend in responses to Question 4.
- The data indicates that beliefs about learning are generally more student-centered than beliefs about teaching, and may demonstrate that the participants' beliefs about teaching are derived from their experience, while beliefs about learning may be more influenced by coursework related to child development and learning. This trend also indicates a gap between theory-driven beliefs about learning and the teachers' actual practice in the classroom. One initial assumption that was made by researchers was that beliefs about learning would fall into the same categories (traditional and instructive) as beliefs about teaching. This hypothesis was not supported by the data. The responses to questions that were focused on beliefs about learning demonstrated a perspective that was more student-centered throughout the study when compared to the beliefs about teaching. What is especially interesting is the persistence of the responses about these beliefs into the teaching phase. Even after the beliefs about teaching have returned to a

traditional perspective during the first year, the beliefs about learning remain transitional for most of the participants.

- Individual beliefs about teaching and learning may be stable throughout the study or may fluctuate as the participant progresses. This process varies by individual, but the common feature of all stable beliefs is that they are rooted in important experiences held by the participant in the past.
- By the end of the study, beliefs about teaching and learning are either clustered in one belief category or they become bi-modal, indicating beliefs that are either strongly traditional or transitional in nature or are spread equally among traditional, instructive, and transitional categories.

TRENDS IN PRACTICE:

Observations of practice along with the expressed views of how they implemented inquiry-based instruction in the classroom informed the participants' levels of practice. Table A.5 shows the progression of the participants' practice toward an inquiry-based approach throughout the program. These categories and data from the general interviews were used to generate the following patterns:

- The expressed views by participants on their teaching practice are generally more advanced than the documents and videotaped segments of observed classroom practice. In other words, participants believe that they practice teaching science as inquiry at a higher level than the observations indicate.
- Despite the strong inquiry focus from the program, observed practice in the field does not reach beyond a limited level for participants by the time they enter the classroom. Other constraints, including classroom management, pressure to conform to more teacher-centered department guidelines, and/or a lack of

school/district support for implementing inquiry-based lessons, take precedence over instruction.

- The inquiry focus of the program is seen as separate from the practical realities of teaching on a daily basis. Inquiry-based teaching is viewed as too time-consuming, difficult to implement, or theory-based to have applications for the participants, especially in the high-stakes testing environment that participants envision themselves in. Jan views inquiry as "fluffy" and not practical on a daily basis. Chris and Hal sees themselves implementing inquiry after they have mastered classroom management and procedural skills as well as becoming acclimated to the school culture. Noelle and Walt continue to struggle with implementing inquiry-based lessons in their classroom but have yet to be successful.

IMPACT OF PROGRAM:

The general demographics and general interviews yielded a number of important commonalities among participants concerning the value and importance of the program on their professional development as science teachers. These are summarized below:

- The strong community aspect of the program appeals to participants. They feel supported and that they are in a tight-knit group with other students, mentors, and faculty. For example, Jan entered the program on the recommendation of friends already enrolled. She clearly valued the community atmosphere and was active in establishing a series of town hall meetings to address concerns and issues between students and program staff. It is not clear how or if the support from the program affected the beliefs and practices of the students, but it is certain that tight-knit communities can influence the actions of the members.

- In a related pattern, when asked to discuss artifacts or describe current experiences that best represent their growth as teachers, study participants focus on preparation program coursework that they feel is the most practical in nature. Typically, these examples include courses in the program that have field components and/or are seen as directly useful for their career.
- Participants do not see the connection between courses that provide an explicit grounding in educational psychology (Knowing and Learning), or explicit theoretical framework for the program (Perspectives), and courses with more practical applications, like Step 1, Step 2 and Classroom Interactions. The participants do see the value of having an educational theory class, but don't see how the class relates to their experience as developing teachers or helps them grow as a professional.
- Field experiences are viewed as the most valuable part of the program for participants, as long as they are directly applicable to the classroom. Research methods and PBI are viewed as interesting but not practical (based on resources available in schools for technology or freedom to plan extended field trips).
- While the participants do articulate the value of subject matter coursework for their undergraduate degrees and their interest in science as a field, comments from interviews indicate that they may not see the relationship of advanced subject matter courses to their development as teachers. When asked what experiences or classes are not valuable in their professional growth each semester, the participant typically mentions advanced subject matter courses as unnecessary and too advanced for the content they will be teaching in the classroom. Of the participants, only Noelle expressed the opinion that a strong content background was an important part of her preparation to teach. The refrain of "we'll never use

this stuff when we teach, so it's not important for me as a teacher" was commonly heard when researchers asked the study members about their subject matter preparation.

IMPORTANCE OF CONTEXT:

- The prior personal and professional experiences of the participants also played a role in establishing conceptions of teaching. Walt and Chris were both trained in the military under highly structured and stressful circumstances, and both students excelled in these circumstances. However, Chris and Walt have divergent beliefs about their roles as teacher. Chris began the study with transitional beliefs about both teaching and learning but steadily moved toward a more traditional perspective by the end of the study. Interview and observation data indicated that Chris held foundational beliefs about teaching that were formed from his own schooling and military service. These ideas contrasted sharply with his expressed ideas at the beginning of the program, but became more apparent after time in the field. Chris seemed to be "trying on" new beliefs about teaching and learning at first, but later rejected these beliefs and reverted to the traditional model of teaching from his own past. Walt, on the other hand, is still attempting to negotiate a shared role in the classroom with his students. He does not seem ready to give up on the promises of an inquiry-based classroom. His own experience as a younger student may reveal the roots of this persistence. Walt struggled with his initial experience at the university level and dropped out after "a truly historic blowout" from full academic scholarship to failing student who "liked to party." Service in the military helped Walt refocus after this and recognize that he wanted to contribute something to the world. Thus, his beliefs are centered more on student motivation. In this way, the individual background of the person shapes their beliefs and practice.

- Participants referred to the “reality shock” of teaching full-time. They were concerned by the myriad tasks and other factors that make the transition into the classroom so challenging. The participants cite these extra duties (meetings, parent conferences, planning and grading assignments, taking attendance, etc.) as being overwhelming for them and leaving them no time for planning student-centered lessons.
- In addition, the climate of the individual school may influence the practice of the teachers. Jan, who is teaching in her old high school, has landed in a supportive environment with peers and an administration that values her contributions. Her school is performing well on state assessments and is situated in an affluent area. Hal, on the other hand, is struggling to make it through the semester in a failing school with administrators that he perceives as incompetent. These relationships and the culture of the school are important to consider when trying to understand the forces that affect the participants’ beliefs and practices.

SUMMARY

This study was designed to explore the evolving beliefs and practices of prospective science teachers as they move through a university preparation program. After careful examination of the individual cases, a number of trends and patterns emerged. In summary, the cross-case analysis revealed the following general trends.

First, there appears to be general growth toward student-centered beliefs by participants as they move through the program, but this progression abruptly reverses to a teacher-centered perspective by the time students have reached the classroom. Additionally, the participants' observed practices tend to fall within the beginning or limited levels of inquiry-based practice at the beginning of the program, and do not appreciably change throughout the study. Finally, the contextual factors that influence the teachers' growth once in the schools clearly affect their practice and override any gains made toward contemporary science teaching in the program.

CHAPTER 5 – DISCUSSION AND IMPLICATIONS

One egregious gap in secondary science teacher preparation research has been understanding how preparation programs and the climate of the schools can influence prospective teachers' beliefs. This area of research has been difficult to bridge because of the complex interactions among preparation program, school setting and individual prospective science teachers. Each component has a unique impact on the others, and the contextual nature of teacher beliefs in general serves to complicate the picture. This dissertation has attempted to clarify some of the interactions among these elements and add to the knowledge base of how beliefs change and evolve over a three-year period.

At its inception, the study pool consisted of 17 preservice secondary science teachers who were first-semester students in a traditional teacher preparation program. As the study progressed, two preliminary pilot studies were conducted that related to the main research question. At the present time, there are nine participants left from the original seventeen who are active in the study. Of the nine, there are four who are still in the program and five who have completed their first year in the classroom. The focus of this study was on the five participants who had successfully completed the program and who are now teaching secondary science.

While many studies over the last few decades have examined the structure of belief systems and their influence on practice (Hollingsworth, 1989; Joram & Gabriele, 1998; Lemberger, Hewson, & Park, 1999; Scamp, 2001), none have been located that follow participants from the first semester of a science teacher preparation program through the first year in the classroom and examine their evolving beliefs and practices. This study is therefore crucial in adding to the literature on how individuals carry and arrange their beliefs about teaching and learning over time. In addition, the unique longitudinal nature of this work sets it apart as one of the only multi-year studies that has captured the growth of beginning teachers from recruitment courses to their first year in the classroom.

The framework for this chapter includes an explication of the findings from Chapter 4 along with a description of the agreement or disagreement of the findings with the original hypotheses. Additionally, reviews of literature that support or counter the results will be added and limitations and implications from this study will be addressed.

Discussion

The main research question asked:

> *How do the beliefs and practices of beginning secondary science teachers evolve through a traditional university teacher preparation program?*

The assumption from this main question was that the beliefs and practices of the participants would develop and reflect the strong inquiry-based focus of the program and would remain student-centered as the teacher entered the classroom. The results were mixed. In other words, the initial premise was not supported for the respondent's *beliefs about teaching* and *practice*. However, the responses for *beliefs about learning* reflected a consistent transitional approach. The work of Bryan (2003) might provide some insight into this. Bryan examined one prospective elementary teacher's beliefs about teaching and learning in relation to practice, and reported that the teacher (Barbara) held both foundational and dualistic beliefs about teaching and learning that were "nested." One nest of beliefs about teaching was grounded in her lifelong experience; it reflected a didactic orientation and dominated her observed practice. The other nest of beliefs espoused a constructivist perspective and guided her expressed vision of her practice. This result corresponds with the clustered nature of belief systems proposed by Green and confirms the general gap between vision and practice that is evident from the results of this study for both beliefs and practice.

BELIEFS ABOUT TEACHING: ONE STEP FORWARD, TWO STEPS BACK

As a more complete picture of participant belief structures has developed, the work of Green (1971) presents a useful way to discuss belief structures through multiple levels of analysis. For example, in this study, Noelle believed that teaching with inquiry was essential and that students should have time to explore natural phenomena before classroom explanation—a primary belief. But the psychological strength of that belief was not strong when faced with typical pressures of first-year instruction. Because of this, Noelle's use of inquiry suffered. Additionally, Green's description of the aggregation of isolated belief clusters is relevant when thinking of the sometimes-contradictory statements of the participants. For example, Hal may believe strongly that students learn best by hands-on exploration and building their critical thinking skills, yet he sees his role as teacher not as a guide for this process but as a library of information (Interview 2, 27.20).

The delineations of the nature of belief structures set forth by Clark and Peterson (1986), Nespor (1996), Pajares (1992), and Richardson (1996) are also useful in helping to understand the findings that emerged in this study. First, those studies agreed that core beliefs are formed early and are well-established by the time future teachers begin their training. Second, they recognized that these core beliefs are resistant to change. Finally, their collective research and reviews of other work indicated that newly formed belief systems (peripheral beliefs) are subject to change more readily than those belief systems formed early in life.

The results from this study both confirm and challenge these three principles. For instance, the participants in the study entered the program with established beliefs about teaching that were grounded in many years of traditional teacher-centered instruction. Their overall beliefs about teaching from the first interview demonstrated this traditional orientation (Traditional and Instructive responses accounted for 68% of the responses for Interview 1).

During the coursework phase of the study, the beliefs about teaching became more student-centered. In one sense, this is understandable due to the strong focus of contemporary theory and practice. For example, all lesson plans mandated by the program are generally required to be in 5E format. This instructional format is the core constructivist science-teaching and planning model created by BSCS and related to the learning cycle model (see Trowbridge, Bybee & Powell [2000] for explanation and history of 5E model). In addition, the students are enrolled in courses that build a theory base for teaching in a reform-based way.

However, if one agrees that core beliefs are resistant to change, then the mid-program shift of teaching beliefs toward a student-centered perspective is surprising. If these beliefs are foundational, then one would consider them to stay rooted in a traditional frame. It may be that these teachers are trying on the new ideas from the program coursework and are not invested fully in changing their beliefs. Yerrick et al. (1996) described similar outcomes and made the claim that teachers are able to assimilate the theories and practices from reform-based programs into their own set of beliefs, broadening their conceptions of teaching to include the ideas presented but not changing their own cognitive schema as a result. In other words, the teachers rationalize and resolve the messages from the program without changing their own practices. It is unclear from this study if this is, in fact, the case. By the end of the study, despite three years of immersion in contemporary theory and practice, the participants' beliefs did return to a traditional orientation as they entered the schools.

When examining the responses closely, an interesting distribution of beliefs emerges. The shift back toward a traditional perspective by the teaching phase comes from the abrupt shift of the two questions that relate to the teacher's instructional choices (How do you decide what to teach and what not to teach?) and assessment (When do you move on to a new topic?). When asked these questions during later interviews, the teachers reported that their choices were limited by the district curriculum and testing calendar. In the same way, the participants decided to move on when the district calendar/curriculum indicated it was time to do so. It seems clear that for these participants at least, school-based contextual factors that include district assessments and curricular guidelines were important factors in their responses to the questions asked by researchers. Rather than assuming that the program alone has had a limiting effect on the development of contemporary beliefs and practices of these teachers, it is important to recognize the importance of any dominant fo influencing their practice at the moment of the interview.

Mapping the beliefs of the teachers may not be the most important piece to come from this study, however. Another valuable contribution from this work is the recognition that teaching is a deeply personal activity in which the teacher must confront prior beliefs about teaching as they relate to expectations from a variety of sources, from program to school district expectations, as well as relate to the context of the students and overall school setting, which may be of the most importance (Wideen, Mayer-Smith, & Moon, 1998). In other words, making clear the complex and changing nature of influences that affect the teachers' instructional choices may be of prime importance. These factors include the participants' personal and professional background, the nature of the preparation program and their pathway through it, and the political, social, and demographical nature of their eventual placement in the schools as a beginning teacher.

BELIEFS ABOUT LEARNING: ON THE BALANCE BEAM

While the beliefs about teaching for the participants moved first toward a reform-based perspective and then back to a more traditional stance, the teachers' beliefs about learning were fairly consistent, with a slight trend toward a traditional approach by the first year in the classroom. There are a number of possible explanations for why this result occurred. First, the teachers are still actively constructing a working set of beliefs about learning. Most new teachers have little exposure to learning theory before entering preparation programs and so have little prior knowledge to work with when articulating their understanding of how students learn. The program coursework both explicitly (Knowing and Learning) and implicitly advances a constructivist stance on how children learn, and this orientation is most typically stated (albeit shallowly) by participants during the study. The responses may recognize the fact that students construct their own understanding, but tend to focus on explanation of the material presented, or on teacher/student relationships that are subjective in character. For example, Hal consistently remarks that "seeing the light bulb go on" in his students is how he is aware that they understand. Noelle and Walt speak of students making connections and being able to explain their ideas as key factors in student understanding.

PRACTICES OF TEACHERS: STANDING STILL

One of the goals of the preparation program is to create teachers who can design and teach inquiry-based lessons and "who understand and can involve students in science inquiry" (Program Brochure, p.3). One of the general premises at the inception of this study was that the participants would evolve through the program to enact inquiry-based practices, based on program mentoring from experienced public-school teachers and faculty, early field experiences in a variety of classroom settings, and supporting theoretical and content-based coursework. The findings from this study do not support the original hypothesis concerning the trend in practice for the teachers.

The overall practices of the teachers remained at a beginning/limited level for the duration of the study, despite the stated goals of the program and the teachers' own expressed visions of inquiry-based practice. There have been a number of studies that share similar results. Simmons et al. (1999) conducted a three-year study on the relationship between beliefs and practices of beginning teachers, and one assertion reported indicated that the professed student-centered beliefs about their teaching practice were incongruent with their observed practice, which had a strong teacher-centered focus.

Overall, the dichotomy between the participants' visions of their practice and their observed practice again reflects the complexity and importance of context when studying prospective teacher belief systems and their relation to the actual work in the field.

CONNECTION OF BELIEFS AND PRACTICES: RIGHT FOOT IN, LEFT FOOT OUT

Fang's (1996) synthesis of literature on the relationship between teachers' beliefs and practice provides evidence from previous research that there is often a reported inconsistency what the teachers report in their interviews and the instructional decisions they make in the classroom. Fang listed a number of constraints that may impede teachers' enacting their vision of contemporary science teaching. These constraints included issues of classroom management, differentiating instruction to meet the needs of all learners, school and classroom culture conflicts, and district evaluation.

In a study related specifically to beginning secondary science teachers, Roehrig and Luft (2004) explored constraints experienced by teachers on implementing reform-based lessons. Results from this study found five constraints that prevented inquiry-based practice. These were knowledge of the nature of science and science as inquiry, content knowledge, pedagogical content knowledge, teaching beliefs, and classroom management. Perhaps the greatest impediment to the teaching with an inquiry framework is the lack of control over the curricula present in all of the classroom settings.

This is most apparent in Noelle's responses. Noelle was more advanced in her understanding of contemporary teaching from her previous experiences as an education student at a different university. Her beliefs about teaching and learning quickly aligned with a responsive perspective as she began her program coursework. Noelle's early field experiences and student-teaching observations reflect a beginning/proficient teaching orientation with inquiry. Noelle clearly understood the tenets of a constructivist classroom and was able to articulate those to the interviewer. However, her practice abruptly changed when she entered the classroom. Suddenly, the constraints of time, the calendar, and pressure from her supervisor to conform to a pre-established textbook-driven curricula left Noelle frustrated with how she believed she should teach and how she ended up teaching. It may be that Noelle was not prepared well to deal with the typical day-to-day tasks of teaching. Noelle and the other participants may leave the program with a good understanding of constructivist theory and general teaching strategies, but may lack the skills and background to work within the context of their individual school. The attention participants must pay to covering a wide array of content and following a strict calendar timeline appears to be a major constraint for the successful implementation of contemporary teaching in their classrooms.

CONTEXTUAL FACTORS THAT INFLUENCE THE FORMATION OF BELIEFS AND PRACTICES

The preparation program is designed to provide a collegial, supportive environment with rich field experiences, strong content courses, technology integration, and ongoing assessment and professional development (Program Mission Statement, 2006). As a part of the interview process, participants were asked to bring artifacts and speak about courses and experiences that contributed or did not contribute to their growth as science teachers. During these conversations and the artifact collection, a number of contextual factors emerged.

Modeling Good Science Teaching

Unfortunately, for both the field experiences within the program (early field experiences and student teaching) and first-year positions, mentors with an inquiry-based science-teaching focus were not generally available for the participants. Chris and Jan both had mentors whose beliefs about teaching and learning were didactic in nature. Noelle felt constrained by her mentor's classroom environment and struggled with little support. Hal and Walt both had mentors who were supportive of inquiry-based instruction but did not implement it themselves. This is problematic for two reasons.

First, it is clear that the relationship with the mentor teacher is crucial for beginning teacher socialization. Zeichner and Gore (1990) referred to this as group socialization and stated that induction into the subject (science teaching, in this case) is also induction into the culture of that subject, and that culture carries certain assumptions about the role of teaching and learning (p. 13). Enculturation into a contrary worldview that is separate from the goals and objectives of the preparation program may be one important factor in why the participants' beliefs and practices return to a traditional orientation so quickly after leaving the program. After all, it is hard enough to change beliefs and practices, but to attempt to do so in a context that actively or passively does not support the effort may well be insurmountable.

The second problematic issue concerns correct modeling of the concepts and strategies necessary for inquiry-based practice. The teachers may have never seen (or recognized) an experienced teacher lead a successful inquiry-based lesson that addresses science content. With a lack of good examples, it is easy to see how the teachers in this study might mistrust the classroom application of the theory. In other words, the “Do as I say, not as I do” dynamic may foster the idea that inquiry is useful only as a theory.

Testing

McNeil and Valenzuela (2001) reported that the testing system in Texas adversely affects teachers’ curricular choices and instruction in Texas public schools. The pressure from administrators and school districts to raise student test scores leads teachers to spend valuable class time drilling students on practice exam materials as well as supplanting or replacing course curricula with test-prep materials that have little relevance to subject matter. In some cases, especially in low-performing schools, this test-preparation curriculum has *become* the school curriculum. Teachers are required to teach fragmented, isolated skills that lack relevance and meaning for the student (p. 5). Teaching in this manner clearly constrains any student-centered teaching beliefs that the teachers in this study held. In Texas and other states with high-stakes testing and harsh controls on teacher creativity and self-governance, teacher preparation programs with strong inquiry-based approaches are no match for the district and state mandates that dominate especially in urban areas with the greatest need for relevant, innovative science teachers.

Theory and Practice

Joram and Gabriele (1998) studied the beliefs about teaching and learning of 53 prospective teachers enrolled in an introductory educational psychology course. One of the central beliefs shared by respondents from this study was that university coursework had little to offer, and that the most valuable experience for professional development came from field experience (p. 179). In an earlier study, Book et al. (1983) found that preservice teachers believed that field experience ranked above content area coursework, teaching methods courses, and educational psychology courses that addressed theories of child development and learning. The findings from this study seem to echo these sentiments. In part, this perspective may be driven by the concerns that the teachers have about teaching. Fuller (1969) set the groundwork for a developmental model of teacher development that relies on a series of stages to chart the professional growth of teachers. Beginning teachers often focus on survival, and this may fuel their perception that practical knowledge trumps theory.

Subject Matter Knowledge and Teaching

The responses of the teachers in this study seemed to place content knowledge and pedagogy on two distinct pedestals. On one platform, the teachers see the importance of a strong content background and recognize the importance of being an expert in their field. On the other platform, the teachers see their development as “teacher,” and this vision seems to consist primarily of pedagogical skills and knowledge. The responses garnered during the interviews may also have been focused on what the participant thought we wanted to hear. When asked what was important to their growth as a teacher that semester, the student may have decided that this was a “College of Education” question, not a “College of Natural Sciences” question, and responded with a pedagogy-rich response instead of one that recognized the contributions of subject matter to their professional growth.

Implications and Suggestions for Science Teacher Education

The results from this study have important ramifications for the preparation of secondary science teachers. The qualitative nature of this study has provided a rich and thick description of five preservice science teachers' beliefs and practices. While the interpretive nature of the inquiry prohibits generalizing the results beyond the context of the participants, there are some general comments that may serve to highlight what has been learned from this work as well as to provide directions for future study.

1. *Science teacher preparation programs should explicitly address and challenge teacher beliefs about teaching and learning*. Effective science teacher preparation programs recognize that future teachers come to the program with firmly entrenched beliefs and values about teaching. Feiman-Nemser (2001) remarked that "[e]xemplary preservice programs support continuity in preservice students' learning by providing a dynamic culture and a coherent curriculum, by monitoring students' personal responses to new ideas and experiences, and by offering an appropriate mixture of support and challenge in response to students' changing knowledge, skills and beliefs" (p. 1025).
2. *Conceptual coherence is crucial for programs in closing the perceived gaps among theory, subject matter, and practice*. In a review of Darling-Hammond's (2000) research on successful teacher preparation programs, Feiman-Nemser (2001) found that clear guiding values and beliefs gave the successful programs a directed purpose and an integrated sequence of courses. A strong conceptual framework provides a shared vision among university staff, faculty, and students, along with cooperating teachers and other community members. This framework can provide structure for the design and integration of coursework and the

inclusion of meaningful field experiences. At the program level, staff must craft a shared vision that can be used to build the sequence and framework of courses and other experiences. The theoretical framework of the program should then be shared repeatedly with participants and others involved.

3. *The development of partnerships with like-minded mentor teachers for both early field experiences and student teaching is critical*. Participants in the program are heavily influenced by their interaction with the "experts" in the field. It is critical to have a well-trained and conceptually aligned cadre of mentor teachers available for preservice early field experiences and the final student-teaching practicum. Based on the results of this study, the use of mentors who have gone through the program is not enough to ensure that a contemporary experience will be fostered and expected of the preservice teacher.
4. *Science teacher preparation must include modeling secondary science content within an inquiry-based context*. If we expect our students to move beyond a shallow appreciation for "hands-on" learning into a rich and thoughtful knowledge of how to think and teach in a contemporary way, then subject matter courses should model not only how to think in this manner, but how to teach in this manner. For example, students generally did not see the connection between the "research methods" course (specifically designed to address inquiry in the sciences) and their teaching. A stronger link must be forged between content courses and pedagogy. In contrast, both Chris and Noelle mentioned the value of learning physics through an inquiry-based framework (Physics by Inquiry) because they were both challenged to think of the content in new ways and were also carefully supported by the faculty.

Conclusion

This study contributes to the growing literature base that characterizes teacher beliefs about teaching and learning. It stands apart as one of the few studies that examines these beliefs longitudinally. The findings support studies that have shown the gap between theory and practice, the persistence of long-held beliefs, the complexity and multilayered nature of belief systems, and the importance of context when examining individual teacher change. In addition, the results from this study emphasize the dynamic interactions that occur among individual, preparation program, and school site as teachers learn the craft of science teaching. Future areas of study can help to add to the growing body of research in this area. Some of these areas are discussed below.

First, because these results ended at the first year in the classroom, little is known about whether the participants will continue to hold their current beliefs and practices or begin to align their beliefs about teaching and learning as they learn to manage typical beginning-teacher constraints and concerns. More longitudinal research is needed to explore the nature of teacher beliefs as they progress into the fourth or fifth year in the classroom.

Also, further research is needed on the relationship between strategies that encourage critical examination of teaching and teacher beliefs and practices. Current work with lesson planning, co-generative dialogue (see Tobin and Roth) and other teaching and research strategies that promote critical reflection may be useful to consider when challenging resistant teacher beliefs and practices.

Finally, the context was clearly an important factor that affected the teachers' beliefs and practices. More research would be welcomed that further explored the ways in which school environment, professional and school-related prior experience, gender, culture, and other factors influence the beliefs and practices of beginning science teachers.

It is hoped that future work in understanding the development of science teachers' beliefs about teaching and learning and the intersection of these beliefs with teacher practice will continue to uncover valuable insights into how prospective and beginning science teachers can best prepare students for a scientifically literate adulthood.

APPENDIXES

APPENDIX A: TABLES RELATED TO DATA ANALYSIS

Table A.1: Summary of data for cross-case analysis.

	Recruitment phase	why	Coursework phase	why	Teaching phase	why
Beliefs about teaching	Predominantly Instructive	Educ. backgrounds	Instructive and transitional	Impact of constructivist courses on responses	Bimodal: Strong return to traditional or remain at transitional	Impact of school climate on Q4, Q5
Beliefs about learning	Predominantly Transitional	Novice perspectives	Transitional and trend towards responsive	EFE's that support and require inquiry Supporting courses	primarily transitional with mix of traditional, instructive and responsive	Still dealing with concerns of self
Trends in beliefs	Stable with trend towards student-centered by second interview	New ideas from initial courses	Trend towards teacher-centered by student teaching	Impact of other concerns	Bimodal: Stable or trend towards teacher-centered by first year in classroom	Support from school and motivation to teach play role
develop-ing Practice	Expressed: limited Observed: beginning		Expressed: limited/proficient Observed: beginning/limited	Gap between expressed and observed	Expressed: Limited Observed: Beginning	NOS under-developed
Program Impacts	Community aspect of program important		Early Field Experiences crucial, want more hours do not see usefulness of advanced content courses, PBI not practical, Mixed reactions to courses based on instructors, K/L & Perspectives not		Student teaching want more hours, relationship with mentor Theory to practice gap Attention to special needs students / time management. Inquiry not practical - "fluffy". Constraints	

	connected to program	from curriculum/dept due to testing issues/standards

Table A.2: Summary of participant's profiles throughout study.

	Jan	Walt	Chris	Noelle	Hal
Personal and professional factors	Teaching in own high school. Strong links to local community and school. Values relationships with students.	Military Background. Older student. Interest in teaching to "make a difference".	Military background. HS teachers were important role models. Strict but supportive.	Came to program from other teacher prep program. Interest in teaching from strong content background.	Interest in field-based studies. Well established world-view.
Development of Beliefs about teaching	Began instructive and ended split between traditional and transitional. Teacher is a respected friend.	Shift towards traditional beliefs. Learning frustrated by theory to practice transition. Teacher is a guide to science.	Major shift towards didactic teaching. Teacher is a role model.	Teacher is a motivator. Shift towards teacher centered by classroom.	Stable teacher-centered beliefs. Teacher is a resource for students.
Development of beliefs about learning	Stable over time. Instructive/ transitional in nature.	Begin transitional, move to reform-based and then return to transitional. Learning means application.	Major shift towards didactic teaching.	Overall shift towards teacher-centered based on context of school.	Stable transitional beliefs. Learning is through experience with world.
Development of inquiry-based practice **Stable VNOS**	Little shift in practice. Expressed and observed both at beginning level. Stable VNOS.	Limited practice by observation, Proficient by expressed views. Stable VNOS.	Beginning level of inquiry practice. Limited level of expressed practice. Stable VNOS.	Shift to contemporary VNOS.	Gap between expressed and observed practice at end. Stable VNOS.

Impact of the program	Program was important for social reasons. Friends and community seen as biggest asset.	Practical nature was most important aspect. Opportunities to intern valuable Link from theory to practice weak.	Theory important, On fast track. Doesn’t see link between content and teaching.		Little impact by program on practice or beliefs. Personal and political factors play important role.

Table A.3: Profile of combined participant responses per belief category.

Beliefs about teaching

	Traditional	Instructional	Transitional	Responsive	Reform-based
Interview 1	****	***** ***** *	****		
Interview 2	**	***** ***	***** *****		
Interview 3		***** *****	***** *	****	
Interview 4	***** ***	****	***** ***		
Interview 5	***** ***** **	**	***** *		

Beliefs about learning

	Traditional	Instructional	Transitional	Responsive	Reform-based
Interview 1		****	***** *****	*	
Interview 2		*	***** ***** *	***	
Interview 3		****	*****	*****	*
Interview 4	**	***	***** **	***	
Interview 5	**	****	***** **	**	

Note: Each "*" represents one coded response from the TBI. For example, the first upper left cell with three asterisks (Beliefs about teaching: traditional responses from the recruitment phase) refers to three individual responses that were labeled traditional during TBI coding during the first interview. This table was compiled to categorize the overall patterns of beliefs about teaching and learning from all participants in the three phases of the program. The reason for this was to learn in a general sense what trends might emerge for the cross case comparison of the sub-case data.

Table A.4: Comparison of Participant's Stable and Variable beliefs over the length of the study.

	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7
Jan	V⇨	S	V⇨	⇦V	V	S	V
Walt	V	⇦V	V⇨	⇦V	S	S	V
Chris	⇦V	⇦V	⇦V	⇦V	⇦V	⇦V	⇦V
Noelle	V⇨	S	S	⇦V	⇦V	⇦V	⇦V
Hal	S	V	V	⇦V	S	V	S

Note: The arrows refer to the direction of change. "⇦" refers to an overall shift towards teacher-centered beliefs by the study end. "⇨" refers to an overall shift towards student-centered practices by study end. "V" refers to variable beliefs that fluctuated during the study but ended within one category of the initial coding. "S" refers to beliefs that remained stable throughout the study (as defined in chapter 3). The shaded regions delineate beliefs about learning from beliefs about teaching (non shaded columns). The individual delineations (V,S etc) were made based on the tables of beliefs about teaching and learning created for each participant.

Table A.5: Level of practice for participants.

	Recruitment Phase		Coursework Phase		Teaching Phase	
	Expressed	Observed	Expressed	Observed	Expressed	Observed
Jan						
Beginning	X	X	X	*	X	X
Limited						
Proficient						
Experienced						
Walt						
Beginning						
Limited	X	X		X		X
Proficient			X		X	
Experienced						
Chris						
Beginning		X		X	X	X
Limited	X		X			
Proficient						
Experienced						
Noelle						
Beginning						X
Limited	X	X		X	X	
Proficient			X			
Experienced						
Hal						
Beginning		X		X		X
Limited	X		X		X	
Proficient						
Experienced						

* No observation data available

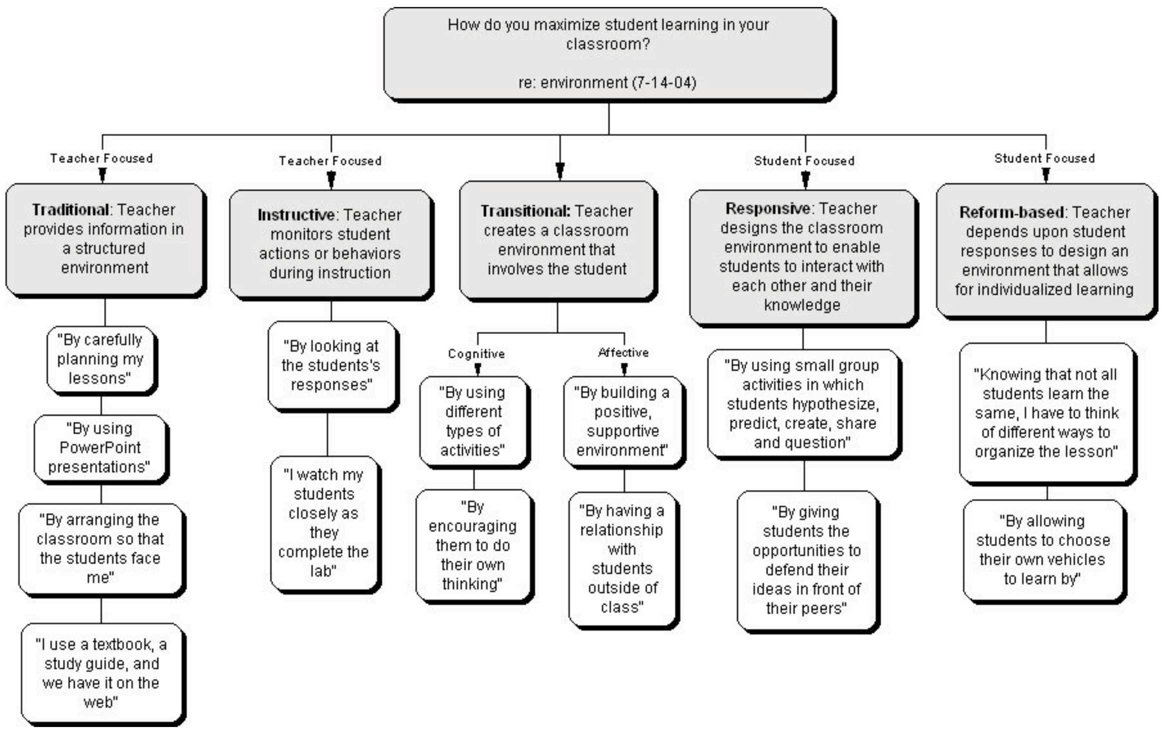
Table A.6: Summary of VNOS.

	Traditional	Contemporary	Naive
Jan			
Recruitment	**		******
Teaching	*	***	****
Walt			
Recruitment	****	**	**
Teaching	****	***	*
Chris			
Recruitment	***	**	***
Teaching	**	***	***
Noelle			
Recruitment	**	***	***
Teaching	*	******	*
Hal			
Recruitment	*	**	*****
Teaching	**	*	*****

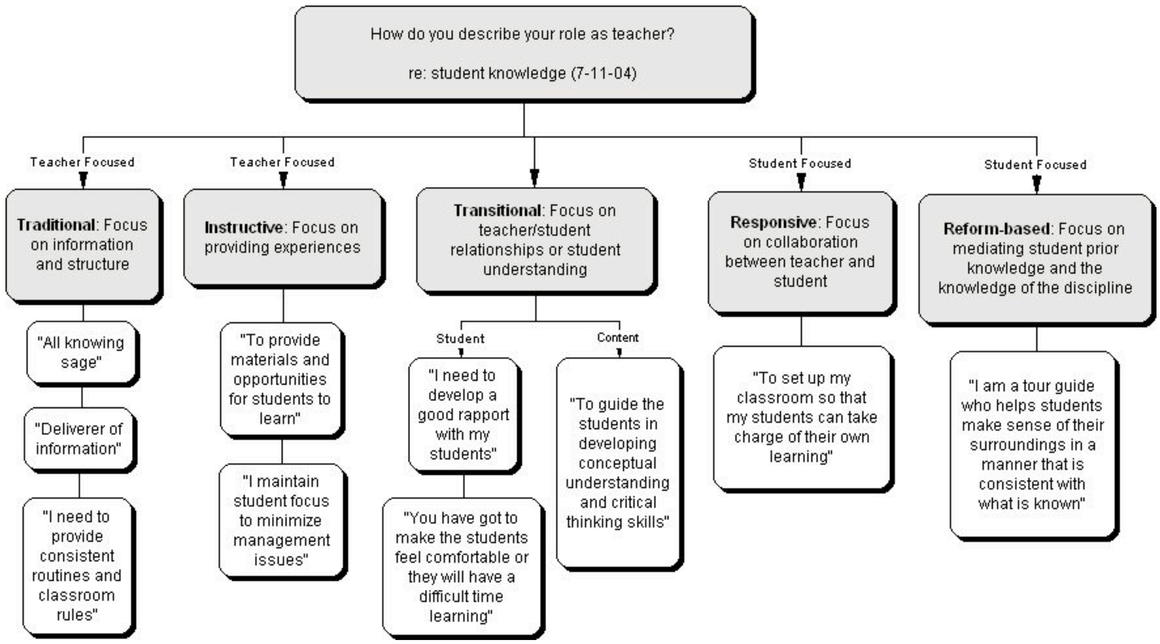
APPENDIX B: FIGURES RELATED TO DATA ANALYSIS

Figure B: Teacher Beliefs Interview Maps

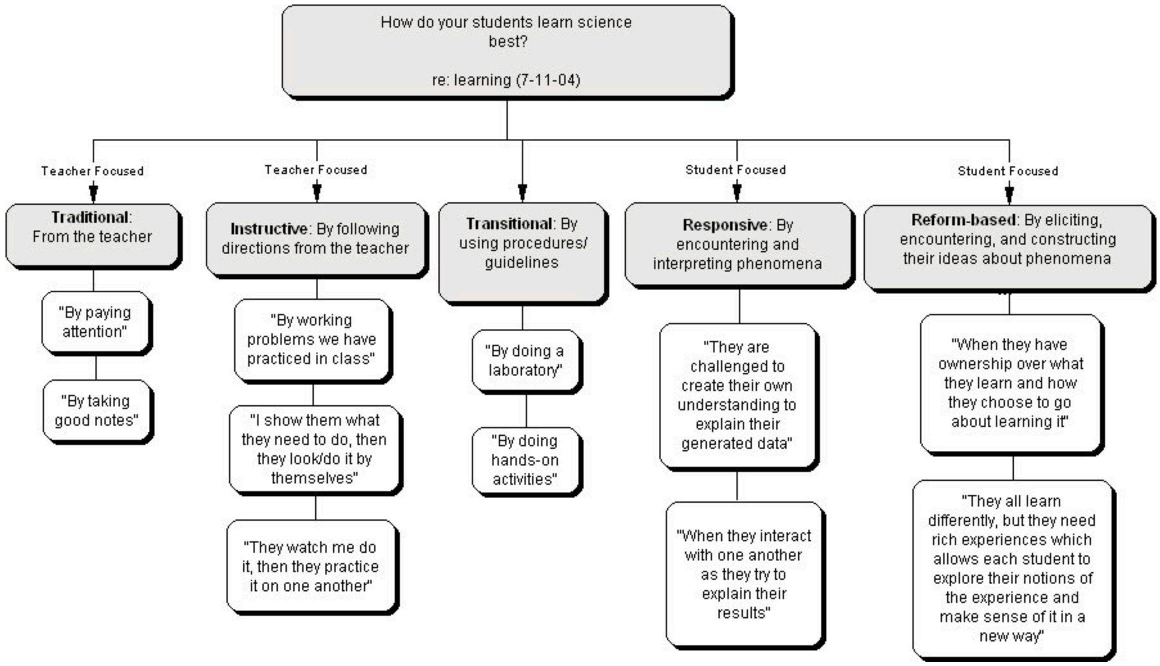
1. How do you maximize learning in your classroom.



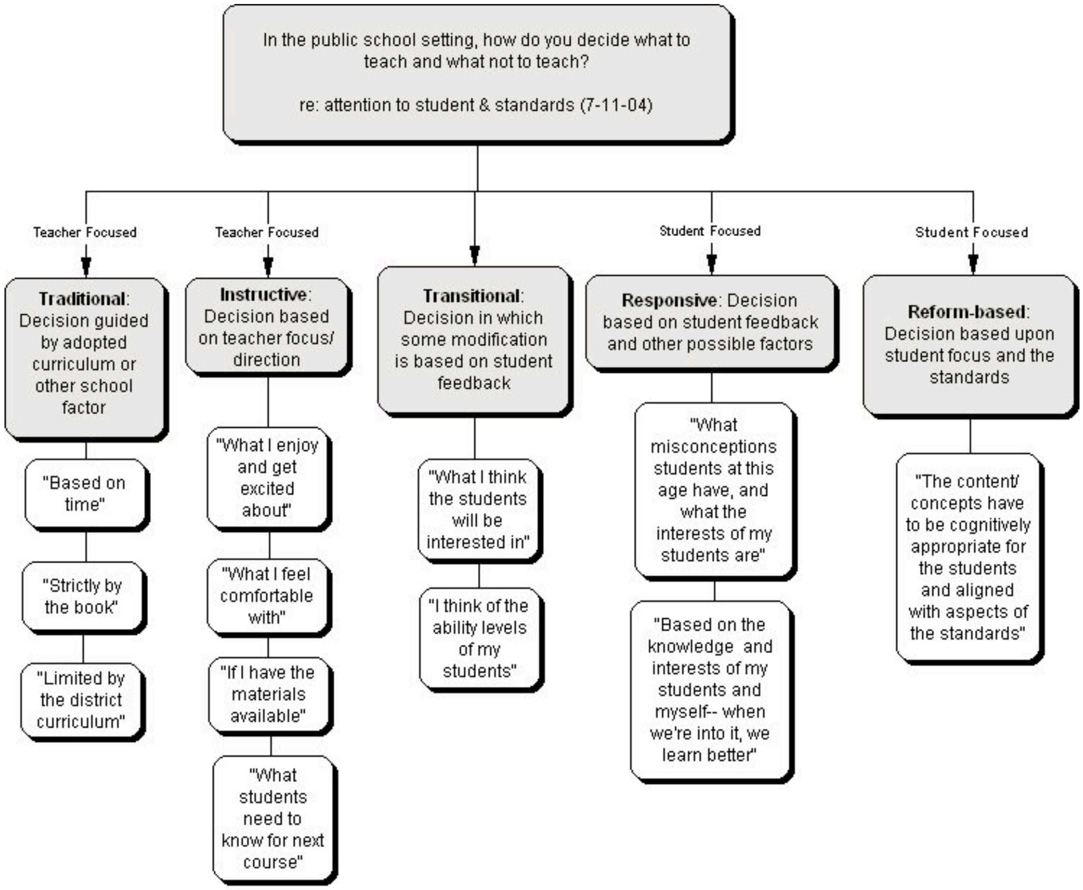
2. How do you describe your role as teacher?



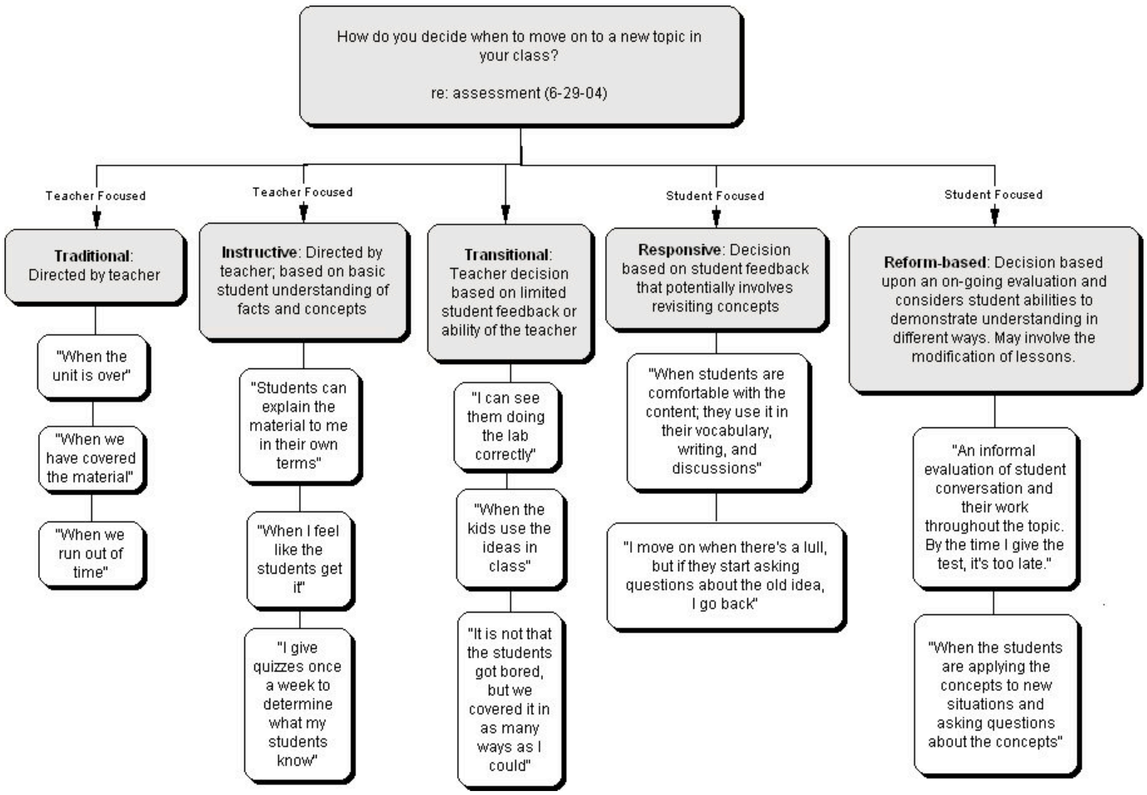
3. How do your students learn best?



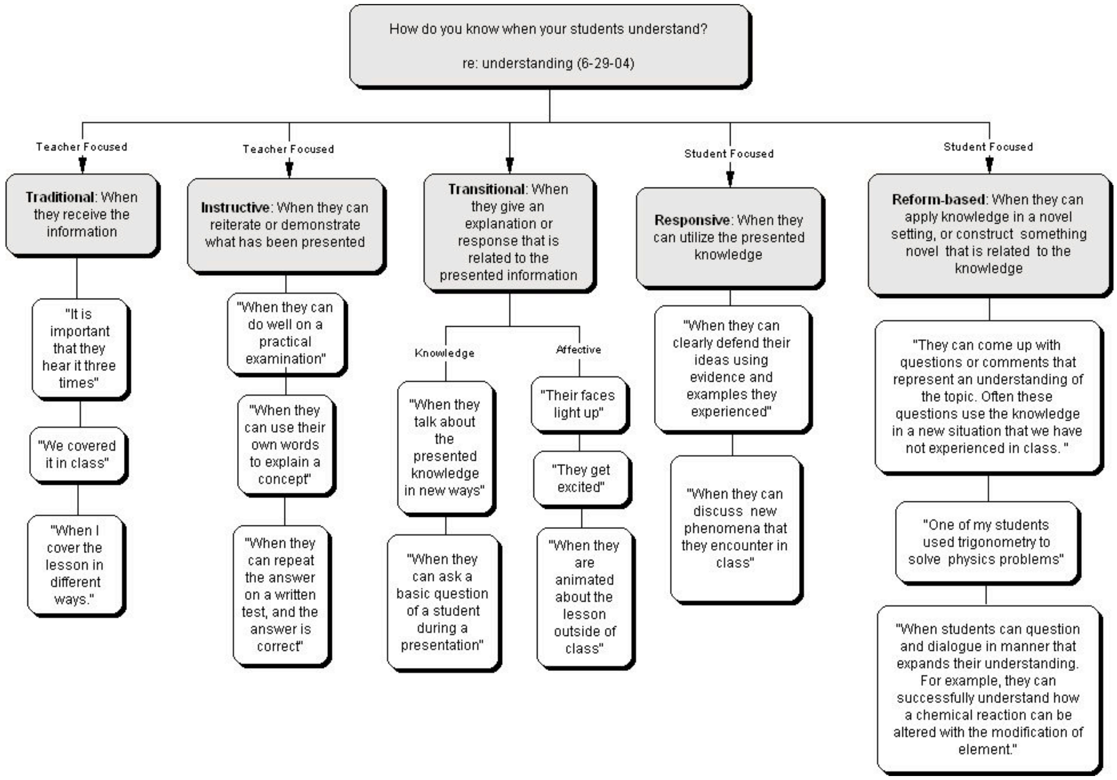
4. How do you decide what to teach and what not to teach?



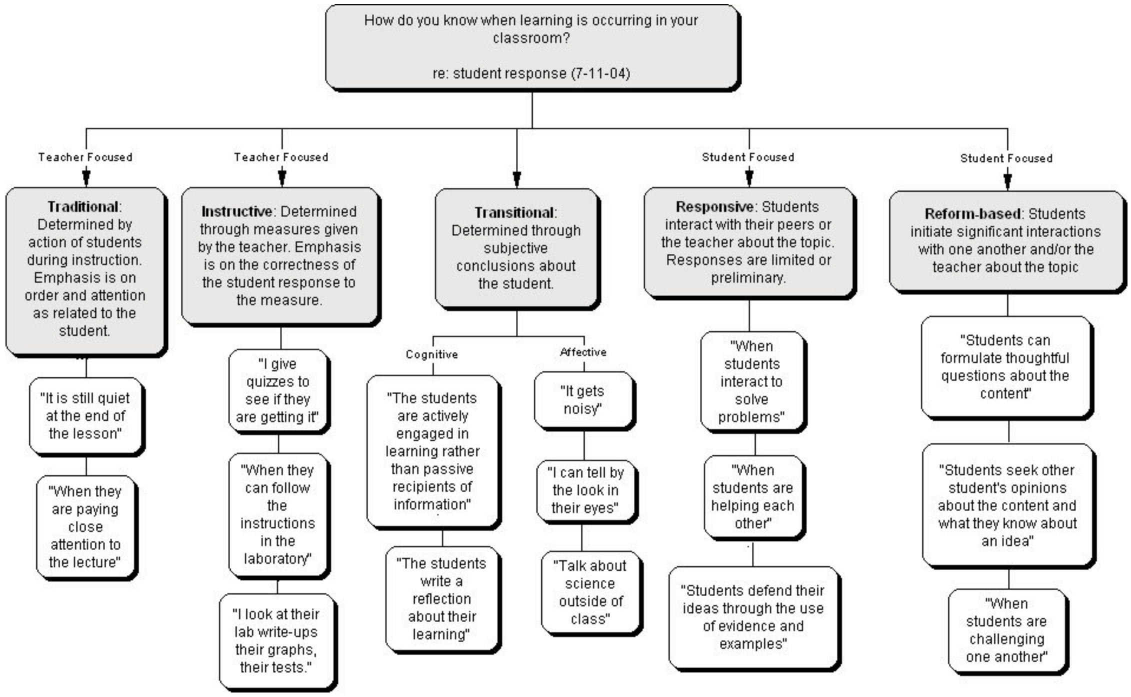
5. How do you decide when to move on to a new topic in your class?



6. How do you know when your students understand?



7. How do you know when learning is occurring in your classroom?



APPENDIX C: INTERVIEW PROTOCOL

Figure C.1: Initial interview protocol.

1. Where are you from originally? What year are you in school? Did you go directly to college or take time off? Did you come from community college?

2. How did you decide to come to UT? Did you have other options? What is your anticipated major?

3. Do you have a favorite course? What makes it your favorite?

4. Do you have a least favorite course? What makes it your least favorite?

5. How did you hear about the program?

6. How did you happen to enroll in STEP 1?

7. How do you think the program or other entities will assist you in becoming a teacher ?
8. Is there anything else you would like to tell me about the program or Step 1?

Figure C.2: General interview protocol.

1. Clarify where the person is in the program. Get information about what courses they are taking and his/her projected graduation plan.

2. If they brought documents, have them discuss the documents.

3. "Why did you select these?" "How does this help you to become a teacher?" "What role does this play in your learning about teaching?"

4. What was important to you last semester in terms of learning to become a science teacher?

5. What was not important to you last semester in terms of becoming a science teacher?

    a. What are you looking forward to this semester? Anything you are not looking forward to?

6. Is there anything else that you would like to tell me that I have not asked about that pertains to your learning to teach experience?

7. Other questions to get at their development as a teacher.

Figure C.3: VNOS questionnaire.

Instructions:
• Please answer each of the following questions. Include relevant examples whenever possible.
• There are no “right” or “wrong” answers to the following questions. We are only interested in your opinion on a number of issues about science.

1) What, in your view, is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g., religion, philosophy)?

2) What is an experiment?

3) Does the development of scientific knowledge **require** experiments?
- If yes, explain why. Give an example to defend your position.
- If no, explain why. Give an example to defend your position.

4) Science textbooks often represent the atom as a central nucleus composed of protons (positively charged particles) and neutrons (neutral particles) with electrons (negatively charged particles) orbiting that nucleus.
How certain are scientists about the structure of the atom?
What specific evidence, or types of evidence, **do you think** scientists used to determine what an atom looks like?

OR

4) Science textbooks often define a species as a group of organisms that share similar characteristics and can interbreed with one another to produce fertile offspring.
How certain are scientists about their characterization of what a species is?
What specific evidence, or types of evidence, **do you think** scientists used to determine what a species is?

5) Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example.

6) After scientists have developed a scientific theory (e.g., atomic theory, evolution theory), does the theory ever change?

• If you believe that scientific theories do not change, explain why. Defend your answer with examples.

• If you believe that scientific theories do change:
(a) Explain why theories change.
(b) Explain why we bother to learn scientific theories. Defend your answer with examples.

7) Scientists perform experiments/investigations when trying to find answers to the questions they put forth. Do scientists use their creativity and imagination during their investigations?

• If yes, then at which stages of the investigations do you believe that scientists use their imagination and creativity: Planning and design, data collection, after data collection? Please explain why scientists use imagination and creativity. Provide examples if appropriate.
• If you believe that scientists do not use imagination and creativity, please explain why. Provide examples if appropriate.

8) It is believed that about 65 million years ago the dinosaurs became extinct. Of the hypotheses formulated by scientists to explain the extinction, two enjoy wide support. The first, formulated by one group of scientists suggests that a huge meteorite hit the earth 65 million years ago and led to a series of events that caused the extinction. The second hypothesis, formulated by another group of scientists, suggests that massive and violent volcanic eruptions were responsible for the extinction. How are these **different conclusions** possible if scientists in both groups have access to and **use the same set of data** to derive their conclusions?

9) Some claim that science is infused with social and cultural values. That is, science reflects the social and political values, philosophical assumptions, and intellectual norms of the culture in which it is practiced. Others claim that science is universal. That is, science transcends national and cultural boundaries and is not affected by social, political, and philosophical values, and intellectual norms of the culture in which it is practiced.

- If you believe that science reflects social and cultural values, explain why and how. Defend your answer with examples.
- If you believe that science is universal, explain why and how. Defend your answer with examples.

APPENDIX D: INFORMED CONSENT FORM FOR PARTICIPANTS

Figure D.1: Student consent form.

IRB#2003-10-0164

SUBJECT'S CONSENT FORM

TITLE

Longitudinal study of UTeach students' beliefs and practices from Step 1 through their induction years.

I am being asked to read the following material to ensure that I am informed of the nature of this research study and of how I will participate in it, if I consent to do so. Signing this form I will indicate that I have been so informed and that I give my consent. Federal regulations require written informed consent prior to the participation in this research study so that I can know the nature and the risks of my participation and can decide to participate or not participate in a free and informed manner.

PURPOSE

I am being invited to voluntarily participate in the above titled research project. The purpose of this project is to understand how secondary science teachers change their beliefs and practices throughout their pre-service program and their first years of teaching.

SELECTION

I am being invited to participate because I am a student in a Step 1 class, in the UTeach program. Approximately 20 subjects will be enrolled in this project.

PROCEDURE

If I agree to participate, I will be asked to consent to two interviews per year about my beliefs about teaching and my experiences in the UTeach program that contribute to my development as a teacher. Once a year I will be asked to complete a survey about my understanding of the nature of science. I will also be asked to provide any documents that I consider important in my development as a science teacher. The interviews will take approximately 1 to 2 hours each, with the first interview longer than the others, and they will be taped. Completing the forms will take between 30-60 minutes.

RISKS and BENEFITS

There are no known risks or benefits.

CONFIDENTIALITY

Names will not be used in the transcription or in the written report. Once interviews are collected they will be numbered and a pseudonym (false name) given. This pseudonym will be used in the publication.

PARTICIPANT COSTS and SUBJECT COMPENSATION

There will be no cost to me for participating except for 5 hours of my time per year.
There will be no compensation for my participation in this study.
I can obtain further information from Steven Fletcher, M.Ed., at 232-6170. If I have questions concerning my rights as a research subject, I may speak to Dr. Lisa Leiden, Director of Research Support and Accountability at 471-8871.

AUTHORIZATION

Before giving my consent by signing the form, the methods, the inconveniences, risks, and benefits have been explained to me and my questions have been answered. I understand that I may ask questions at any time and that I am free to withdraw from the project at any time without causing bad feelings. My participation is this project may be ended by the investigator for reasons that would be explained. New information developed during the course of the study which may affect my willingness to continue in this research project will be given to me as it becomes available. I understand that this consent form will be filed in an area designated by the Human Subjects Committee with access restricted to the principal investigator, Steven Fletcher, or authorized representative of the Science and Mathematics Education Center. I understand that I do not give up any of my legal rights by signing this form. A copy of this signed consent will be given to me.

_________________________________ ________________________________

Subject's Signature Date

Investigator's Affidavit

I have carefully explained to the subject the nature of the above project. I hereby certify that to the best of my knowledge the persons signing this consent form understand clearly the nature, demands, benefits, and risks involved in his/her participation and his/her signature is legally valid. A medical problem or language or educational barrier has not precluded this understanding.

_________________________________ ________________________________

Signature of the Investigator Date

Figure D.2: Faculty Consent form.

IRB#2003-10-0164

Informed Consent to Participate in Research

THE UNIVERSITY OF TEXAS AT AUSTIN

You are being asked to participate in a research study. This form provides you with information about the study. The Principal Investigator (the person in charge of this research) or his/her representative will also describe this study to you and answer all of your questions. Please read the information below and ask questions about anything you don't understand before deciding whether or not to take part. Your participation is entirely voluntary and you can refuse to participate without penalty or loss of benefits to which you are otherwise entitled.

Title of Research Study:

Longitudinal study of UTeach students' beliefs and practices from Step 1 through induction years

Principal Investigator(s) (include faculty sponsor), UT affiliation, and Telephone

Number(s):

Steven Fletcher
Ph.D. Candidate, Science Education
232-6170

Jennifer Christian Smith , Ph.D., (Faculty Sponsor)
Assistant Professor- Curriculum and Instruction
232-6206

Funding Source:

None

What is the purpose of this study?

The purpose of this study is to examine the impact of preservice education and an induction program on the beliefs and practices of beginning science teachers. The induction years are the first three years of teaching. Approximately 20 students and 15 faculty and staff will be enrolled in this project.

What will be done if you take part in this research study?

I will be asked to submit copies of my syllabus and handouts and participate in short interviews that will be audiotaped during the academic year. During the interview I will be asked questions about my work as a teacher and role in Uteach. The questions will primarily provide background information about me.

What are the possible discomforts and risks?

There may be risks that are unknown at this time.

What are the possible benefits to you or to others?

There are no known benefits for participation. Your participation may benefit others by increasing the knowledge base about beginning science teachers, thereby enabling the creation of better teacher preparation programs.

If you choose to take part in this study, will it cost you anything?

There is no direct cost for participation other than time for which you will not be compensated in any way. The interviews will take the most amount of time as each interview will take approximately 1 hour. The possible total time is 2 hours per year.

Will you receive compensation for your participation in this study?

I will receive no compensation for my participation in this study.

What if you are injured because of the study?

No treatment will be provided for research related injury and no payment can be provided in the event of a medical problem.

If you do not want to take part in this study, what other options are available to you?

Participation in this study is entirely voluntary. You are free to refuse to be in the study, and your refusal will not influence current or future relationships with The University of Texas at Austin and/or participating sites.

How can you withdraw from this research study and who should I call if I have questions?

If you wish to stop your participation in this research study for any reason, you should contact: Steven Fletcher at (512) 232-6170. You are free to withdraw your consent and stop participation in this research study at any time without penalty or loss of benefits for which you may be entitled. Throughout the study, the researchers will notify you of new information that may become available and that might affect your decision to remain in the study.

In addition, if you have questions about your rights as a research participant, please contact Lisa Leiden, Ph.D., Director, Office of Research Support and Accountability, (512) 471-8871.

How will your privacy and the confidentiality of your research records be protected?

Authorized persons from The University of Texas at Austin and the Institutional Review Board have the legal right to review you research records and will protect the confidentiality of those records to the extent permitted by law. If the research project is sponsored then the sponsor also has the legal right to review your research records. Otherwise, your research records will not be released without your consent unless required by law or a court order.

If the results of this research are published or presented at scientific meetings, your identity will not be disclosed.

The syllabi, handouts, and interview will be coded so that no personally identifying information is visible on them. They will be kept locked in a file cabinet in the investigator's office. They will be used only for research purposes by the investigator and her associates. They will be destroyed seven years after the completion of the study.

Will the researchers benefit from your participation in the study?

Other than presenting or publishing the findings of the study, the researchers will receive no benefit from your participation in this study.

Signatures:

As a representative of this study, I have explained the purpose, the procedures, the benefits, and the risks that are involved in this research study:

Signatures and printed name of person obtaining consent **Date**

You have been informed about this study's purpose, procedures, possible benefits and risks, and you have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time. You voluntarily agree to participate in this study. By signing this form, you are not waiving any of your legal rights.

Printed Name of Subject **Date**

Signature of Subject **Date**

I hereby give permission for the audiotape made for this research study to be also used for educational purposes.

Signature of Subject **Date**

Signature of Principal Investigator **Date**

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