IN THROUGH THE SIDE DOOR: A PORTRAIT OF THREE SECOND CAREER
SCIENCE TEACHERS

by

RACHEL ANNE DIGIOIA WILLIAMSON

(Under Direction the of Deborah J. Tippins)

ABSTRACT

The demand for certified science teachers continues to be a challenge for school systems. One strategy used in many states to address this need is to expedite placement of individuals with science backgrounds into science classrooms through alternative certification programs; this constitutes a second career for many of these individuals. Although these programs vary, the consistent feature of alternative certification programs is to place people into the classroom in a shorter period of time and with less preparation. While studies of the effectiveness of alternative certification programs have been done, lacking is data regarding the life stories and teaching beliefs of second career science teachers.

This study explored the beliefs with regard to science teaching and learning of three second career science teachers as viewed against the backdrop of their life stories and career paths. What emerged from the study was a complex tapestry, composed of four interwoven strands: 1) a life long love of science and academic achievement, 2) career experiences that prompted a career change; 3) beliefs with regards to science teaching and learning; and 4) challenges faced as they completed the journey from the world of science to the world of school science. The tapestry was woven using the methodology of oral history and case study. Data collection methods included: historical timelines, autobiographies, teaching metaphors, journals, life learning maps, photoessays, semi-structured interviews, and case narrative stories.

Through with-in case and cross-case analysis of data, themes composing the portrait of the participants emerged. Key themes emergent through data analysis and interpretation included: 1) completing the portrait, 2) the sci-evangelists, 3) adding to the passion, 4) finding my center, 5) to know is to teach/content is king, 6) misgivings on the passage, 7) paying the piper, and 8) why do I have to learn this?

Based on the emergent themes, I have proposed a certification program designed to meet the needs of people in a science career who desire to make a move to the world of
school science. The program, called the Residency In Science Education, addresses the issues raised by the participants throughout the study.

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DEDICATION

My dissertation is dedicated first to my family. My husband, James, who has encouraged me so much throughout the time I have worked on this project. He has been my friend, encourager, proofreader, and advisor. James spent many nights cooking and cleaning for the family so I could go back to school and embark on a goal such as this. I could not have accomplished this goal without his love and support.

This dissertation would not have been possible without help from my children, Franklin, Philip, and future daughter-in-law, Jennifer. Franklin and Jennifer spent numerous hours at the library for me, copying materials, finding books, returning books, etc. Their help and support is greatly appreciated. Philip encouraged me throughout this process and helped lift my spirits when the process seemed overwhelming.

Finally, this dissertation is dedicated to my colleagues who agreed to participate in this study. Their hard work throughout the data collection process demonstrated their desire to further the profession of science education. Any knowledge gained from this work is due, in large part, to their willingness and courage to explore and to share deeply held beliefs and very personal life remembrances. In a real sense, this dissertation represents their efforts to ease the journey for other scientists who wish to enter the world of school science.
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CHAPTER 1

INTRODUCTION

A chronic, reoccurring problem encountered by many school systems is a shortage in the number of certified teachers needed to meet the demands placed on the systems by increasing student populations; these shortages are often most acute in the areas of math, science, and foreign language. One effort designed to address this problem involves recruitment and employment of individuals with college degrees in areas other than education. These potential educators, often referred to as second career teachers, possess college degrees, specialized training, and career experiences that deepen the content knowledge they bring to the classroom that can enrich the instruction they offer students. What is lacking in the preparation of these individuals for the classroom is the pedagogical training and expertise necessary to effectively communicate their content knowledge to students (McDiarmid & Wilson, 1991; Wise, 1994). In an effort to meet the needs of these potential educators a number of alternative certification programs have been developed throughout the country (Cornett, 1986; Darling-Hammond, Hudson, & Kirby, 1989; Feistritzer, 1993; Feistritzer, 1999; Hassard 1989; Shannon & Bergdoll, 1998 and others). The teacher certification processes in place in each of the fifty states strive to insure a uniform, quality educational experience for America's youth by certifying that all educators possess the knowledge and skills needed for effective teaching and learning. Alternative teacher certification programs have a similar mission; they also seek to insure that capable individuals are instructing our young people through
a method by which individuals with advanced training and experience in their subject area can acquire the pedagogical skills needed to facilitate meaningful student learning.

The purpose of these alternative certification programs is twofold: 1) to meet the need for certified classroom teachers; and 2) to prepare individuals with college degrees and prior career experiences for the challenges faced by classroom teachers while offering a streamlined certification process that takes into account the prior content preparation of the individual (Denton & Morris, 1991; Hassard, 1989; Kirby, Darling-Hammond, & Hudson, 1989; Ludwig, Stapleton, & Goodrich, 1995).

Teacher Certification: The Historical Context

An Overview

The history of public education and teacher certification in the United States goes back to the 18th and 19th centuries and reflected an increasing move toward more training and preparation for teachers as well as an increasing degree of government involvement to insure that teachers were qualified to effectively educate young people. During Colonial times, schools in America were influenced both by traditions brought by the colonists from Europe and by the church (Dial & Stevens, 1993; Pulliam & Patten 1995). The development of education in America during the colonial period occurred along three lines: 1) the role of government in the education of children; 2) the role of religion in public education; and 3) the principle of equality in education for all children (Butts & Cremins, 1953). At the outset of the colonial period, education was the primary responsibility of the church. As American political thought grew to embrace the concepts of personal liberty, representative government and separation of church and state, American educational philosophy evolved in concert to mold the schools in reflection of
these ideas; this development occurred along three lines. The move toward the concept of separation of church and state led to less church influence on schools and to educational goals that focused on more secular and scientific knowledge. Citizen control of government led to the idea of citizen control, through a representative government, of schools. Finally, the concept of personal liberty led to the idea of equal opportunity for all citizens in terms of educational opportunities. These trends were slow to develop and did not gain widespread acceptance until after the American Revolution (Butts & Cremins).

Post-revolution American educational thought continued to center on equality of educational opportunities, the demand for stronger academics, and the call for government support and control of schools. Education of children came to be viewed as vital to the interests of American society as a whole. That being true, then, it was necessary that the government provide a quality education for all children through governmental control and support. Even though the idea of governmental control to insure a quality education for all children became more accepted, through the first quarter of the 19th century there existed no formal requirements or certification programs for teachers; in fact, the only informal requirement was that a teacher be of good moral character. It was reasoned that if teachers were to work closely with children it was imperative that they be above reproach in terms of their actions and beliefs; it is interesting to note that no such imperative was felt with reference to the knowledge and skills possessed by the teacher. During the second quarter of the 19th century, there came calls for better training for teachers as public education underwent rapid development and, as a result, this increasing demand for better prepared teachers brought
about the establishment of institutions for the training of teachers. These teacher training
schools, or normal schools, were first used for training teachers who were already
teaching; they began to attract prospective teachers and broadened their scope to include
teacher preservice preparation. The normal schools issued the first true teaching
certificates and these certificates replaced the old moral certificates that had been in use
(Dial & Stevens, 1993). By the early 1900's requirements for certification had increased
to include items such as high school diplomas, normal school diplomas, and
examinations.

Following World War I a trend emerged which required teachers to complete four
years of college preparation before entering the classroom. In the 1930's teacher
education and certification were very unstructured, as highlighted by the 1933 National
Survey of Education of Teachers. According to Lazerson (1987) the results of this
survey indicated the following: 1) differences existed between the preparation of teachers
across diverse economic levels and geographic areas; 2) teachers in rural areas were less
experienced than those in urban areas; 3) public schools were staffed primarily by young,
unmarried women; and 4) inadequate preparation and transience in the field were
encouraged by low minimum age requirements. In general the education and preparation
of teachers for the classroom was inconsistent at best.

During the 1960's and 1970's teacher certification continued to be controlled by
individual states and there was no consistent set of requirements. The state programs did
agree there should be instruction in content area, in general educational practices, and
some subject matter specialization; there was disagreement concerning how much
instruction was needed in each area. Most states required a bachelor's degree while some
required a fifth year of preparation (Dial & Stevens, 1993). A study by Conant (1963) found that the states were consistent in their belief that the process of teacher certification was awkward and that the reason for this awkwardness was the philosophical disagreement between state departments of education and the colleges of education over the requirements of adequate teacher preparation. Another factor that affected the development of state certification procedures was the impact of professional teacher organizations (Dial & Stevens). The institution of practice teaching occurred as the result of a recommendation arising from the Conant study (Dial & Stevens).

In the 1960's some states developed and implemented alternative teacher certification programs as one method to address the need for certified teachers. These early steps toward alternative certification were temporary because in the 1970's the supply of teachers rose to meet the demand and there was no longer any need for alternative certification (Dial & Stevens, 1993). By the end of the 1970's however, the balance of supply and demand concerning teachers shifted toward the demand side once again as the supply of qualified teachers had decreased significantly. The decline in supply of qualified teachers led to further developments in the area of alternative certification for classroom teachers. Some states saw alternative certification as one method to quickly certify more teachers and as a more effective route to train and certify teachers (Feistritzer, 1994). The states of New Jersey and Texas were the first to establish alternative certification programs for classroom teachers; other states soon followed and by 1993, 41 states had established some form of alternative certification program (Feistritzer, 1994).
In summary, the trend toward alternative certification programs for teachers began as a response to an anticipated national shortage of teachers. These programs were designed to be short cuts through the maze of bureaucratic regulations that, to this day, surrounded state certification programs and were intended to provide a rapid increase in the numbers of classroom teachers. These plans tapped into a large pool of college educated adults who desired a career change and to whom the teaching profession offered an attractive alternative. As interest in alternative certification grew, political and educational leaders came to view these programs as one way to improve America's educational system.

Teachers certified in subject areas such as math and science, bilingual education, and special education continue to be in special demand (Cornett, 1990; Feistritzer, 1993; Feistritzer, 1994; Hassard, 1989). There seems little doubt that alternative teacher certification programs are attracting large numbers of qualified individuals into the classroom. Applicants to these programs number in the thousands and include highly educated, life-experienced adults who want to improve the education of our children; many agree with the alternatively certified teacher who stated, "I view my teaching as more than a job or a career; it is a calling, an avocation, and a dedication to the education of our youth." (Williamson, 1998).

Alternative Certification of Science Teachers

A number of states addressed the shortage of teachers in math and science by passing legislation that implemented programs that loosened professional education requirements to provide increased access to the teaching fields for individuals with degrees in those fields. The intent of these programs were fourfold: 1) to provide more
teachers in shortage fields such as math and science; 2) to allow arts and science graduates to enter the teaching field; 3) to remove barriers for career changers; and, 4) to end the monopoly on teacher education held by colleges of education (Cornett, 1990). A good example of the types of alternative certification programs that were developed was the plan begun by the State of Georgia. In 1990, then governor elect, Zell Miller, before taking office in 1991, called for "removing barriers to entering the teaching profession" and for streamlining certification for graduates who do not take education courses but who have subject matter expertise (Cornett).

There have been several studies of the Georgia 1988 Alternative Certification Program (Fox, 1989; Sisk, 1989; Guyton, 1989; as cited by Guyton, Fox, & Sisk, 1991). The Georgia 1988 Alternative Certification Program appeared to produce teachers whose efficacy compared favorably with that of traditionally certified teachers (Fox's study as cited in Hassard, 1989). The Georgia alternative certification model has provided an effective route through which people with strong academic backgrounds can enter the teaching field; the program has also attracted many individuals who have worked for several years as engineers, scientists or mathematicians in industry and government and who, for one reason or another, desire a change in career (Hassard, 1989). Most of the people involved in the Alternative Certification Program operated by Georgia State University in collaboration with the Georgia Department of Education reported they chose teaching as a second career because they: 1) wanted a chance to work with young people; 2) were interested in their subject field; and 3) felt that teaching was a way to communicate their interest to others (Hassard). A study by Darling-Hammond, Hudson, & Kirby (1989) found similar results.
For the purposes of this study, I define any person with a college degree and long-term career experience in a field other than education, who enters the field of education, as a second career teacher. In this group of individuals I include those who obtained certification through alternative certification programs and those who obtained certification through a graduate degree program; but, whose aim was only certification – not an additional degree. In this respect, the term second career teacher, rather than alternatively certified teacher, more accurately describes the participants in this study.

Purpose of the Study

There have been many published works concerning alternative certification, the effectiveness of these programs and the efficacy of the teachers entering the teaching profession in this way (Cornett, 1990; Guyton, Fox, & Sisk, 1991; Feistritzer, 1993; Feistritzer, 1994; Hassard, 1989). In addition, there have been numerous studies of the characteristics of individuals entering alternative certification programs, their career backgrounds and, their motives for pursuing teaching as a second career (Crow, Levine, & Nager, 1990; Kirby, Darling-Hammond, & Hudson, 1989; MacDonald, Manning, & Gable, 1994). However, there exists a lack of information concerning the teaching beliefs of second career science teachers who are alternatively certified; little is known about the effect of their previous career on the way in which they view science teaching and learning. The need for science teachers has resulted in an increasing influx of second career science teachers to the classroom. These second career teachers comprise a significant percentage of the population of science teachers and will likely increase over the next few years; therefore, it is important to explore the life and career experiences and their beliefs concerning science teaching and learning of this subset of teachers to gain
understanding of the life experiences they bring to the classroom. The purpose of this study was to explore how prior career and life experiences mediated the teaching beliefs of three second career science teachers. Specifically, the research questions informing this study included:

1) What are the life stories of second career science teachers?

2) Where is science in their life stories?

3) What beliefs do second career science teachers hold with regard to science teaching and learning?

4) What professional, cultural, and societal borders did these second career science teachers have to negotiate to successfully participate in the world of school science?

Theoretical Perspectives: An Overview

When considering the bodies of theoretical knowledge that form the foundation of this study, a dual structure emerged that included the theoretical framework for my research questions and the methodological framework that grounds the methods by which the research questions were explored. In other words, my theoretical framework represented the body of theory from which the research questions arose while the methodological framework represented the theoretical body of information that described the methods used to explore the research questions.

Literature in the field of Education presents a variety of definitions for the term "theoretical framework". According to Merriam (1998), the theoretical framework of a study is the structure, the scaffolding, and frame of the study. It represents a body of knowledge that serves as the basis for interpreting the data of the study; this structure
consists of theoretical understanding upon which new knowledge gained through this study will be interpreted and assimilated. For me, theoretical framework is similar to the frame of reference from which motion is measured. Einstein's theories describe the idea that a person's perception of motion depends upon their frame of reference or point of view. For example, from the point of view of the earth's surface, the stars as well as the sun appear to be moving across the sky; from a point of view in our solar system it appears that the stars and sun are fixed and the earth is moving. From a point of view outside the milky way galaxy it appears that the sun, stars, and earth are all moving. The explanation and understanding of the observations made depend upon the observer's point of view. In much the same way, the theoretical framework of a qualitative study serves as the point of reference by which observations are evaluated and some meaning assigned to the results. The framework, therefore, makes up the body of knowledge that serves as the vantage point from which to evaluate and interpret the results of a study.

The concept of theoretical framework also includes the researcher's academic discipline or orientation. Any research problem may be approached in various ways depending on what the researcher is looking for and the body of knowledge with which she/he is concerned. Schultz, as cited by Merriam (1998) stated that a theoretical framework guides the entire research project – from selecting the topic and research questions to the analysis and interpretation of data. Data can be analyzed in different ways to create different units of knowledge; the knowledge created from the data depends upon the researcher's orientation (Merriam). An analogy related to the construction industry serves to illustrate this point. The data represent bricks that can be used to build different types of buildings, for instance, a house, a church, or a factory. What is built
from the bricks depends on the builder's orientation, the architect's blueprints and the frame that has been constructed. In much the same way, the data from a qualitative study can be interpreted in various ways to create different understandings. The theoretical framework of a study, much like a building's framing, determines what types of understanding will be created by the researcher from the data. In summary, the choice of theoretical framework defines the way in which the data will be analyzed (Merriam & Simpson, 1995).

My theoretical framework has three main pillars: life cycle theory (as it relates to career change), border crossings, and teacher beliefs. The primary supporting pillar was life cycle theory. Supporting pillars were border crossings and teacher beliefs.

**Life Cycle Theory**

My study focused on science teachers who entered the teaching field after first having pursued a non-teaching career. Why did these people feel the urge to leave their first career? What factors were responsible for the sense of dissatisfaction that led these individuals to seek secondary careers? Much has been written (Levinson, Darrow, Klein, Levinson, & McKee, 1978; Super, 1957; Super, 1986, et al.) in the field of psychology on life-cycle changes and how the individuals making career changes view both themselves and their careers.

Life cycle theory holds that adulthood is not a plateau but is, in fact, a period of change. The period of adult growth and development has been described as a cycle during which an individual passes through various stages and confronts different issues and challenges (Kanchier & Unruh, 1988). Levinson et al. (1978) described a theory of adult development that stated that adults move through alternating periods of
development and transitions; every period presented a unique set of tasks to be mastered and challenges to be overcome. The transition periods were marked by the re-examination of needs and goals, reflection upon life components such as occupations and relationships, exploration and evaluation of available options for life components, and decision making concerning the future course of one's life (Levinson et al.). According to Levinson et al., developmental periods were typically 6 - 8 years long and transition periods generally extended for 4 - 5 years. The participants of this study have experienced alternating periods of development and transition in their professional lives. Following a period of professional growth and development in one career, each participant reevaluated their career goals in light of personal needs and perspectives; this reevaluation resulted in a career change and led them to careers as professional science educators. Therefore the perspectives that life cycle theory bring to adult growth and development will prove helpful in developing understanding of the life stories of these participants.

Borders Negotiated

As individuals leave a prior career and enter teaching, various borders must be negotiated in the transition. Certain challenges must be faced by any individual moving from one career to another; these challenges include returning to school to receive additional training and the reduction in salary associated with leaving one career to pursue training required for a second career. The participants' move to the world of school science required that they assume, once again, the role of student to acquire the additional training needed to complete the certification. With the return to student status, often came the reduction in income needed to support themselves and their families.
These challenges might be referred to as structural borders negotiated in the move to the world of school science. Another border, psychological in nature, involved the move from a professional scientist to student to novice science teacher. The participants had been actively engaged as professionals in a variety of science careers for all of their adult life. Through their careers they had acquired experience, expertise, and a degree of professional respect from coworkers. They had built a professional reputation in their first career and entering the science classroom meant that each participant was forced, once again, to build a professional reputation. This rebuilding process could be viewed as a psychological border for the participants. Other borders reflected epistemological differences. As professionals in a science career, these individuals had likely been educated utilizing an objectivist epistemology which holds that the universe has an underlying objective reality and meaning and that carefully planned scientific research can uncover that reality and meaning. Upon entering the field of science education, other epistemological theories concerning the nature of knowledge, such as constructivism and subjectivism, must be considered and integrated with prior belief systems. These differing views of knowledge may present a border that must be negotiated. Science seeks to uncover tangible and reproducible facts concerning the world and uses these facts to build theories and construct meaning; reality is outside the person in nature and must be discovered by observation and experimentation. Such an approach to the acquisition of knowledge could be described as positivist in nature. A person trained in science would most likely view student learning in a similar manner. As these participants took courses needed for teacher certification they were introduced to educational philosophies concerning the nature of learning such as constructivism, which
proposes that individuals construct their own knowledge based on their personal experiences and that knowledge is reality for them. These differing epistemological traditions presented a potential philosophical border for people trained in science entering the world of school science. Border crossing has been the subject of much research (Aikenhead, 1996; Aikenhead & Jegede, 1999; Costa, 1995; Phelan, Davidson, & Cao, 1991; et al.). This body of work has focused primarily on the boundaries students must cross when entering science classrooms. "The terms boundaries or borders refer to real or perceived lines or barriers between worlds" (Phelan et al., 1991, p. 2). These barriers consisted of cultural factors such as language, beliefs, and customs. These studies have identified various family, social, and cultural factors that affected the student's ability to adjust to school and achieve in the classroom.

A study by Crow et al. (1990) also examined the challenges faced by second career general education teachers as they progressed from one career to another; factors the authors referred to as mediating forces. These forces appeared to represent borders individuals had to negotiate to enter the teaching field. Among the forces described in Crow's study were the fear of inability to do graduate work, economic factors, concerns over being responsible for children's learning, and the need to assume a novice role after having achieved mastery in a field. The challenges, or mediating forces, identified by Crow et al., were analogous to be borders described by Phelan et al. (1991), Aikenhead (1996), and Aikenhead & Jegede (1999) in that each challenge represented a border between two sometimes congruent and sometimes divergent worlds.
Teacher Beliefs

Teacher beliefs comprised the third pillar that framed my research. Beliefs have been defined in numerous ways using a number of related terms such as beliefs, attitudes, perspectives, perceptions, and orientations. There exists a debate among educators concerning the distinction between beliefs and knowledge. Researchers such as Fenstermacher (1994) maintain that beliefs and knowledge are two separate and distinct constructs. Other researchers such as Tobin & LaMaster (1995) stated that beliefs are knowledge. There is considerable similarity between the terms knowledge and beliefs as used by Clandinin & Connelly (1987) in their concept of practical personal knowledge.

For me, beliefs and knowledge are two separate, but related constructs; there is no clear cut distinction between the two. Both constructs represent personal ideas or concepts about an entity; the difference seems to lie in the need for verifiability of the personally held concepts. A belief is something that one feels to be true in the absence of, and outside the need for, supporting evidence; whereas knowledge is information that is based on facts. The need for factual verification acts as a catalyst to transform beliefs into knowledge. If the beliefs a person holds about an entity are found to be supported by facts, then those ideas are better described as knowledge about that entity. In terms of the scientific method, a belief would be analogous to a hypothesis and knowledge would be analogous to the results of an experiment.

Despite inconsistent understanding of the specifics concerning the definition of the term "belief", there is general consensus with regard to the value of studying teacher beliefs in science education. Based on the results of their study, Oliver & Koballa (1992) stated that the following four elements are common to the various definitions of belief: a
relationship exists between belief and knowledge, through communication beliefs are acquired, action is prompted by beliefs, and there exists a range of beliefs from factual to evaluative. Tobin, Tippins, & Gallard (1994) maintain that "teacher beliefs are a critical ingredient in the factors that determine what happens in classrooms" (p. 64).

The study of teacher beliefs is important to researchers in the field of science education research because teacher beliefs appear to exert a significant effect upon how teachers teach. Teacher beliefs are formed from a variety of experiences including life experiences, school experiences, and experience with formal knowledge. My own research focused in large part on the beliefs held by second career science teachers, the body of knowledge concerning teacher beliefs served as an appropriate backdrop to interpret the data collected.

Methodological Framework: An Overview

Crotty (1998) described methodology as a "plan of action" (p. 7) linking the choice of methods with the overall goals for the research. This plan enables the researcher to select appropriate methods to collect data that is meaningful for the questions guiding a study. The methodology for this study grew out of the over arching goals of the study, i.e., 1) describing the life stories of second career science teachers, 2) exploring the beliefs of these teachers, and 3) uncovering convergences between the participants' first and second careers. My study, which represented a biographical study, drew upon aspects of life-history methodology and case study. This study presented a complex portrait of the lives of three second career science teachers, the role science, as a discipline and as a way of viewing the world, played in their life stories, the challenges faced and borders negotiated as they transitioned from one science related career to the
world of school science. Further, this study uncovered and elucidated beliefs concerning science teaching and learning these participants brought to the classroom. Finally, this study explored areas of convergence between the participants' life story, their experiences as a science learner, their first career experiences, and their beliefs concerning science teaching and learning. Life history methodology constituted one branch of my methodology for this study by guiding, connecting, and organizing the methods and procedures that are used to collect and analyze data concerning the life stories of the participants.

Case studies can be classified as either as a methodology or as a method of data collection. Marshall & Rossman (1995), Merriam (1998), and Yin (1994) viewed case study as a methodology. Stake (1994) viewed the construct as an object of interest, which may be investigated utilizing a variety of methodologies, for a particular study. Therefore, for Stake, the case study was what an investigator is studying, not the way in which the investigation was conducted. For me, case study represented more than the object of interest; it was a research strategy utilized to gain a rich understanding and to generate a thick, rich description of experiences of the participants in a study.

This study utilized data sources that included autobiographies, historical timelines, case narrative stories, life learning maps, semi-structured interviews, journal entries, teacher metaphors, and photoessays to investigate and to create a rich description of the life histories of the participants. As a photographer views her/his subject through the lens of the camera, life history methodology and case study served as lenses through which the data collection methods were developed and utilized.
Personal Biases

In the interpretation and analysis of data collected there is a risk that deeply held beliefs and opinions may consciously or unconsciously color the meanings gleaned from the data. With this in mind, it is important for me to identify, as completely as possible, the preconceived ideas and beliefs that I hold. In reflecting on this challenge, it seemed to me that my biases stemmed from three aspects of my professional and personal life experiences. One set of personal biases stemmed from my experiences over the past 25 years as a traditionally certified high school science teacher. Over these years, I have utilized many science teaching techniques and classroom management strategies. Some of these have worked well for me and some have not. My science teaching career might cause me to unconsciously judge data through the lens of my personal experiences, thus clouding any meaning that may be gleaned from the participants' individual experiences. In other words, my experience has resulted in an ingrained set of personal beliefs concerning science teaching and learning which may color the analysis and interpretation of the data gained from the participants. A second set of personal biases stemmed from my undergraduate training as an entomologist. My background has predominately been objectivist which may color my analysis of the data. In my science training research projects were begun with a definite question to be answered yes or no – a very closed ended type of process. The results of one experiment were used to plan further experimentation. My work represented a qualitative study of second career science teachers; therefore, the goal was to cast a wide net around the data so as to glean different meanings that may be present. The risk was that my analysis of the data may be too narrow and meaning may slip away undetected. A third set of biases stemmed from the
fact that my husband was alternatively certified as a science teacher fourteen years ago. I have intimate experience with his career change journey and the risk was that I would interject some of his experiences into the data obtained from the participants. If this occurred any meaning drawn from the data would be contaminated by experiences that were not a part of the participants' journeys.

Acknowledging my set of personal biases and recognizing the risks they present to correct interpretation and analysis of the data, it is my hope that my keeping these biases in the forefront of my consciousness and by reflecting upon my data analysis in light of the potential impact of my personal biases, I may minimize their effect upon the meaning gleaned from the data. Being consciously aware of the effect of personal bias upon my study I hope to quickly identify any other areas of bias that remain hidden from my present consciousness.

Summary and Preview

In this chapter I have presented an overview of the study. Chapter 1 began with a historical perspective on teacher certification, a brief history of alternative certification, and a description of the need for and purposes of the study. The specific research questions guiding the study were introduced. The theoretical framework and methodological framework which ground the study were briefly described. The set of personal biases which my color my interpretation were also presented and discussed. Chapter 2 highlights the salient literature regarding the history of teacher certification and alternative certification, as well as the theoretical framework that supports my study. My theoretical framework consisted of three pillars – life cycle theory, borders crossings, and teacher beliefs. Chapter 3 discusses the framework which supported the methods used to
collect and interpret data. This framework consisted of oral history and case studies.

Chapter 4 presents life stories of the participants as well as an in-case analysis of the data collected from each participant. Chapter 5 presents a cross case analysis of the participants' life stories and a discussion of commonalities and differences in the participants' data. Chapter 6 presents conclusions and implications of this study for science teacher education with respect to the preparation of second career science teachers. This chapter also proposes a model for a certification and training program for prospective second career science teachers. This model, called the Residency in Science Education (RISE), provides a certification program that more effectively meets the needs of second career science teachers based on the data gathered in this study.
CHAPTER 2

FOUNDATIONS OF THE STUDY:

REVIEW OF LITERATURE UNDERPINNING THE STUDY

Teacher certification: A historical context

Introduction

This study focused on the life stories and teacher beliefs of science teachers who entered the field of education as a second career; the pathway to the classroom led these "second career" teachers through non-traditional routes to obtain the certification needed to teach. The development of alternative certification procedures was fueled, in part, by the desire of state governments to facilitate the process by which individuals in a science related career who desired to teach could obtain the necessary certification. This chapter begins with a brief overview of the history of public education in America and the development of certification procedures designed to promote quality instruction in the nation's classrooms. The chapter continues with a description of the development of alternative certification programs and presents a discussion of the alternative certification programs for prospective teachers, including the programs developed in the State of Georgia. This chapter continues with a discussion of theoretical perspectives which guide and focus this study.

European Traditions

The educational system in America had its roots in Great Britain and Europe. Many aspects of our public school system, including such characteristics as educational
philosophy, teaching practices, and curriculum traveled to America from the "old
countries"; some of the challenges faced by American educators were also imported from
these locales. A major challenge faced by teachers in the colonies, which had its roots in
Britain and Europe during the 1800's, was the low esteem in which teachers were held by
the general population. During this period, teachers were regarded as the "dregs of the
population" (Peterson, 1962, p. 264). The low esteem in which teachers were held was
due in large part to the quality of person who was attracted to the teaching profession; "in
the South and Pennsylvania, itinerant schoolmasters were often portrayed as drunken,
foreign, and ignorant" (Kaestle, 1995, p. 20). The quality of the people interested in
teaching was influenced by the low salaries that were offered. "Society gets out of the
labor market what it wants and what it pays for" (Peterson, p. 263); therefore, the quality
of prospective teachers was low because the economic value placed on teaching by the
general population was low. Teachers in the 19th century often had to double "as farm
laborers, tavernkeepers, prospectors, and craftsmen." (Kaestle, p. 20). The result of such
opinions toward schools and teachers was twofold: 1) the caliber of person attracted to
the teaching profession was less than ideal, and 2) teachers were regarded as little more
than beggars subsisting on the alms of others (Peterson).

Opinions such as these served to highlight in the minds of educational reformers
the absurdity of entrusting the care of children to such low quality individuals and the
stupidity of regarding teaching as an activity that required no skills or qualifications.
Educational reformers in France and Prussia addressed this dilemma by instituting
requirements that no one be allowed to teach unless they proved themselves to be morally
and intellectually competent individuals and agreed to undergo some degree of training;
the French required prospective teachers to sign certificates attesting to their high moral character (Peterson, 1962).

Early American Foundations of Teacher Certification

The history of public education in America extends back to the colonial times and has been marked by increasing opportunities for the education of all members of society through increased governmental control and funding of schools, stronger emphasis on training of teachers, and ever-changing methods of teacher certification. During the 1700's, education in the United States was largely the responsibility of the church, family, and workplace (Kaestle, 1995). During this period in American history, three cultural patterns affected the development of the teaching profession: 1) the move toward representative government; 2) the weakening of established religions in face of the development of the idea of religious freedom; and 3) the emergence of a strong middle class in a capitalistic economic system (Butts & Cremins, 1953). As the idea of liberty and self-government spread, citizens developed mechanisms by which to govern their communities; responsibility and control over the education of the children in a community were natural outgrowths of the practice of self government. The idea of separation of church and state led to less and less church involvement in education. If the citizens were to accept responsibility for education through their local elected governments, then the constitutional requirement of separation of church and state required that there be no religious involvement. Community control of education required community support for the schools; the development of a strong middle class led to a source of tax dollars with which to support the schools.
The schools reflected these trends in their move away from the church and toward true "public schools" that were free of charge and were open to all children. A pioneer in the history of education in America, particularly in the development of state supported education for all citizens, was Thomas Jefferson; the idea of free education for all the populace can be traced his Bill for the More General Diffusion of Knowledge. Jefferson believed strongly in the value of education for the citizens of the new United States and that it was the responsibility of the government to provide an education for all its citizens. He wrote in a letter to George Washington, "It is an axiom in my mind that our liberty can never be safe but in the hands of the people themselves, and that too of the people with a certain degree of instruction. This it is the business of the state to effect, and on a general plan" (Urban & Wagoner, 2000, p. 70). However, Jefferson did not propose equal education for all citizens. His plan outlined in the bill proposed a two tract system of schools – one for common laborers and the other for the "learned". The average individual or common laborer would attend three years of elementary school, at public expense, where basic reading, writing, arithmetic, and basic concepts of republican government would be taught. Public funding for education would end at that point; however, families who could for afford to pay for additional education were free to do so. The second educational tract, also publicly funded, involved secondary schools which accepted the top student from each elementary school each year. Students selected for the secondary schools received an additional two years of instruction. The best students from each of the secondary schools were accepted to William and Mary where their education would be paid for by the public. Students from wealthy families were able to attend William and Mary, but without the use of public funds (Urban & Wagoner). In
addition, the Jefferson bill represented the beginnings of the idea of state control over state supported education in that his plan envisioned a state-wide curriculum supervised by the faculty of William and Mary (Kaestle, 1995). The development of our modern ideas of a state supported and state controlled, free education for all children can be traced to the Jefferson bill.

During the colonial period, the turnover rate among teachers was very high; wages were low and, as mentioned earlier, teachers often had to work other jobs to support themselves (Kaestle, 1995). For many of the teachers during this time teaching was a temporary profession held until marriage or another, more permanent job opportunity was available. The teachers' economic problem lay in the fact that the public, who was expected to pay for this educational system, was unwilling to spend large amounts of their own money to support the system. There was minimal formal training required to obtain a teaching position; community expectations had little to do with subject knowledge and teaching ability and were primarily concerned with the maintenance of a moral lifestyle. In New England, teachers were approved by town councils, school committees, and ministers; in the mid-Atlantic colonies they were approved by royal governors or religious groups while in the South they were approved by religious agencies, governors, or parish officials. There existed no formal requirements or certification program for teachers; in fact, the only informal requirement was that a teacher be of good character. Peterson (1962) states that the only teaching certificate required of teachers was a moral certificate in which a teacher declared that she/he would, among other things, become involved in church activities, refrain from conduct such as dancing and immodest dressing, promise not to encourage familiarity
with students, promise not to fall in love, promise to maintain a nutritional diet, sleep eight hours a night, and remain in good spirits. While the public had high expectations concerning a teacher's morality, there was little expectation concerning their level of training and knowledge; the popular thinking was that a teacher should know enough about their subject to pass on that knowledge to their pupils and there was little need for college training for teachers (Butts & Cremins, 1953).

The call for public schools required a shift in the funding of education for all children to governmental funding of education. Along with the move for public support for the school system was the call for public control of the nation's schools. Arguments offered in support for public control of education centered on two ideas: 1) if monies collected from the public were to be used to fund the schools it only seemed appropriate to have officials, elected by the public, to control how those funds were spent; 2) if the educational system was not controlled by elected officials there was the risk that private interest groups would take control and impose their teachings on students (Butts & Cremins, 1953). Educational reform in America in the 1800's centered on the idea of "the common school". The term common school referred to the idea that all children would be educated using one common curriculum. These common schools would educate younger children, would be free of tuition (usually paid for with property taxes), and would be open, with some exceptions, to all children (Urban & Wagoner, 2000). In addition, common schools were meant to develop the morality and ethics of children as well as prepare them for success in later life (Urban & Wagoner). The common school movement represented an effort to attract children of all economic and social classes into a free public school. The common school was not meant to be common in terms of
inferior; the education provided all children was meant to be the finest available (Kaestle, 1995). A quality education required teachers who were well prepared for the role of teacher (Urban & Wagoner). With the development of these schools came the need to develop procedures for the training and certification of teachers.

**Genesis of Teacher Preparation and Certification**

During the first half of the 19th century, the growth of public schools in the United States increased and, therefore, there was an even greater need for qualified teachers. The 1820's and 1830's saw calls for improvement in teacher training that resulted in the establishment of schools dedicated to teacher preparation. These training academies were referred to as "normal schools". Normal schools originated in Europe. The term "normal" meant that teachers would be trained to perform to high standards or "norms" (Kaestle, 1995). The normal schools were first used for training teachers who were already teaching and were limited to training elementary school teachers; as they began to attract prospective teachers their philosophy changed to include preservice teacher training and their scope extended to include the training of secondary teachers (Dial & Stevens, 1993). The typical curriculum of a normal school included theories of learning, child development, pedagogy, as well as common school subject material such as geography, history, and philosophy. Some schools, for example, The Academy at Canandaigua, New York, included lectures on "the laws of health, teacher's associations, schoolhouses and blackboards, also upon the teacher's social habits and duties as a member of the community" (Kaestle, p. 130 - 131). There was a debate as to the need for normal schools. Educational reformers such as Horace Mann were strong supporters of the normal school concept; while others such as the superintendent of the common
schools in the State of New York, John Spencer, considered the normal schools to be an unneeded and unnecessary expense (Kaestle). Irregardless of the debate, normal schools spread to the point that in 1898 there existed 127 public and 127 private normal schools (Tyack, 1967). The instruction offered students at a normal school was considered inferior to that available at other schools and perhaps the greatest impact of the normal school movement was to focus public attention to the need for well prepared teachers in American schools (Tyack). The development of normal schools accelerated near the end of the 1800's with the establishment of public normal schools in all of the states. The growth of normal schools was unable to meet increasing demands for trained teachers. As the 1900's began, school systems gave increasing emphasis on the quality of the teaching offered in their schools. This emphasis led to calls for increased education and training for teachers; training beyond that which the normal schools could provide. The demand for better educated teachers led the normal schools to expand their curriculum to offer four year degrees in education. The first such four year normal school was organized in Michigan in 1897; the school was named the Michigan State Normal College and it issued its first Bachelor of Arts degree in 1905. By 1920 there were 46 similar colleges and the number grew rapidly after that time (Butts & Cremins, 1953).

It was during the second half of the 19th century that teacher certification changed from lay certification, in which a citizen's committee was responsible for certifying and hiring a teacher for their community, to state certification boards; the normal schools issued the first true teaching certificates which replaced the old moral certificates (Dial & Stevens, 1993). By the 1890's public schools, especially in urban areas, had taken on the look and feel of modern schools; the schools had individual grade levels, school met nine
months a year, teachers were expected to have some formal training, and teachers had classrooms of their own. Courses of study and curricula set the standards of what students were expected to learn; report cards and homework were already standard practice. Rural schools were, for the most part, quite different. These schools were housed in older buildings and many were nothing more than one room school houses where students from five years of age up to young adults were taught by one teacher who was likely to have little formal training. By the early 1900's requirements for certification had increased to include items such as high school diplomas, normal school diplomas, and examinations.

Following World War One a trend emerged which required teachers to complete four years of college preparation before entering the classroom. By 1925, twenty-one states required teachers to be graduates of high school and to have received professional training to qualify for certification (Tyack, 1967). A knowledge of pedagogy was required for all state certificates and certificates were separated into elementary and secondary teaching levels (Tyack). The proliferation of schools of education made it possible to meet the demand for professionally prepared teachers; however, what developed could be described as a case of putting the cart before the horse. The educational reformers decided on state requirements for state certification; then college programs were established which met these regulations. "The pattern of teacher education thus became crystallized into legally fixed courses which differed from state to state but which were fairly uniform within the state" (Tyack, p. 419). The field of education, however, was not deemed worthy of respect by the general academic
community since teacher preparation was viewed as vocational training (Dial & Stevens, 1993).

In the 1930's teacher education and certification was very unstructured, as highlighted by the 1933 National Survey of Education of Teachers. According to Lazerson (1987) this survey, undertaken by the U.S. Department of Education, concentrated on inadequate teacher preparation, high teacher turnover rate, and the challenges faced by teachers in rural areas and in predominately black schools. Among the findings were: 1) public schools were taught primarily by young, unmarried women, 2) there were significant differences in teacher preparation in rural and urban communities, and 3) high turnover rate among teachers was caused primarily by teachers moving to larger communities and from elementary to secondary schools (Lazerson). Among the recommendations were: 1) the amount of educational preparation should be a minimum of two years of college for elementary teachers and four years for teachers in secondary schools, 2) the same standards should apply regardless of race, 3) school systems should provide adequate salaries, security of tenure, and appropriate retirement plans for all teachers (Lazerson).

During the 1940's and 1950's teacher preparation and certification systems continued to develop and evolve; however, like today, there were criticisms of these systems and the way in which they trained teachers. Critics claimed that teacher preparation emphasized more courses and requirements and did not improve teaching; the process of teacher education produced teachers who were ill equipped for success in the classroom (Tyack, 1967).
Well into the middle of the 20th century gross inconsistencies existed in the preparation and the certification of teachers. There were many colleges training educators but there was no consensus as to exactly what courses teacher candidates should take; nor was there agreement among the states as to the requirements for teacher certification. The state of teacher education for both primary and secondary schools was studied by J. B. Conant in 1963. In his study, Conant (1963) found that while there were over 1000 teacher training colleges awarding baccalaureate degrees, a problem existed in that there was no consistency between states in terms of the requirements for teacher certification. All state programs required a certain number of college courses; of that number, a certain number of hours must be instruction in professional education, and a certain number of hours in subject material specialization (Conant). The inconsistencies in content requirements were highlighted by a 1961 study of secondary school science and mathematics teachers conducted by the National Association of State Directors of Teacher Education and Certification and The American Association for the Advancement of Science. Among the inconsistencies found were differences in state requirements for number of content hours taken in college. The study revealed that 43% of biology teachers had less than 30 hours of coursework in biology in college, 67% of high school chemistry teachers had less than 30 hours of chemistry in college, and 79% of the 7th and 8th grade mathematics teachers had fewer than 30 course hours in mathematics. This study suggested that teachers were teaching subjects with which they were not intimately familiar (Conant). From the results of his study, Conant made three recommendations with regard to teacher certification: 1) states should require a baccalaureate degree, 2) the successful completion of practice teaching, and 3) that candidates hold a teaching
certificate from a college or university which attests to the fact that the person was adequately prepared to teach (Conant).

Beginnings of the Alternative Certification Movement

The alternative certification movement began in the 1980's as a response to a projected shortage of teachers entering the field of education (Crow et al., 1990; Dill, 1996; Feistritzer, 1993; Feistritzer, 1994). The National Center for Educational Statistics (NCES) projected that by 1992 the supply of new graduates from colleges of education would meet only two-thirds of the demand for new teachers (Feistritzer, 1993; Feistritzer, 1994). The shortage projection was based on three assumptions: 1) an increase in the enrollments of elementary and secondary schools; 2) a rise in attrition rates for teachers; 3) no increase in the number of education majors over the level that existed in the early 1980’s (Feistritzer, 1993; Feistritzer, 1994). Concerns over this teacher shortage prompted a few states to investigate and develop alternative programs through which people could obtain a teaching certificate. By law no person can teach in a public school without a legal teaching certificate; the specific requirements of teacher certification were the prerogative of each state and, therefore, certification programs varied greatly between the states. Some states viewed alternative certification as a way to circumvent the oftentimes awkward and circuitous teacher certification regulations and thus provide a larger pool of teachers at an expeditious rate. The states of Virginia and New Jersey led the nation in the creation and implementation of alternative certification programs (Cornett, 1990; Feistritzer, 1993). Some early programs brought teaching candidates into the classroom through the issuance of emergency certificates until the candidate could complete all the requirements for regular teacher certification. As these early
programs developed, they came to provide a means for noneducation majors to obtain teaching certificates.

Interest in alternative programs has waxed and waned throughout the 1980's and 1990's. Alternative certification programs were developed in response to a projected need for certified teachers; teacher shortages did not materialize and therefore, state departments of education saw a decreasing need for these types of programs. The expected shortage of certified teachers did not materialize in large part because there was misunderstanding by the researchers of the terms "new teacher" and "new teacher graduate" (Feistritzer, 1993; Feistritzer, 1994). It was assumed that the demand for new teachers to fill the expanded number of classrooms would be met exclusively by recent graduates from a teaching college, and therefore, the two terms were synonymous.

The state departments of education did not anticipate the large number of adults who, desiring a professional change, became interested in a career as a certified teacher. The large increase in demand for alternative certification caused rapid growth in these programs. By 1992, based on National Center for Education Information (NCEI) surveys, the number of states offering alternative routes of teacher certification had risen to forty and the number of teachers certified through alternative routes had risen from 20,000 in the years 1985 to 1990 to 40,000 by the year 1992 (Feistritzer, 1994). The increased demand for alternative certification seemed to stem from several factors. The first of these involved certain demographic trends in America that led to an older, more educated work force with fewer jobs to support them (Feistritzer, 1993). Feistritzer (1994) stated that the United States Bureau of the Census Reports revealed that the percentage of adults 25 years of age and older who had four or more years of college
reached 21.4% in 1991; this figure compares with 16.2% for the same statistic in 1980 and 10.7% for 1970. As the number of adults attending college grew, so rose the rate of unemployment and underemployment among persons who had attained a higher degree (Hecker, 1992). By 1990 the number of workers in the U.S. who were employed in jobs that did not require a college education had risen to 5.8 million workers from a total of 3.6 million in 1980 and 1.1 million in 1970 (Hecker). These statistics indicated that, by 1990, one in five adults with a college education were working in jobs that did not require a college degree. The trend of increasing underemployment of college graduates suggested that one reason for the large demand for alternative certification programs was the increasing numbers of college graduates attempting to find employment. The growing interest in the teaching profession came from several sources: educated individuals in other careers who now wished to teach, ex-military personnel who desired a second professional career upon retirement from the military, former teachers trying to re-enter the profession, and people who trained to teach but never entered the classroom (Feistritzer, 1993; Feistritzer, 1994).

A second factor that played a part in the development of heightened interest in alternative certification programs was the publicity and support given by the educational and political community; many political and educational leaders came to view alternative certification programs as a means of improving the quality of the teaching profession and thereby improving educational achievement among the nation's youth (Feistritzer, 1994). NCEI surveys conducted in 1987 and 1988 revealed that 85% of school board presidents, 82% of superintendents, 7% of public school principals, and 88% of private school principals favored certification programs for the inclusion in the teaching field of
individuals who had earned at least a bachelor's degree in a field other than teaching. In contrast, another NCEI survey, conducted in 1990, showed that 56% of public school teachers and 68% of private school teachers felt that the inclusion of such "second career teachers" would improve America’s educational system (Feistritzer, 1993).

In summary, the trend toward alternative certification programs for teachers began as a response to an anticipated, but unrealized, national shortage of teachers. These programs were designed to be short cuts through the maze of bureaucratic regulations that surround state certification programs and were intended to provide a rapid increase in the numbers of classroom teachers. These plans tapped into a large pool of college educated adults who desired a career change and to whom the teaching profession offered an attractive alternative. As interest in alternative certification grew, political and educational leaders came to view these certification programs as one way to improve America's educational system.

Today alternative teacher certification programs are attracting large numbers of qualified and enthusiastic individuals into the classroom (Feistritzer, 1994; Littleton & Holcolm, 1994). Applicants to these programs number in the thousands and include highly educated, life-experienced adults who want to improve the education of our children; many agree with the alternatively certified teacher who stated, "I view my teaching as more than a job or a career; it is a calling, an avocation, and a dedication to the education of our youth." (Williamson, 1998).

Alternative Certification of Science Teachers in Georgia

A good example of the types of alternative certification programs that were developed was offered by the State of Georgia. In 1990, then governor elect, Zell Miller,
before taking office in 1991, called for "removing barriers to entering the teaching profession" and for streamlining certification for graduates who do not take education courses but who have subject matter expertise (Cornett, 1990). In 1985, the State of Georgia passed the *Quality Basic Education Act* which gave the State Board of Education the authority to issue renewable teaching certificates to persons who had not completed a teacher preparation program (Cornett, 1990; Hassard & Jensen, 1988; Hassard, 1989). This law called for a subject matter degree, a one year internship, the assessments required for all teachers, completion of a college course related to human growth and development, and a course in the identification and education of children with special needs (Cornett, 1990; Hassard & Jensen, 1988; Hassard, 1989). The guidelines established by the State Board of Education for the program required 20 college quarter hours of credit in a specific area such as human growth and development, or the equivalent in staff development hours. To implement the program the Department of Education developed a document entitled *Alternative Certification Program for Critical Teaching Fields* (Hassard, 1989) that outlined the specific criteria for individuals desiring to obtain a teaching certificate in Georgia; these guidelines included a degree obtained from an accredited college or university, an overall grade point average of 2.5 on a four point scale, successful completion of the Teacher Certification Test, successful completion of a year long supervised classroom internship in the candidate's teaching field, a satisfactory completion of college courses, or the equivalent, in the areas of: 1) identification and education of children with special learning needs; 2) curriculum; 3) teaching methodology; and 4) human growth and development.
There have been several studies of the Georgia 1988 Alternative Certification Program involving mathematics, science, and foreign language teachers (Fox, 1989; Sisk, 1989; Guyton, 1989; as cited by Guyton, Fox, & Sisk, 1991). As cited by Guyton et al. (1991), the Fox (1989) study found that the Georgia program produced teachers whose teaching attitudes paralleled those teachers certified through the traditional route. The Sisk study (1989), as cited by Guyton et al. (1991) indicated, furthermore, that there were no differences between the two groups of teachers with regard to teaching efficacy (Sisk, 1989). Guyton et al. in a study of teacher attitudes, performance, and effectiveness of both alternatively and traditionally certified teachers, found similarities between both groups of teachers. These researchers concluded that alternative teacher certification programs that include a condensed program of pedagogy and supervised program of internship were as effective as traditional teacher preparation programs for those who hold degrees in the subject in which they wanted to teach. According to these researchers, the Georgia alternative certification model has provided an effective route through which people with strong academic backgrounds can enter the teaching field; the program has also attracted many individuals who have worked for several years as engineers, scientists or mathematicians in industry and government and who, for one reason or another, desire a change in career. Most of the people involved in the Alternative Certification Program operated by Georgia State University in collaboration with the Georgia Department of Education reported they chose teaching as a second career because they: 1) wanted a chance to work with young people; 2) were interested in their subject field; and 3) felt that teaching was a way to communicate their interest to others (Hassard, 1989). A study by Darling-Hammond et al. (1989) found that the three
most important reasons for entering the teaching field among those involved in the program were: 1) an intense interest in their subject area, 2) personal abilities that are well suited to teaching, and 3) the opportunity to work with young people.

**Alternative Certification of Science Teachers Nationwide: Current Trends and Issues**

Concerns continue over the need for teachers; it is thought that the demand for teachers will continue to grow since student enrollments are expected to increase. During the time that the student population is projected to increase, teacher numbers are projected to decrease due to the number nearing retirement age. Teachers certified in subjects such as mathematics and science, bilingual education, and special education are currently in special demand (Cornett, 1990; Feistritzer, 1993; Feistritzer, 1994, Hassard, 1989) and this trend is expected to continue. In the fields of mathematics and science, the attrition rate is especially high (Haury, 1998). Many states have experienced shortages of mathematics and science teachers; through the last decade, 67% of states have reported shortages in these areas (Darling-Hammond et al., 1989). A number of states addressed the shortage of teachers in mathematics and science by passing legislation that implemented programs that loosened professional education requirements to provide increased access to the teaching fields for individuals with degrees in those fields. The intent of these programs was fourfold: 1) to provide more teachers in shortage fields such as mathematics and science; 2) to allow arts and science graduates to enter the teaching field; 3) to remove barriers for career changers; and, 4) to end the monopoly on teacher education held by colleges of education (Cornett, 1990). A 1995 survey revealed that thirty-nine states had some form of alternative certification program (Buck, Polloway, & Robb, 1995). Today almost every state in the union has some type of alternative teacher
education program. These programs have similar requirements and similar designs. Requirements vary somewhat from state to state; but, in general at least a bachelor's degree and experience in the field the applicant wants to teach are required as well as a GPA of 2.5 in college course work is required. As compared to traditional certification programs, these programs required fewer hours of classroom work, generally six to twelve hours of educational coursework, and a longer period of supervised teaching (Darling-Hammond et al., 1989). Current alternative certification programs are designed to benefit both the school system and the applicant. School systems benefit in that newly trained teachers are put into classrooms more quickly. Teacher applicants benefit because the process of obtaining teacher certification is expedited. Current programs are designed to facilitate the career change process of adult career changer in several ways: 1) the course work required is lessened and often is offered at night so that a person can continue to work; 2) the neophyte teachers are placed into the classroom as salaried employees so as to lessen the financial burden of a mid-life career change; and 3) much of the instruction is "on the job training" and is more practical and applied in nature.

Listed below are summaries of the alternative certification programs offered by selected states, school districts, and universities.

One alternative program found in California teamed the Lawrence Livermore National Laboratory (LLNL) with San Jose State University to offer a teacher training program for scientists and lab technicians who were currently employed by LLNL but currently desired a move into teaching (Walker & Risacher, 1998). Employees were surveyed to determine the percentage that were interested in a career change to school science. Of the 4000 in the laboratory over 800 expressed a desire to teach (Walker &
Risacher). Through a lengthy selection process, a class of 24 students was formed. The class included 13 students with PhDs, 5 with Master's degrees, and 6 with B.S. Degrees (Walker & Risacher). Instruction was carried out by the science education program at San Jose State University. The program consisted of four content courses involving such subjects as methods of teaching, secondary school science, classroom management, and foundations of science education along with a student teaching component (Walker, 1998). The total program was four semesters in length. Throughout the four semesters there were numerous periods of observation and student teaching experiences.

In New Jersey, the genesis of an alternative program has occurred over the past 20 years. The program was developed to address existing teacher shortages and to attract talented men and women to the teaching profession. Teachers hired through this program were referred to as provisional teachers and so the program was named the Provisional Teacher Program. This program involved instruction in the areas of curriculum/evaluation, student learning and development, and classroom and school (Smith, 1991). In addition, all candidates completed a period of supervised teaching under the tutelage of a mentor teacher. Over the years there has occurred a convergence of both certification routes; to address the problem of attrition among traditionally trained teachers, in 1992 New Jersey began requiring all teachers to undergo the same mentoring process as provisional teachers (Klagholz, 2000).

In Pennsylvania, candidates for alternative certification must join what is termed "a collaborative unit" consisting of a public school and a teacher preparation program. The candidate has fifteen months to complete twelve hours of coursework that includes instruction in classroom management and effective teaching strategies. The program
leads to a professional certificate only after the coursework is completed, a certification exam is passed, and the candidate is recommended for certification by the collaborative unit. To be eligible, a person must have a bachelor's or graduate level degree in the subject area in which they will teach or they may have a bachelor's degree and ten years experience in the area in which they hope to teach (Gov. Tom Ridge, 2001).

Virginia Wesleyan College has established an evening program designed especially for "career switchers". Applicants must have earned a bachelor's degree, must have been involved for at least five years in a career related to the degree, passing scores on the Praxis I exam, and demonstrate computer literacy. There are separate programs for K - 6, and 7-12. Both programs involve college level courses in foundations of education, human growth and development, curriculum and instructional procedures, and the exceptional child. Both programs include a student teaching component (Alternative Certification for Teachers, 2001).

Hamilton County in Tennessee, in partnership with the University of Tennessee at Chattanooga, has established an alternative program by which an individual may obtain a teaching certification. The applicant must: 1) have a bachelor's degree, 2) agree to complete the program of study, 3) pass the Praxis I exam, 4) complete an internship, and 5) agree to teach in Hamilton County for five years after completion of the program. The applicant first spends one summer completing coursework in education and then teaches for one year working cooperatively with a mentor teacher and "an induction specialist". The applicant agrees to attend staff development activities and training sessions that are held throughout the year. Certification is earned upon recommendation by mentor teachers, administrators, and the University of Tennessee at Chattanooga staff and upon
completion of a second summer of coursework to address needs (Hamilton County Schools, 2001).

In Alabama, applicants for alternative certification must have earned a bachelor's degree, have documented 24 months of experience or specialized study in the field in which they desire to teach and must be assigned a mentor teacher by their prospective employer. Applicants must complete twelve semester hours of coursework that includes: classroom management, teaching and learning, inclusion of special needs students, and teaching methods. The applicant then teaches with an alternative certificate for three years; after three consecutive, successful years, they may apply for a regular teaching certificate (State of Alabama, 2001).

The State of Illinois has established two alternative methods by which a person may obtain a teaching certificate. The first, entitled "The Alternative Route to Teacher Certification" requires an applicant to have earned a bachelor's degree, to have been employed for five years in an area representing an application of that degree, and to have passed a basic skills and subject matter test. The applicant then completes an intensive course in educational theory, methods, and student teaching. The applicant must then teach for one year with the assistance of a mentor teacher. Upon completion of the teaching year and an evaluation of teaching performance, the applicant is issued a nonrenewable four-year initial teaching certificate. After four years, the applicant may apply for a regular teaching certificate. The second program entitled "Alternative Teacher Certification Program" is essentially the same as the first program with the exception that it involves a college program and the evaluation of the application is carried out by the college faculty (http://www.isbe.state.il.us/, 2001).
In Georgia, the alternative certification program has three components: 1) pre-assignment instruction, 2) induction, and 3) post assignment. Applicants for the program must hold a bachelor's degree, pass the Praxis I exam, and have a job offer as a beginning teacher. All applicants must successfully complete four learning modules during the pre-assignment phase of the process; these modules present instruction in planning and preparation for teaching, the classroom environment, instructional methods, and professional responsibilities. Candidates then are required to complete a two year induction period during which the candidate is observed and supervised by an instructional support team. The post-assignment phase of the program consists of workshops, modules, and support meetings designed to prepare the applicant for the Praxis II content exam (Alternative preparation program, 2001).

In the spring of 2001 the State of Georgia established a new initiative designed to address a continuing shortage of teaching professionals in the state. This program, entitled the Teach for Georgia Program, condenses and collapses the amount of classroom instruction required to obtain certification and represents a "classroom based preparatory option for individuals with the basic qualifications to teach in elementary, middle or secondary schools who have not completed a teacher preparation program" (Teach for Georgia, 2001). This program consists of an instructional phase offered the summer of 2001 that serves as an introduction to teaching, a job offer from a school system, and a two year classroom based induction training period that is completed as the applicant teaches.
Summary of Alternative Certification: A Historical Perspective

The history of teachers and teaching in America is a complex tapestry, woven from numerous threads, that unites many aspects of society as a whole. Included in the many threads that compose this tapestry are: 1) teacher respectability; 2) government supported schools; 3) increased teacher preparation and certification; and 4) the alternative certification movement. These four threads have been woven together by history into the complex tapestry that reflects the public school system in America today.

One thread in the history of teacher certification in America has been the search for respectability as reflected in terms of public opinion and level of compensation. American education had its roots in England and Europe; many aspects of our educational philosophy, teaching practices, and curriculum were imported from the Old World along with some negative attitudes concerning teachers and teaching that still hamper progress in the field of education today. One challenge faced by America's earliest teachers and today's educators as well is the inappropriately low opinion of teachers and teaching held by many of the citizens. A related challenge for educators is the relatively low level of compensation afforded teachers. One strand in the history of teacher certification in America has reflected the struggle to address these issues.

The history of teacher certification in America's schools also reflected a movement toward government supported education for all citizens. In the early days of our nation a child's education, if it happened at all, was the responsibility of the parents or the church and primarily consisted of religious training. In the United States, along with the idea of separation of church and state came the idea of state supported and controlled education that was independent of any religious or other special interest group.
Statesmen such as Thomas Jefferson were instrumental in the formation of an American educational philosophy. A second thread in the history of teacher certification in America has been the movement to provide a free education to all of our nation's children.

A third thread in the history of teacher certification in the United States was the increase in the preparation and training of the nation's teachers. Ideas concerning the need for teacher training have progressed from the thought that no special training was needed at all to a sophisticated level of preparation including the awarding of Doctoral degrees in education. Along with this movement have come changes in teacher certification. Over the course of educational history in America, certification has moved away from church or community approval based on a person's promise of moral behavior, to evaluation and certification of a person's level of knowledge in the subject area she/he is to teach and their expertise in the art and science of teaching. Along with improved certification procedures came improved teacher training schools; teacher training began with the normal schools and then spread to major universities. This thread in the history of teacher certification in America is reflected in the move to provide quality teachers for our nation's students through more stringent and effective methods of teacher certification.

A fourth thread comprising the tapestry of teacher certification in America concerned the certification of teachers through alternative methods. This movement developed in response to the perception of an increased need for teachers and the desire to bring into the classroom individuals with high levels of content knowledge. The
alternative certification movement has fulfilled a desire among many professionals of other fields to enter the classroom and work with the nation's youth.

Theoretical Perspectives of the Study

**Life Cycle Theory**

My study focused on science teachers who entered the teaching field after first having pursued a non-teaching career. Why did these people feel the drive to leave their first career? What factors were responsible for the sense of dissatisfaction that lead these individuals to seek secondary careers? Career transition has been defined "as the period during which an individual is either changing roles...or changing orientation to a role already held..." (Louis, 1980, pg. 330). As individuals age, they begin to perceive themselves and their occupations differently. Levinson et al. (1978) have explored various transition periods as individuals age. Levinson et al. determined that individuals go through periods where critical evaluation of their career and goals take place.

Levinson et al. (1978) viewed the cycle of a person's life as a process or journey that begins at birth and ends with death. A person's life cycle is marked by a series of four sequential, yet somewhat overlapping, developmental periods or stages which have defining characteristics and which extend throughout the entirety of the adult life. These stages are: "1) childhood and adolescence: age 0 - 22, 2) early adulthood: age 17 - 45, 3) middle adulthood: age 40 - 65, and 4) late adulthood: age 60 - ?" (Levinson et al., p.18).

Life cycle theory holds that adulthood is not a plateau but is, in fact, a period of change. The period of adult growth and development has been described as a cycle during which an individual passes through various stages and confronts different issues
and challenges (Kanchier & Unruh, 1988). Levinson et al. (1978) described a theory of adult development that states that adults move through alternating periods of development and transitions; every period presents a unique set of tasks to be mastered and challenges to be overcome. Each developmental period in the person's adult life is marked by the need "to make crucial choices, to create a structure around them, to enrich the structure, and to pursue one's goals within it" (Levinson et al., p. 317). The transition periods are marked by the re-examination of needs and goals, reflection upon life components such as occupations and relationships, exploration and evaluation of available options for life components, and decision making concerning the future course of one's life (Levinson et al.). According to Levinson et al. developmental periods are typically six to eight years long and transition periods generally extend for four to five years.

Increases in the numbers of people pursuing career changes have prompted research on why people change careers. Studies by Levinson et al. (1978) have shown that life cycle changes affect how individuals perceive themselves and their occupation and can lead some to consider changes in their career. Graham (1973) described career identity as one part of an adult's overall sense of personal identity. A person's sense of identification with their career goes through certain periods of development; Graham described these periods as commitment/immersion, mastery/involvement, and boredom/indifference. The commitment/immersion stage of occupational identity development is a period marked by commitment to the job which leads to a person to immerse themselves totally in their job. This immersion results in intense involvement in the tasks associated with the job, development of the skills needed to successfully
perform the job, and the creation of a sense of identity that reflects the person's involvement in the career. In the mastery/involvement stage, the worker acquires experience, attains excellence, and achieves a sense of accomplishment, enjoyment, challenge, and purpose. For an adult worker to maintain a sense of accomplishment, challenge, and enjoyment there must, according to Graham, be an expansion of work tasks, an enhancement of job responsibilities, or a shift to an alternative job situation. If the person is unable to expand or enhance her/his career situation, the involvement period is replaced by boredom and indifference to the job. One alternative for adults to avoid this period of boredom and indifference is to change to another career where this cycle starts over. Today, for adults to continue to grow, they must build a number of career identities throughout their lives (Kanchier & Unruh, 1988); Graham (1969), as cited by Kanchier & Unruh (1988), in a study of air traffic controllers in Los Angeles, found the average length of a healthy career identity to be five to eight years. Failure to maintain growth in career identity results in boredom, indifference, deterioration of job performance, and possibly hostility as the worker enters the disengagement stage of career identity (Kanchier & Unruh).

The traditional concept of career – holding the same job or a series of jobs with the same company – has evolved to include the trend toward multiple careers during the work life of an individual. Louis (1980) defined career transition as a time in a person's career where they are changing the focus of their current career or are changing from one career to another. Other researchers, Crow et al. (1990) cited Driver's (1980) categories of alternative careers; among the career alternatives that have been identified are the steady-state career in which an individual gains skills within a single field without
upward advancement and the spiral career in which an individual advances through many related and unrelated fields.

Other studies have focused on career change as it impacts the field of education (Crow et al., 1990; Stevens & Dial, 1993). One study by Crow et al. (1990) looked at a group of graduate students at the Bank Street College of Education who entered the teaching program via a career change from other professions. Researchers identified three patterns present in this group of career changers; these sub-groups were identified as: the homecomers, the converted, and the unconverted.

The group identified as homecomers represented people who described entering the teaching field as a type of homecoming. These individuals, while preparing for and pursuing other careers, had always felt they wanted to teach and, for reasons such as parental pressures, societal forces, market forces, and economic forces, felt the need to abandon their first love. These individuals reported that their decision to change careers was prompted by dissatisfaction with their current career and an increasing need to engage in more fulfilling work. The homecomers appear to have viewed teaching as their profession from an early age. The homecomers comprised a minor group among the second career teachers who were a part of Crow et al.'s (1990) study.

The group identified as the converted represent career changers who did not consider teaching until some pivotal event or significant change in their lives caused them to reconsider their professional goals and plans. Upon reassessment of their careers these teacher education students recognized and expressed a sense of disillusionment with their previous occupation, especially with profit values and competitive working
relationships. The converted represented the largest group of second career teachers identified by Crow et al.'s (1990) study.

A third group identified in this same study was identified as the unconverted; this group, small in number, represented a group of teacher education students who had achieved success in a previous occupation and who experienced dissatisfaction with aspects of their chosen career and felt the desire for new challenges. Unlike the homecomers and the converted, this group was disenchanted with a teaching career; they were not teaching and it appeared unlikely that they would enter the classroom in the future. These career changers entered the teacher education program with a broad, somewhat vague interest in education and viewed teacher education as a stepping stone to another, as yet unidentified, career. This study by Crow et al. (1990) provided a profile of one group of individuals who responded to life cycle and career cycle changes by changing careers and provided a glimpse into their reasons for entering the teaching profession.

Why individuals leave a career to enter science teaching has not been as thoroughly investigated. Science teaching involves both classroom and laboratory based instruction and is process oriented. Science is approached as not only a body of information to be learned but as a way or method of exploring the world and generating new knowledge. The job of the science educator is to help students master not only science concepts but the process skills with which to do science. In fact, science education is not so much learning about science as it is learning to do science. In light of these practical and pragmatic aspects of science education, the influx of science teachers to the classroom who have life experiences "doing science" in a prior career setting
brings a wealth of practical science knowledge and experience to students. These prior science experiences of second career science teachers add a unique and important component to the goals and aims of science instruction. Therefore, exploration of their life stories, the role of science in their careers, and their beliefs concerning science teaching and learning has relevance to the field of science education not only in the development of an understanding of the factors that led these professionals to school science as a career, but also in how their practical science knowledge and experience translates into their beliefs concerning science teaching and learning.

The body of research concerning life cycle changes that occur during the adult years formed an effective framework from which to examine a group of second career science teachers. Life cycle theory explains adulthood as a period of change that is marked by periods of development and transition. An expansion of life cycle theory to consider cycles in the careers of adults attempts to understand the psychological changes that workers undergo as they pursue their chosen career. These theories and their explanations of cycles of growth, development, and transition facilitated the understanding of some of the factors that brought each of these teachers into the classroom and why these career professionals chose to change careers in mid-life and enter the teaching field.

Cultural Border Crossing

As individuals leave a prior career and enter teaching, various borders must be negotiated in the transition. These borders consist of cultural factors such as language, beliefs, and customs. The body of research concerning border crossings (Aikenhead, 1996; Aikenhead & Jegede, 1999; Costa, 1993; Costa, 1995; Jegede & Aikenhead, 1999;
Phelan et al., 1991; Phelan, Davidson, & Yu, 1998) focused almost exclusively on the borders students must cross to achieve in the school science classroom. Phelan et al. (1998), in study of 55 students in four desegregated urban high schools in California, identified four cultural worlds in which students had to negotiate; these identified worlds were self, family, peers, school. The cultural world of the self is characterized by a set of meanings, perceptions, and understandings about each personal experience as well as unique patterns of thoughts, feelings, and strategies used to cope with and adapt to uncertain and uncomfortable situations. The other cultural worlds are characterized by a set of expectations for normal behavior, actions, values, and beliefs. Instances of intersection between two or more worlds in which no differential value is placed on any of the worlds are described as boundaries; however, if preferential value is placed on the thoughts, values, and behaviors of one cultural world over another, the boundaries becomes a border (Phelan et al., 1998).

In another study of 43 high school students from two culturally contrasting southern California high schools, Costa (1995) explored the ways in which students' responses to science class are related to the level of compatibility between the students' worlds of family, friends, school and science. Based on interviews, observations, and examinations of student records, she identified five groups of students who differed in the ways they related to science in a school setting; these student groups were: potential scientists, other smart kids, I don't know students, outsiders, and inside outsiders. These categories illustrate different forms of convergence that may occur between students' cultural worlds and the world of school science. The degree of convergence between worlds is inversely proportional to the degree of effort necessary to negotiate the border.
The potential scientists consider science an important subject and associate science class with the future goal of becoming a scientist, doctor, etc. Other smart kids realize that doing well in science is important, yet they are not interested in a science related career. They work hard in order to maintain their good grades, not because they love science but because they view science as useful to their later educational and career plans. I don't know students do not have any real feelings for or against science. They look at science as something they have to take to graduate from high school. The outsiders are those that do not consistently perform well in school; in fact, school is something they prefer not to think about. The inside outsiders feel alienated from school society and as a consequence also do not perform well in school. They seem to have the ability to do well in school, but choose not to. Costa concluded that success for students in science courses depended upon: 1) the amount of congruence or incongruence that students perceive between their personal lives and the science classroom, 2) how effectively the connections between students’ lives and school science are demonstrated, and 3) how well students are supported and assisted in the transition between the world and the classroom.

The act of transitioning a boundary from one cultural world to another requires little effort; whereas, the transition, or crossing, of a border between two different worlds requires a greater expenditure of emotional, intellectual, and psychological energy. Phelan et al. (1998) described six patterns of transitions that illustrate how students and teachers move from the world outside of school into the world of school science. These categories were: 1) congruent worlds/smooth transitions – students have a high degree of similarity from home to school and moving from one setting to another is uncomplicated; 2) different worlds/border crossings managed – differences in family,
peer, and/or school worlds exist and students are required to adjust as movement between worlds occurs; 3) different worlds/border crossings difficult – differences in peer and/or school worlds exist and students find the transitions between the worlds difficult; 4) different worlds/border crossings resisted – cultural differences between home, peers, and/or school are so great that they are conflicting and students perceive borders as uncrossable and resist the transition; 5) congruent worlds/border crossings resisted – cultural components of home, peer, and/or school are similar and students are unable to successfully make the transition between the two; and 6) different worlds/smooth transitions – the worlds of home, peers, and/or school are distinct but transitions between the worlds is easy.

According to Aikenhead (1996) and Aikenhead & Jegede (1999) students must negotiate cultural and societal borders frequently during a typical school day. As they move from their peer groups in the halls or commons areas to their classrooms, where other students present are not necessarily their peer group, they are negotiating cultural borders. These areas could be thought of as microcultures or subcultures (Aikenhead & Jegede, 1999).

A study by Crow et al. (1990) examined the career change process and the meaning it had for fifteen people who desired a career change into teaching. These individuals were involved in a year long teacher education program at Bank Street College of Education. Crow et al. identified three different patterns among the participants: 1) the homecomers, 2) the converted, and 3) the unconverted. Homecomers were those individuals who always envisioned themselves as teachers. The converted were those who never considered the possibility of teaching until some significant life
event caused them to reconsider their professional goals. The unconverted were individuals who had achieved a high status in another occupation, thought they wanted to teach, but never committed themselves to a teaching career. The researchers identified a series of life experiences which initiated the career change in the participants. Among those initiating factors were: 1) dissatisfaction with the current career and a desire to enter a career which was more satisfying, 2) a significant life event which prompted a reassessment of career goals and desires, and 3) a desire for new career challenges. The researchers identified certain mediating factors which influence the process of changing careers. These factors included: 1) concerns over the fear of inability to do graduate work, 2) economic factors, 3) concerns over being responsible for children’s learning, 4) and the need to assume a novice role after having achieved mastery in a field.

In this study of science professionals transitioning to a career in the world of school science a similar model, patterned after Phelan et al., presented itself. Much like the students in Phelan's et al. study, these individuals experienced multiple cultural worlds across which they must effectively transition. Analysis of the interviews and writings of the participants in this study identified a series of cultural worlds in which their life experience resided as well as a number of cultural borders negotiated in the move from the world of professional science to the world of school science. The participants in this study spoke of the congruent worlds of their own self perceptions and beliefs, their family lives and responsibilities, their experiences as a science career professional, experiences as the learner – both in preparation for their primary career and in their pilgrimage back to the classroom seeking the preparation needed to become a science teacher, and their journey thus far in the world of school science. Participants
also spoke of cultural borders that they negotiated in the transition to a second career.

Among these borders were: 1) the move from a science professional back to the classroom as a science education student, 2) the monetary challenges presented by the career change process, 3) the loss of prestige resulting from the change from experienced professional scientist to neophyte science educator, 4) differing understandings and viewpoints concerning the philosophy and nature of science, and 5) the different set of knowledge and skills needed to successfully perform in both areas.

Teacher Beliefs: A survey of literature and working definition

Researchers in the field of education have come to appreciate the influence of teachers' beliefs on the way teachers pursue their craft. Teacher beliefs represent a cluster of deeply held propositions concerning the nature of teaching and learning that include, for example: the nature of students, the role of the teacher, and the effectiveness of instruction. Teacher beliefs compose one facet of an individual's overall belief system concerning world view and one's role in the world. By "world view" I refer to a set of basic assumptions concerning the fundamental character of the world. Personal beliefs exhibit unique characteristics that give them significant power to influence the way persons view themselves and their world. Beliefs are personally held to be true by an individual, are generally formed early in life and are not dependent on agreement with other persons. Personal beliefs do not rely upon independent verification and are resistant to change even in the face of contradictory evidence. There exists confusion among researchers concerning the exact definition of the construct, "teacher belief". Belief has been referred to as a "messy construct" (Pajares, 1992) and indeed it seems, at times, that the variations on the definition of this construct is limited only by the number
of researchers weighing in with their personal definitions. Disagreement among researchers concerning the exact definitions and relationship between knowledge and belief further complicates the understanding of this construct.

While there exists confusion and varying personal descriptions for belief, there is consensus among researchers as to the importance of teachers' beliefs on the field of education. The confusion over an exact definition of beliefs extends into the field of science education; beliefs are important factors that determine the way science teachers approach their craft. Teacher beliefs impact the field of science education in at least three ways. The importance of teacher beliefs on the field of science education include the influence of teacher beliefs on: 1) science instruction, 2) teacher preparation, and 3) educational reform. The purpose of this section is: to outline the impact of teacher beliefs on science education, to describe characteristics of beliefs, to discuss definitions of belief and the relationship between belief and knowledge, and to present a personal working definition for this somewhat elusive construct.

Characteristics of beliefs

A person's beliefs could be described as the way one views the world. Beliefs are deeply held assumptions about people, events, or other aspects of the world that are assumed to be true and are not dependent on facts, logic, or independent verification. Beliefs serve as a kind of framework from which to view and make sense of the world. The interpretation of new experiences and the incorporation of new knowledge takes place through the filter of one's belief system. A person's "belief system" represents an aggregate of a person's beliefs about their world (Pajares, 1992). The beliefs in an individual's belief system are connected to each other with one belief exerting an effect
on other beliefs. These "belief interconnections" are an important feature of a belief system; the more an individual belief is linked to others, the greater its potential effect upon an individual's behavior. Rokeach (1972) defined the importance of beliefs "solely in terms of connectedness: the more a given belief is functionally connected or in communication with other beliefs, the more implications and consequences it has for other beliefs and, therefore, the more central the belief" (p. 5). People hold some beliefs more deeply and firmly than others. Beliefs that are deeply held are more resistant to external factors such as contrary evidence or conflicting data. Rokeach stated that beliefs vary in terms of their importance to an individual, their resistance to change, and their effect on the belief system as a whole and that all the belief components of an individual's belief system are interconnected and "organized into architectural systems having describable and measurable properties which, in turn, have observable behavioral consequences" (p.1). A person's central beliefs are those concerning a person's own identity and existence in the world, those learned by direct interaction with the object of the belief, and those beliefs that have been shared with others (Rokeach). In contrast, less central beliefs include matters of personal taste, beliefs not associated with identity, and beliefs learned, not by direct contact with an object, but indirectly from other persons; for example, one "hears" how good the newest movie release is (Rokeach).

Nespor (1987) presented a description of four qualities of beliefs that describe their structure and organization; these features are: existential presumption, alterativity, affective and evaluative loading, and episodic structure. Existential presumption describes the assumptive characteristic of beliefs. Beliefs are assumptive in that the holder of the belief assumes the information to be true in the absence of evidence or even
in the face of contradictory evidence. Related to the assumptive nature of beliefs is the feature Nespor refers to as alternativity. Alternativity refers to the fact that a person's beliefs may have a significant affective and evaluative component; in other words, beliefs consist of feelings, moods, and subjective evaluations that operate independently of other cognitive activities. Therefore, "knowledge of a domain can be conceptually distinguished from feelings about that domain" (Nespor, p. 319). For example, I may believe that golf is a very enjoyable game; however, I may have little knowledge of how to play golf. In this scenario I will likely play golf quite frequently although my knowledge level and my scores may not improve. On the other hand, I may have much knowledge concerning cooperative learning and yet not believe it to be an effective teaching strategy. In this instance, while I have the knowledge, I am unlikely to utilize cooperative learning as a teaching strategy. Therefore, my beliefs concerning an activity are important determiners of how much effort and energy I am likely to put into that activity. Beliefs are likely retained in a person's memory in association with the memory of personal experiences, episodes, or events; a trait Nespor refers to as episodic storage.

Nespor (1987) discussed two additional features which characterize personal belief systems: nonconsenuality and unboundedness. Nonconsenuality refers to the fact that personal belief systems are not dependent upon group consensus with reference to the validity or the "correctness" of the belief; it does not matter if a person's beliefs are shared by others. Beliefs are open to argument or dispute and are solely dependent on personal evaluation and opinion; this renders a belief relatively static or resistant to change. Unboundedness refers to the application of the information held as a belief. Beliefs tend to be unbounded, or unlimited, in terms of application. Whereas knowledge
concerning a domain generally has limited and well defined areas of application, beliefs concerning a domain may be applied to situations in which their validity has not been demonstrated. For instance, I may use a particular strategy in an accelerated physical science class with good success. My decision to use the same lesson in another class is based in part on my "personal knowledge" of the strategy as well as my beliefs concerning the effectiveness of that strategy. A decision to use the strategy in the same type of class, i.e. another accelerated physical science class would be based more on personal knowledge while a decision to use the strategy in a different type of class, such as a biology class, would be based more on a belief in the lesson. It is generally accepted that a relationship exists between beliefs and action; this relationship is currently thought to be interactive – each construct can affect the other. An illustration from the classroom comes to mind: a teacher believes that students learn the parts of a cell best by using analogies because that's how she/he learned them in college. The belief, which will most likely affect the way in which the teacher teaches the parts of the cell to her/his class, is based on personal experience. This example illustrates how both beliefs and actions effect each other. As Richardson (1996) stated, "beliefs are thought to drive actions; however, experiences and reflection on action may lead to change in and/or additions to beliefs" (p. 104).

The belief construct

The construct that is presumed to be belief has been defined in various ways by different researchers (Bryan, 1997; Clandinin & Connelly, 1987; Dewey, 1991; Lewis, 2000; Nisbett & Ross 1980; Pajares, 1992; Richardson, 1996; Rokeach, 1972). The vast array of definitions point to the various understandings held by researchers concerning
this elusive construct. Beliefs have been defined as propositions about the nature and characteristics of objects (Nisbett & Ross, 1980). Dewey (1991) describes belief as a type of thought that "is based upon real or supposed knowledge going beyond what is directly present. It is marked by acceptance or rejection of something that is reasonably probable or improbable." (p. 4). A belief may be accepted with or without examination of the degree to which the belief is corroborated by evidence. Rokeach (1972) described belief as any proposition that can be inferred from what a person says or does. Rokeach argued that beliefs may be descriptive in that they describe one's perception of an entity; for example, one may proclaim that the sun sets in the west, the earth is flat, or it is time for science class. Rokeach described a second type of belief as being evaluative; for example, I believe this movie is good, or I love science class. Rokeach described a third type of belief as prescriptive; for example, I believe it is helpful for children to take music lessons or I must study science each night. It is rare that a belief is in only one of these areas, instead, Rokeach stated that beliefs consist of all three components. He went on to describe the descriptive component of a belief as cognitive in nature representing one's personal knowledge concerning an entity. The evaluative component of a belief he further characterized as an affective component since it represents a person's emotional response, either positive or negative, to the object of a belief. The prescriptive component of a belief, according to Rokeach represented a behavioral component because it suggests some form of action with reference to the object of the belief.

Belief versus knowledge

Another confusing aspect of the definition of belief is the exact relationship between belief and knowledge. As stated above, Rokeach (1972) described beliefs as
having three components: a cognitive component that represents knowledge, an affective component that stimulates emotion, and a behavioral component that leads to action. Therefore, for Rokeach, knowledge is a form of belief or a component of a belief system. Nisbett & Ross (1980) argued that a person's knowledge may be composed, at least in part, of beliefs, a term Nisbett & Ross described as "reasonably explicit 'propositions'" about the characteristics of objects or object classes (p. 28). What people understand about a specific person or thing may be based, in part, on all inclusive belief statements concerning the nature of the entire group to which an entity belongs; for example, all physicians are wealthy or imported cars are cheaply made. On the other hand, a person's knowledge of an entity also seems to have a cognitive component based on one's own experiences with the entity; for example, one's knowledge of the parables in the Bible or how one understands baseball. Therefore Nisbett & Ross implied that beliefs represented one form of a person's general knowledge of an object or class of objects. Clandinin & Connelly (1987) in their work on personal practical knowledge stated that it is difficult to determine exactly where the knowledge gained from an experience ends and the beliefs generated from that experience starts; therefore, beliefs and knowledge are synonymous. Along the same line, Kagan (1992) believed it is impossible to make a clear distinction between teacher beliefs and teacher knowledge; she maintained that teachers create knowledge from their personal experiences and the knowledge they create is based on their assumptions about the world. In other words, what teachers know about their craft appears to be based on their experiences in the classroom and, rather than being objective, factual knowledge, is "defined in highly subjective terms" (Kagan, 1990, 421). Belief has been described as a form of knowledge (Tobin, 1995; Tobin, Tippins, &
Gallard, 1994). For Tobin et al. (1994) the differentiation of teacher knowledge as either propositional belief or experiential knowledge is of secondary importance. The authors speak of the importance of viability – that is, the usefulness of the knowledge – in helping individuals make sense of their experiences and conclude that "...belief [is] a form of knowledge that is personally viable in the sense that it enables a person to meet his or her goals" (Tobin et al., 1994, p. 55). Another view was offered by Lewis (2000) who stated that beliefs "are personal evaluations … about the 'good', the 'just', and the 'beautiful'… that propel us to action, to a particular kind of behavior and life." (p. 8). Lewis described beliefs as having two components – affective and prescriptive. Lewis described beliefs and knowledge as two related but dissimilar entities; knowledge, for Lewis, represented a belief that has been given credence through supportive evidence gained through personal experience, logic, or experiment.

Pajares (1992) explained that beliefs "...are seldom clearly defined in studies or used explicitly as a conceptual tool, but the chosen and perhaps artificial distinction between belief and knowledge is common to most definitions: belief is based on evaluation and judgment; knowledge is based on objective fact." (p. 317). Richardson (1996) also drew a distinction between the two constructs belief and knowledge. She defined belief "as a proposition that is accepted as true by the individual holding the belief. It is a psychological concept and differs from knowledge, which implies epistemic warrant" (Richardson, 1996, p. 104). Nespor (1987), as presented previously in this paper, described four features of beliefs – existential presumption, alternativity, affective and evaluative loading, and episodic structure – that "can serve to distinguish beliefs from knowledge" (p. 318). A similar view was expressed by Bryan (1997) who
stated "…my use of the term belief implies a construct different from knowledge in that beliefs do not require a condition of truth (Green, 1971). Although beliefs and knowledge are intricately related, I do not use these terms synonymously." (Bryan, 1997, p. 14).

In summary, beliefs represent a cluster of ideas that are held to be true. Confusion exists as to exactly what is a belief. Definitions for belief range from personal understandings to purposely held propositions to propositions concerning nature. Additional confusion exists concerning the exact relationship between beliefs and knowledge; beliefs are considered a form of knowledge by some researchers, others consider beliefs and knowledge to be synonymous, while others maintain that knowledge is composed of beliefs.

**Personal working definition of beliefs**

My personal working definition of the term "beliefs" comes primarily from reading the works of Bryan (1997), Nespor (1987), Pajares (1992), and Richardson (1996). Beliefs, for me, represent personally held propositions about some entity that are assumed to be true and that guide actions. The validity given to the propositions is not dependent upon support of evidence. Knowledge, on the other hand, implies information that is verifiable, observable, and mutually agreed upon by peers. While recognizing various understandings of the relationship between knowledge and beliefs, from a pragmatic point of view, it seems most logical to differentiate between the two constructs in terms of fact. The two terms, belief and knowledge, can be thought of as representing opposite ends of a continuum. The degree to which an idea that is personally held to be true can be described as belief or knowledge depends upon the degree to which the idea
has been verified and confirmed by evidence gained through personal experience or the experiences of others. As Pajares (1992) stated, "the chosen and perhaps artificial distinction between belief and knowledge is common to most definitions: belief is based on evaluation and judgment; knowledge is based on objective fact" (p. 317). Along the lines of Pajares my use of the term belief implies a construct that is distinct from knowledge. Especially in the field of science education, beliefs concerning effective science teaching and learning may or may not depend on direct evidence but on other factors such as personal experiences and remembrances. Therefore, a teacher's beliefs concerning their craft may be different from their knowledge – what they believe to be the "right" thing to do may not be based on knowledge gained through experiment.

Science teachers may know, based on authority and examination of research in science education, what are more effective methods of teaching science, however, they may deeply believe, based on personal experiences, that an alternative set of methods is "better" for teaching science in their particular classroom. This belief is held in spite of evidence to the contrary. Therefore, while beliefs and knowledge are interrelated constructs, I do not consider the terms synonymous.

Beliefs and Education

Among the beliefs teachers hold concerning their craft are propositions concerning their subject, the ways in which students learn, their effectiveness as teachers, their role as a teacher, and the need for educational reform. The beliefs that teachers hold concerning their subject, so called content beliefs, affect how they arrange and teach a course, as well as how they present the course material. Kagan (1992) described the results of a survey of 2000 college faculty that reveals that the strongest factors that
influence the ways they organize and teach their courses are their own beliefs concerning their particular fields. Further, these professors tend to view their academic field as an organized body of knowledge and a set of skills that must be mastered by the students. Therefore, instruction is focused on students acquiring the knowledge and skills necessary for success in that particular field. In addition to content beliefs, epistemological beliefs, beliefs about the ways students acquire knowledge, can also affect how teachers conduct class and teach students. According to Tobin et al. (1994) "…research suggests that a teacher's personal epistemology acts as a constraint to the way he or she thinks in relation to teaching". Epistemology refers to the way a person "knows", or learns something; these ways of knowing include: knowledge that is received from another source, knowledge which is discovered through active inquiry, and knowledge constructed through connections with diverse personal experiences. Therefore, a teacher will interact with students in ways which are consistent with their views on how students learn best.

Beliefs concerning efficacy can influence teachers’ effectiveness (Agne, Greenwood, & Miller, 1994). Teacher efficacy is defined as a teacher's belief in their ability to affect student learning and achievement (Agne et al.). Teachers with a high sense of efficacy believe their efforts are more likely to reach low achieving students thereby causing these students to be successful learners; these teachers are more likely to expend the effort needed to reach these students (Agne et al.).

An individual's teaching beliefs include, not only the degree to which they believe they can affect student learning and achievement, but, as Tobin (1990) stated, their conception of the proper role for the teacher to assume in the classroom.
situations, the practices used by teachers are based, in many cases, at least in part on personal conceptions of their role as a teacher (Tobin, 1990). A person's beliefs concerning her/his role as a teacher may be understood and described in terms of metaphors. Metaphors provide a manner by which to explore an individual's beliefs by making comparisons to more familiar entities. Further, Tobin (1990) citing Tobin & Ulerick (1989), states that a person's teaching metaphors guide many of the practices adopted by teachers. Tobin (1990) indicated that changes in teaching practices can be implemented through an alteration in the beliefs teachers hold concerning their role as educators.

Hashweh (1996) has studied the effect of teacher beliefs concerning the ways students learn and acquire scientific knowledge. Hashweh compared constructivist and empiricist teachers in terms of their general approach to teaching. Constructivist teachers believe that a learner builds her or his own knowledge based on their life experiences; this personal knowledge may not have relevance for other learners. Empiricist teachers believe that knowledge must be tested for validity through observations and experimentation. In his study, Hashweh found that the epistemological beliefs of teachers exerted a strong influence upon their teaching style. Those teachers with constructivist beliefs utilized instructional activities where the students created their own knowledge. Further these teachers' beliefs were "...strong and stable across teachers' field of expertise in science, the educational level at which they teach, or the culture in which they belong" (Hashweh, p. 61). A teacher's content beliefs and pedagogical beliefs play a major role in determining the way in which they carry out instruction and "...exert a powerful impact on the outcomes of teaching..." (Gess-Newsome, 1999,
In summary, the teaching methods and instructional activities a teacher uses in her/his classroom reflect the beliefs held by that teacher concerning how students best assimilate new information.

Although beliefs play a role in teachers' actions in the classroom, the exact relationship between actions and beliefs is not so well-defined. The nature of the relationship between beliefs and actions is often blurred, indistinct, and uncertain. A teacher's actions are based, at least in part, on what they believe as well as on what has worked successfully for them in the past. In other words, actions can be based on beliefs, and beliefs can be based on actions. In a study of teachers' beliefs and their relationship to classroom practice, Brickhouse (1990) concluded "The teachers' understandings of what science is and how students learn science in schools formed a consistent system of beliefs for guiding classroom instruction." (p. 60). Nespor (1987) wrote of the function of beliefs in defining and organizing teaching tasks. Many challenges faced by classroom teachers represent what Nespor referred to as ill-defined and deeply entangled problems. The phrase, ill-defined and deeply entangled refers to challenges that relate to specific classroom situations that are so individualist in nature that the application of general teaching principles is difficult. In such a situation, the teacher is forced to apply the sum total of her/his prior teaching experience and knowledge to a unique situation. When faced with a new teaching situation, the application of knowledge and experience must pass through the lens of the teacher's beliefs. In other words, classroom problems may be unique and specific to the point that the application of information gained from formal education classes may be difficult to apply. In such cases, personal beliefs based on
personal experiences form a powerful method by which to make decisions concerning the best course of action.

A person's existing beliefs form the basis for construction of new beliefs and new knowledge; therefore, incorporation of knowledge concerning teaching is affected by the beliefs held by the teaching candidate. Research from many studies, as early as the 1970s, have shown that many of the beliefs concerning "good teaching" held by educators have their origins in experiences as a student and that many preservice teachers leave their teacher preparation programs with the same beliefs concerning teaching and learning with which they entered the teacher program (Kagan, 1992). Kagan stated that learning to teach is not so much a process of assembling pieces of information, as it is a process of combining formal theoretical teaching knowledge with existing teaching beliefs. Beliefs concerning teaching and learning play a role in teacher preparation programs through their effect on the process of assimilating new information.

Richardson (1996) citing Resnick (1989), stated that cognitive theorists describe learning as "an active and constructive process that is strongly influenced by an individual's existing understandings, beliefs, and preconceptions" (p. 105). In a study of elementary teachers' beliefs concerning science teaching and learning, Jasalavich (1992) found that personal learning experiences did indeed play an important role in the development of teaching beliefs. "Existing knowledge and beliefs play a strong role in shaping what students learn and how they learn it." (Richardson, 1996, p.105 ). In reality, the role of formal teacher education must be one in which existing beliefs are modified through the process of self-reflection to allow for the incorporation of new knowledge. Programs must help students question, evaluate, and rebuild their personal beliefs systems (Kagan).
The beliefs held by teachers also affect curriculum and educational reform. Regardless of formal professional development experiences, teachers are unlikely to adopt practices in which they do not believe. Therefore, for any educational reform to be successful the beliefs of teachers must be taken into account. There must a mechanism for incorporating new teaching knowledge into existing belief systems. Briscoe (1991) found evidence to support this view; in her study, she found that new teaching strategies and educational philosophies were not likely to be implemented unless they were in concert with the teacher's belief system. For the participants in her study, commitment alone on the part of the teachers to adopt new teaching techniques was not sufficient to produce changes in teaching practices; for change to occur, the information had to be filtered, adapted, and assimilated through the existing belief systems held by science teachers. The beliefs teachers hold concerning teaching and learning play an integral role in the process of teacher change and professional growth. Briscoe, in her 1991 study, concluded, "it is clear…that curriculum innovations were adapted and changed to fit the belief systems which supported the teacher's role metaphors" (p. 197). A similar view was expressed by Eisenhart, Cuthbert, Shrum, & Harding (1990). "Whether policy enters the classroom and how it is transformed there seems to be determined, at least in part, by teacher beliefs. Evidence also suggests that educational policies that are incompatible with teacher beliefs are not implemented as intended." (Eisenhart et al., p.137). Cronin-Jones (1991) offers further evidence of the effect of teacher beliefs on curriculum implementation. In a 1991 study, she investigated curriculum implementation in middle school science curriculum and found that teachers implemented the intended curriculum in a way which more closely matched their teaching beliefs (Cronin-Jones). Those
beliefs which Cronin-Jones found to exert an influence on the curriculum implementation process were: beliefs concerning a teacher's role, beliefs about how students learn, attitudes toward curriculum, beliefs concerning the ability level of students, and beliefs concerning desired outcomes for learning.

Summary and Preview

In this chapter a brief overview of the development of education in America was presented. The focus of the overview was the development of teacher training and education from the colonial period to modern day. The development of teacher certification programs was outlined and a description of the alternative movement was presented. This was followed by a description of the theoretical frameworks which informed this study. In summary, the three support pillars of my theoretical framework were life cycle theory, border crossings, and teacher beliefs; these three bodies of theory formed an appropriate framework for my study.

My research interest lies with science teachers who come to the field of science education through an alternative certification process after having pursued a non-teaching career. These are individuals who come to the field of science education after having prepared for and pursued a non-teaching career. My research questions included an exploration of their life stories, how science has been a part of their life, what beliefs these teachers hold regarding science teaching and learning, and the borders that they had to negotiate to enter the world of school science. It seemed appropriate to study the changes that occurred in the lives of these teachers against the backdrop of life cycle theory and the cycles of adult development. I selected research questions that will hopefully bring some understanding of the events in their lives that led these individuals
to the teaching field, a sense of the role science as a discipline has played in their lives, an 
appreciation of the challenges each faced as they made the career move into education, 
and some understanding of the beliefs concerning science teaching and learning held by 
these teachers.

The body of theory related to border crossings was relevant to my study in light of 
the professional, cultural, and societal borders second career teachers must negotiate to 
enter the teaching profession. The existing body of research focused primarily on 
students and the borders they must cross to achieve in the world of school science; 
however, this framework, as it attempts to identify the challenges faced by students as 
they pass from the world outside of school into the world of school science, proved 
helpful in adding understanding to the borders that second career science teachers must 
negotiate to enter the world of school science. How second career science teachers are 
positioned or located with respect to negotiating the cultural borders that connect the 
culture of their first career with the culture of school science and the strategies by which 
the teachers negotiated these borders are two questions that formed the focus of this 
study.

The third component of my theoretical framework was the body of theory related 
to teacher beliefs. The research questions for my study included an exploration of the 
beliefs concerning teaching and learning held by second career science teachers; this data 
was best analyzed in light of the body of existing research knowledge related to teacher 
beliefs.
The following chapter discusses the methodological framework that guided my study in the collection and interpretation of data. The study utilized oral history and case study as components of the methodological framework.
CHAPTER 3
METHODOLOGICAL FRAMEWORKS

Introduction

The purpose of this study was to explore how prior career and life experiences mediated the teaching beliefs of three second career science teachers. This study represented an in-depth exploration and description, centering on the impact of life stories and career experiences on the teaching beliefs. Qualitative research represents a process of inquiry that seeks to explore a human or social issue in a natural setting (Creswell, 1998) with a minimal degree of disruption (Miriam, 1998) and seeks to explore the meaning people construct from their experiences. A qualitative design, that incorporates case study and oral history, was chosen since this study represented an attempt to recreate a rich description of the life remembrances and subjective perceptions and beliefs of the participants.

Oral History

Oral history is a relatively new means of collecting data. Its history can be traced to Alan Nevins and his work at Columbia University; in the late 1940's he used tape recordings to gather information from his study subjects. Nevins originally considered oral history to be a means by which to "collect otherwise unwritten recollections of prominent individuals..." (Dunaway, 1996, p. 8). During the 1960's and 1970's there was increased interest among researchers in recording the memories of different groups of people; this interest, along with improvements in the recording technology, led to an
increase in the number of oral history projects. This new wave of oral historians demonstrated a shift in focus from recording the history of prominent individuals to the disenfranchised and common person. The 1970's saw a shift in the use of oral history; educators, feminists, activists, and historians began to use oral history as a means to document community problems and to promote community improvement and ethnic diversity (Dunaway). As a result of this shift oral history became "more personal"; in other words, the focus of research was concerned more with the personal experiences than major historical events. The 1980's saw an increased use of technology among oral historians such as the use of personal computers, computerized data bases, and the use of audiotapes as an adjunct to museum displays.

Oral history is a form of biographical study that focuses on personal memories of the participant(s) to create a rich detailed description of the person's experiences. The participant assumes an active role in data collection and indeed the term "oral history" implies a collaborative relationship between the researcher and the participant. Data collection involves not only recollections of the past but also the participant's interpretation of her/his past (Perks & Thomson, 1998). According to Creswell (1998), oral history is a research method in which a researcher gathers "personal recollections of events, their causes, and their effects from an individual or several individuals" (p. 49); the participant is recounting some aspect of their life experience by the use of the spoken word. The participant's words are preserved by the use of some recording technique, i.e., a tape recorder, a video recorder, or through written accounts. The strategies used for collecting a participant's oral history range from structured and researcher focused, in which the researcher's intentions are the primary goal, to participant focused, in which the
Participant is asked to tell her/his own story in her/his own way (Clandinin & Connelly, 1994). In this study, a list of open-ended guiding questions was used that allowed the participants opportunities to extend and expand their responses based on their recollections. The type of interview used in this study is termed semi-structured in that participants were asked to tell their own story, in their own way, with some guidance from the researcher.

Collecting oral history data involves interactions between the researcher and the participants. The participant is guided by the researcher to remember and relate life experiences that are of interest to the researcher. This study utilized a variety of methods by which to elicit remembrances of life experiences from the participants. These methods, which are described in more detail later in the chapter, included semi-structured interviews, autobiographies, life learning maps, historical timelines, structured and unstructured journal entries, photoessays, metaphors, and case narrative stories.

Case Studies

One of the more common research tools in qualitative research is the case study. While the case study is an often used method of research, there is little agreement among researchers as to the exact definition of a case study. Merriam (1998) stated that "case study is often equated with fieldwork, ethnography, participant observation, qualitative research, naturalistic inquiry, grounded theory, or exploratory research" (Merriam, p. 26). A somewhat different definition is offered by Yin (1994); he wrote, "a case study is 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). Merriam, citing her previous work, offered the following definition, "a
qualitative case study is an intensive, holistic description and analysis of a single instance, phenomenon, or social unit" (Merriam, p. 21).

Merriam (1998) maintains that the most defining characteristic of case study research is the process of defining and delineating the boundaries of the object under study, the entity known as the case. For some objects of research, the boundaries surrounding the case exist naturally, while in other cases the boundaries must be assigned by the researcher as she/he defines the limits of the research questions for their study. The case is understood by Merriam as "a thing, a single entity, a unit around which there are boundaries" (p. 27). Merriam goes on to state that a case can be a person such as a student or a science teacher, a program, a group such as a class or a school, a specific policy, or a type of educational reform.

Four fundamental properties define the qualitative case study as a mode of research design; the case study is particularistic, descriptive, heuristic, and inductive. According to Merriam (1998) case study research is:

1) particularistic in that it focuses on a particular situation, event, entity, or phenomenon;
2) descriptive in that the final product provides a rich, thick description of the phenomenon under study;
3) heuristic in that it enlightens the reader concerning the phenomenon under study;
4) inductive in that concepts, generalizations, or hypotheses emerge through an examination of the data and the use of inductive logic.

The decision to use case study is guided by what the researcher wants to learn.
Yin (1994) stated that the case study, as a research design, is preferred when the focus of the study is on a contemporary phenomenon and when the researcher has little control over events. Merriam explained, "the less control an investigator has over 'a contemporary set of events', and/or if the variables are so embedded in the situation as to be impossible to identify ahead of time, case study is likely to be the best choice" (Merriam, p. 32). Bromley wrote that case studies "get as close to the subject of interest as they possibly can, partly by means of direct observation in natural settings, partly by their access to subjective factors (thoughts, feelings, and desires), whereas experiments and surveys often use convenient derivative data, e.g. test results, official records" (Bromley, 1986, pg. 23 as cited by Merriam, p. 32 - 33). Case study is an especially appropriate research design if the researcher is interested in process.

Bogdan & Biklen (1998) described the general design of a case study as resembling the shape of a funnel. The wide end represents the beginnings of a study when the researcher casts a wide net searching for sites, subjects, and sources of data that are appropriate for the questions they want to explore. The research design, including aspects such as case definition, sources of data, and data collection techniques are refined, redesigned, and honed to a sharp focus; it is then that exploration of the research questions can begin (Bogdan & Biklen).

There are numerous types of qualitative case study; different types of case study have different characteristics that make them appropriate to the study of different categories of cases. This study represented a blend of life history case study and situational case study. This study involved three second career science teachers and their journey from a science career to a school science career. One goal for the study was to
explore the role of science in their life stories and the professional, societal, and cultural borders which they negotiated as they changed careers. In this respect, life history comprised a significant aspect of this case study. This study explored a particular event impacting science education today; namely, the movement of career science professionals into school science as science educators. In a sense this study, therefore, represented a situational case study of second career science teachers.

This study can be classified as a descriptive case study. This study presented basic information regarding second career science teachers, the role of science in their life stories, their career change journey, and their beliefs concerning science teaching and learning. The study sought to develop a rich, complete description of the participants and their journeys into the world of school science. As Merriam (1998) states, descriptive case studies form a data base that is useful for future studies. The overall goal of this study was to provide data that may be incorporated into future teacher education programs.

Case studies in science education

In education, and science education in particular, case studies can be used for a variety of purposes. Case studies can focus on individual students or teachers in the effort to identify and explain certain problems of practice. In science education, the problem of inappropriate achievement among female students would be a type of study that would lend itself to case study methods. A study of teacher beliefs regarding reform of science education would be another example of a topic appropriate for the use of case study. A third example might be the study of pedagogical beliefs among secondary science teachers. A second type of case study used in the education field is the historical
case study. The historical case study examines a phenomenon over a period of time and the author presents a holistic description and analysis of the case. Examples in the field of science education might include a study of the evolution of science teaching methods over the past 20 years, a study of the teacher beliefs held by new teachers during the first two years of their teaching career, or a study of the development of pedagogical beliefs in pre-service science teachers. A third type of case study useful in the field of education is the psychological case study. The psychological case study uses psychological techniques to study an individual. An application to the field of science education would be an investigation of learning styles among African-American science students or a study of the causes of teacher burnout in science teachers. Case studies in education may employ techniques taken from the field of sociology to study educational phenomena from a sociological standpoint. An example of this type of study in the field of science education is the study of the borders that students or teachers must negotiate to achieve in the world of school science or a study of the effect of family influences on science achievement among female students.

Participants

The participants in this study were three secondary second career science teachers. They were selected using a purposeful sampling method. These three were selected from an available pool of second career science teachers at two south metro Atlanta high schools in two counties. The concept of purposeful sampling involves the selection of a research sample from which the most can be learned. Inherent in this process is a detailed description of the goals and aims of the study and an intimate understanding of what the researcher hopes to learn. This study utilized purposeful
sampling as opposed to random sampling for several reasons. First, since this was a qualitative study the enhanced generalization of results to the overall teacher population which is characteristic of random sampling is not important factor in the experimental design. Secondly, the study sought to produce a rich description of second career science teachers; therefore, it was necessary to select participants who were second career science teachers to explore their personal experiences as they traveled to the world of school science. For these reasons a purposeful or criterion-based sampling technique was most appropriate.

The present study explored beliefs held by three second career science teachers; these teachers were selected because they are second career science teachers, agreed to participate in the study, and were at different points in their teaching career (one being a very experienced teacher, one in the middle of his teaching career, and one a novice teacher). One participant, Rosalind, after pursuing a career in microbiology for seven years, moved to school science. She has taught science in middle school and/or high school for 30 years and thus is termed the experienced teacher. Courses she has taught include: life science, earth science, physical science, biology, accelerated biology, gifted biology, and anatomy/physiology. A second participant, Dave, came to the field of school science from the field of forestry. He obtained a degree in forestry and worked in this field for 12 years before obtaining his teaching certification. He has taught high school science (physical science, biology, physics, chemistry, ecology, and horticulture) for ten years; thus he represents a second career science teacher in the middle of his science teaching career. The third participant, Daffodil, came to school science after a career in the military as well as an extensive education in the field of chemistry. She
represented a novice teacher, in her first year of science teaching. She taught physical science and chemistry. Chapter 4 will provide a more in depth look at the participants' careers, life stories, beliefs, and borders negotiated.

Data Sources and Collection

This study utilized multiple data sources during the research process. Data sources included the following: historical timelines, autobiographies, metaphors, semi-structured journals, personal interviews, case narrative stories, life learning maps, and teaching metaphors; these data sources are described in the pages that follow.

Triangulation was used to examine the viability of the data. The term "triangulation" has come to have multiple, imprecise meanings in the field of qualitative research; meanings assigned to the term by researchers include multiple sources of data, multiple subjects, multiple researchers, and different theoretical approaches to data collection (Bogdan & Biklen, 1998). The theoretical underpinning of the concept is the idea that multiple sources of data result in a more complete understanding of the phenomenon under study. For the present study, triangulation referred to the collection of data through multiple sources and procedures to confirm and assess the consistency of the findings. This form of triangulation, in which data obtained through different research methods and is analyzed for consistency, has been referred to as data triangulation and is the form of analysis used in this study (Janesick, 1994).

Data Sources

Sources of data can be categorized by the degree to which the information gleaned from the source contributes to the creation of understanding regarding the research questions. Those sources of data that provide major pieces of information and
are thus critical to addressing the research questions are referred to as primary data sources; the results of the study are built predominantly from information gleaned from primary data sources. While adding much to the understanding of the research questions, analysis of only primary data can be like looking at a partially completed jigsaw puzzle; one can tell what the picture is but many of the details, and much of the beauty, is missing. To complete the picture supporting data sources were used. The information gathered from these data, while insufficient to address the research questions thoroughly, add completeness and totality to the analysis of the data. Several different types of data sources were utilized in this study. Primary data sources utilized in this study included autobiographies, semi-structured interviews, case narrative stories, and photoessays; supporting data sources included historical timelines, metaphors, structured and unstructured journals, and life learning maps. For the collection of much of these data the participants were relating a portion of their life and career experiences as it related to science and science teaching. Therefore, many of these sources, specifically, autobiographies, case narrative stories, historical timelines, journaling, and life learning maps, could be thought of as forms of narrative.

In recent years, educational researchers have recognized the usefulness of narrative as a technique or tool with which to explore the life experiences of individuals (Clandinin & Connelly, 1994; Cortazzi, 1993). Teacher's narratives, according to Cortazzi (1993) can be used to study questions of teachers' cultures, experience, and beliefs. Narrative represents a powerful tool for studying the ways in which teachers understand their work (Carter, 1995). Narrative analysis, according to Carter, provides...
a way of grasping the richness and indeterminacy of our experiences as teachers and the complexity of our understandings of what teaching is and how others can be prepared to engage in this profession. Furthermore, with the vigorous emphasis on cognition in teaching, story came to represent a way of knowing and thinking that is particularly suited to explicating teacher's practical understandings, i.e., the knowledge that arises from action (pg. 326).

Narrative serves as a window into the life history of a person and allows a more complete look at how a person's past, present, and future are connected into a whole life experience. The body of knowledge concerning narrative served as a useful landscape from which to evaluate the life stories of the subjects of this study. In this study narrative was used to as a tool to explore the life stories of second career science teachers in the subculture of science, their experiences during the process of career change from the subculture of a science career to the subculture of school science. Narrative was also used to explore the beliefs these participants held concerning science teaching and learning.

Narrative stories can be free-for-all stories or may be structured around some event that occurred in the life of an individual. This type of personal narrative serves as a window through which to gain glimpses of an individual's experiences – in this case experiences related to science teaching and learning. Clandinin & Connelly (1994) assert that people express their experiences most fully through the telling of stories; such stories
would include personal stories, anecdotes, folk tales, short stories, novels, and drama.

This relating of life experiences, or the telling of one's story, is what researchers mean by the term narrative.

Table 1

Primary and Supporting Data Sources

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Historical Timelines</th>
<th>Auto-Biography</th>
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<th>Journals</th>
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<th>Life Learning Maps</th>
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<td>What are the life stories of second career science teachers?</td>
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<td>Where is science in their life stories?</td>
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<td>What beliefs do second career science teachers hold with regard to science teaching and learning?</td>
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<td>What professional, cultural, and societal borders did these second career science teachers have to negotiate to enter the world of school science?</td>
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### denotes primary data sources
** denotes supporting data sources
Primary Data Sources

**Autobiography**

*Random House Webster's College Dictionary* defines autobiography as "a history of a person's life written or told by that person" (Costello et al., 1992, p. 93).

Autobiography has been defined in various ways by current researchers (Bogdan & Biklen, 1998; Clandinin & Connelly, 1994; Clandinin & Connelly, 2000; Cortazzi, 1993; Lee & Roth, 2000; Roth, 2000; Smith, 1994). An autobiography is rich in detail and is written for the purpose of telling a person's life story as she/he experienced it (Bogdan & Biklen, 1998). Smith (1994) defined autobiography as a type of life writing in which people describe their perceptions of their life experiences. Clandinin & Connelly (1994), viewed journal writing and autobiographical writing as being closely intertwined; both terms describe a method by which individuals can effectively relate their life experiences. Rather than describing a particular event, autobiographical writing involves description of personal experience in the context of one's entire life experiences (Clandinin & Connelly, 2000). Cortazzi (1993) viewed autobiography as a method by which teachers relate and reflect on lived experiences. Autobiography is a narrative that presents the Self (Lee & Roth, 2000). There are two common threads in the above definitions: 1) a person is relating life experiences as they perceive them to have occurred, and 2) these experiences are related in the total context of their social, familial, and cultural lives. Roth (2000) summarized these threads in this way: autobiography is a form of life writing that describes a culture as it tells about a life. For me autobiography is a telling of life experiences – not necessarily their life – as it relates to a specific influence, in this case science experiences and career changes.
Autobiography and Science Education

Roth (2000) noted that autobiography has not been used as much in science education as in other fields such as feminism, ethnography, and anthropology. He suggested that autobiography can contribute to understanding and learning and is one way "science educators can expose their prejudices which they bring to the understanding of issues in teaching and learning science" (Roth, p. 5). Science education today is often based on a constructivist-based theory, i.e., individuals construct their own learning from their experiences. Therefore, autobiographies have become a popular tool for investigating the knowledge frameworks that learners construct and how those frameworks are modified over time. Eisenhart (2000) used autobiography as a critical tool to examine her own experiences in the publishing of her book. Nichols & Tippins (2000) conducted a study involving an altered type of autobiography termed biomythography. Biomythographies, in the form of photoessays, were used to explore the preconceived ideas, personal beliefs, and deeply held images concerning science teaching and learning of preservice elementary science teachers. Another use of autobiography in science education is represented by a study (Barton, & Darkside, 2000) where autobiography was used both as a way to tell a story and as a way of interacting. Barton & Darkside used autobiography as a way to explore how the lived experiences of students created their science knowledge. Critical educational autobiographies were the basis of a study by Davis (1996) tracing the origins of beliefs concerning science and mathematics teaching and learning among a group of science and mathematics teachers enrolled in a graduate program. She used the term critical since the writers were asked to reflect on the origin of their personal beliefs concerning teaching and learning. In
summary, autobiography, in the above studies, was used to explore the personal perspectives of science teachers and learners and the role those perspectives played in learning about science. With the constructivist theory of learning so often used by science educators, the personal perspectives produced by the sum total of an individual's life experiences play a central role in the way in which science is perceived and the way in which science information is constructed. Autobiography shows much promise as a way to investigate an individual's life experiences and the role that society, family, and culture plays on their perceptions. Not only has autobiography been shown to be effective in developing teacher reflection, but also, from Davis' work, effective as a catalyst for teacher change.

Autobiography was selected for this study as a tool with which to explore life experiences of the participants; I was specifically interested in the role science and science learning played in their lives and career changes. For their autobiographies, participants were instructed to write about informal learning experiences, about themselves as a life long learner of science, to relate significant life influences in relation to science learning, to focus on their feelings, emotions, and beliefs, and to create an experiential, not linear account. This data collection technique represented an adaptation of Davis' (1996) model of critical autobiography in that the participants were writing about experiences related to science, science learning, and science teaching.

Case narrative stories

Case narrative stories represent a second type of personal document that served as a primary datum source. Cases were defined by Miller & Kantrov (1998) "as a narrative organized around a key event and portraying particular characters that is structured to
invite engagement by participants in a discussion" (p. 2). Koballa & Tippins (2000) described cases "as a particular form of narrative that can be used to explicate and clarify the professional knowledge of teachers" (p. 3). Waterman, McErlain, Rasinski, & Styslinger's (1997) definition of cases is similar to those above; they described a case as a narrative which is full of rich description of an event and those involved. They continue saying that narrative cases have a story quality to them and focus on dilemmas faced and the decisions made by the people involved.

Cases are more than merely descriptions of an event – they serve as a "hands-on" educational methods laboratory. The stories form a link between the theoretical and the practical. These descriptions of events represent a "case" of something, i.e., a situation that illustrates an example of a theoretical concept (Shulman, L. (1986) as cited by Shulman, J. 1987). It is much like a science laboratory class in which concepts learned from the textbook are applied in a practical, hands-on type learning activity. For Merseth (1996) cases have three basic components: 1) they are based on real life events or situations, 2) they are used for discussion and debate, and 3) they represent careful research and study of the real life event. In preservice science teacher education classes, cases are a way to evaluate and learn from real class situations. Preservice science teachers, after presentations of the cases, are able to discuss and debate the appropriateness of teacher action. During class discussions the case is related back to relevant theoretical backgrounds. In contrast to simulations, which are controlled and artificial, cases provide a clearer glimpse of classroom reality in all complexities. Three ways that cases may be used in education are: 1) as exemplars, 2) opportunities to analyze and debate action, and 3) to promote teacher reflection (Merseth). For preservice
teachers, visits into the schools may not show the realities of day-to-day classroom interactions; case discussions provide a more complete view of the teaching experience with emphasis on challenges faced in the classroom and the ways in which teachers respond to these challenges. For the inservice teacher exemplary cases provide alternative ways of addressing classroom challenges. Case discussions also provide opportunities for teachers to develop and hone decision-making and problem-solving skills they will need in the classroom. Case discussions are useful tools to promote teacher reflection in that they provide opportunities for teachers to remember similar situations and reflect on their actions. Waterman et al. (1997) maintained that case discussions and reflections on teaching help teachers "reimagine their teaching, their roles and those of their students, and what and how they teach" (p. 6).

Use of Cases in Science Education

For years, students in veterinary medical schools have used "cases" to learn practical application of veterinary medicine. Student groups led by a professor made the rounds of the hospital discussing the patients undergoing treatment. All aspects of the case were discussed in detail thereby allowing each student to acquire knowledge needed to handle similar cases in the future. Similar learning procedures are used in medical schools, law schools, and business schools. Case method learning offers the advantage of instruction that is based on real world problems and the application of "textbook" concepts to address those problems. This approach to learning is being used more and more as an integral part of preservice science teacher education.

Cases are being used increasingly for teacher development in science education. Koballa & Tippins (2000) related that in science education, cases are increasingly
advocated as an effective tool for promoting reflection and strengthening problem-solving skills. The case approach to learning has been used with biology teachers; Waterman et al. (1997) had biology teachers develop a case approach to teaching biology as well as a faculty development course on how to use cases to teach biology. Nichols, Tippins, & Wieseman (1997) described how cases can function as a scaffolding with which to connect theoretical ideas with real-life situations and thereby create personal meaning. Cases also serve to bring together and focus information learned from various sources into a coherent body of knowledge useful for addressing problems common to that field. For example, in veterinary school students may be presented with a case, i.e. a fractured femur. Those students would have learned in class various types of information that play a part in treating this case, i.e., skeletal and muscular anatomy, bacteriology, pharmacology, and surgical techniques. Consideration of this particular case serves as a lens to bring together and focus these various bodies of knowledge into a coherent instrument with which to treat the animal effectively. In much the same way, the case learning approach in education serves to focus various bodies of knowledge related to science teaching and learning and demonstrates how that knowledge is applied in real-life teaching situations.

For this study participants created case narrative stories. These stories consisted of written accounts of a science teaching or learning dilemma. Koballa & Tippins (2000) presented a number of classroom cases each of which present a narrative of a classroom dilemma related to science teaching and learning. In a similar vein, the case narrative stories created for this study represented the participants' personal reflections concerning a specific dilemma related to science teaching and learning; they were
encouraged not to use dilemmas related to discipline matters since they would not be specific to science teaching and learning. The case narrative stories provided participants an opportunity to recount some of the challenges they faced as a science educator and allowed, through analysis of their reaction to the dilemma described, a glimpse of the beliefs they hold concerning science teaching and learning.

**Semi-structured interviews**

Primary data were also obtained through semi-structured interviews. Interviews have been characterized as conversations with a purpose and represent useful tools for gathering qualitative research data for several reasons. In studies concerning participants' life stories or experiences it is usually not feasible to recreate those experiences; therefore, interviews are useful for helping a researcher reconstruct those experiences from the participants' memory. Data concerning a person's thoughts and feelings can be effectively elicited using this method. Merriam (1998) described three categories of interviews ranging, in a continuum, from very structured, questionnaire type formats to semi-structured interviews to open-ended, conversational type formats. The highly structured interview consists of predetermined questions in which the wording of the questions as well as the order of items has been pre-selected. This type of interview represents an oral form of a survey that allows the participant little or no opportunity for input into the types of questions asked, limited control over the direction the questioning may lead, and few chances to voluntarily offer personal perspectives, thoughts, feelings, or experiences. This type of interview is used mostly for gathering sociodemographic data from participants. The semi-structured interview contains a mixture of questions ranging from structured to unstructured. This type of interview allows the participant to
respond to some of the questions in a more free form manner thus allowing for more exploration of the respondent's personal thoughts, feelings, and perspectives. The third type of interview is the unstructured, informal interview in which there is no predetermined set of questions and the interview is an exploration of the respondent's thoughts, feelings, and perspectives (Merriam).

Merriam (1998) stated that interviewing is necessary when it is not possible to observe the participants' behavior, feelings, or "how people interpret the world around them" (Merriam, p.72). As Patton stated, "We interview people to find out from them those feelings we cannot directly observe.... The purpose of interviewing, then, is to allow us to enter into the other person's perspective" (Patton, 1990, p.196). This study entered the world of three second career science teachers to examine their life experiences in science, their journeys into the world of school science, and their beliefs concerning science teaching and learning. The interview represented an effective tool with which to probe the participants' personal perspectives.

**Interviews in science education**

Researchers in the field of science education are increasingly making use of qualitative methods; interviews are often a part of the data collection. The following are a few examples of the research studies in which interviews were utilized. In a 1984 study, Duschl & Wright explored teachers' beliefs about the nature of science utilizing a combination of informal and formal, audiotaped interviews to obtain data concerning teacher's beliefs. Gallagher, in his 1991 study of prospective and practicing teachers' knowledge and beliefs about the philosophy of science, used interviews to obtain data concerning the beliefs and knowledge of the teachers who were a part of the study.
Kagan & Tippins, in their 1991 study of methods by which to help student teachers develop an awareness of student cues, used a combination of semi-structured and structured interviews to guide students' reflections of the lessons they had taught as they watched videotapes of those lessons. These interviews were audiotaped, transcribed, and used as the raw data for the study. A questionnaire was designed and used by Shymansky, Yore, & Good, 1991, to assess elementary school teachers' beliefs and perceptions about elementary school science. Kagan & Tippins (1992) used phone interviews to clarify one aspect of the lesson plan log books the teachers had prepared and submitted. In a study dealing with dilemmas of laboratory science Tippins, Tobin, & Hook (1993) used interviewing as a primary source of data. Tippins, Tobin, & Hook (1993) also used interviews as a primary datum source in a study of ethical decisions in teaching. Crawley & Salyer, in a 1995 study of life science teachers' beliefs concerning curriculum reform in Texas used a combination of written questionnaires and semi-structured interviews to access the beliefs of these teacher participants. Haney, Czerniak, & Lumpe (1996) in a study of teacher beliefs and intentions regarding the implementation of science education reform strands used questionnaires and interviews to obtain data concerning teacher beliefs and intentions. Hashweh (1996) in his study of teachers' epistemological beliefs used questionnaires to identify those beliefs. Adams & Crockover (1997) used teacher interviews in a study of teacher cognition in beginning science teachers to obtain information concerning beginning science teachers' content knowledge, pedagogical knowledge, pedagogical content knowledge, and beliefs about science. These studies represent a few examples of the ways in which interviews are used for research in the field of science education. In general, interviews are used as
primary data sources when information concerning an individual’s thoughts, beliefs, knowledge, perspectives, or understandings is desired.

For the collection of these data, four semi-structured interviews exploring the life stories of each participant were conducted. The first interview was designed to elicit information concerning background information and the process by which each participant was certified. The second interview explored the life stories of the participants including their science legacies. The third interview investigated the place of science in their life stories, personal teaching metaphors, and their teaching beliefs. The fourth interview examined the factors which led the participants to a career in school science and the nature of the borders negotiated by each participant as each made the move to school science.

Image-based research

Another primary datum source for this study was photoessays constructed by the participants. The use of photography in research studies has its roots in the fields of anthropology and sociology. In the early 1900s, anthropologists utilized photographs to provide visual records to classify races and to document information concerning the evolution and development of different cultures (Harper, 1998). Due to a shift in research focus, anthropologists lost interest in using photographs; however, in 1942, Bateson & Mead brought back the practice of using photographs as a datum source in their study of Balinese culture. Their work with the inhabitants of Bali utilized much visual data. The pair had studied and written about the Balinese for ten years when they turned to photography because "we are attempting a new way of stating… relationships…By the use of photographs, the wholeness of each piece of behavior can be
preserved..." (Harper, 1998, p. 25-26). The use of still photography in anthropological research has not developed much beyond this work and, while the emphasis of visual anthropology has shifted to the use of video and films, use of photographs has faded from this discipline (Harper). Researchers in the field of sociology began using visual information in the 1960's. Photographs were used primarily to publicize social problems of the day, i.e., drug problems, black ghetto life, and the civil rights movement, in order to educate the public. There later developed a rift between photography and sociology. There developed a belief that the scientific reputation of sociology would suffer if there were continued utilization of photographs in scientific studies (Prosser, 1998).

Today research involving photography has returned to favor as a research method in light of new ideas concerning social research, i.e., the collaboration between the researcher and the participant, the granting of "voice" to the participant, and the significance of the participant's perspective. Photographs are used as one method to facilitate collaboration between researcher and subject and photography has again come into vogue with researchers in the social sciences. The use of photography unites both researcher and participant; the participant looks at the photograph and relates to the researcher the personal significance the image carries. Photography has been used in several ways in educational research. One method, termed photoelicitation, is defined by Prosser & Swartz (1998) as "a single set of photographs assembled by the researcher...and selected with the assumption that the images will have significance for the interviewees" (p. 124). Harper (1998) described photoelicitation as a modification of an open-ended interview in which photographs replace questions as the means of generating responses. This technique promotes collaboration between the researcher and
the participant in that, although the photographs are generated by the researcher, the participant knows the meanings held by the images; in this respect the participant is the "expert" regarding the meanings of the photographs while the expert knows nothing regarding the significance of the images (Harper). Photoelicitation can take two forms: the photo-interview and the photoessay. Collier & Collier (1986) described the photo-interview in which researcher produced and selected photographs are used as questions to guide and focus the discussion. The photo-interview has an advantage in that "Photographs sharpen the memory and give the interview an immediate character of realistic reconstruction" (Collier & Collier, p. 106). Dempsey & Tucker (1991) expressed a similar thought; that photographs trigger recall because participants tend to react to visual cues more carefully than written or spoken ones. A related use of photographs, photofeedback, is a process in which participants view photographs and are then instructed to write their responses and reactions to the photographs.

Other researchers have enlisted participants to be photographers. Harper (1998) viewed this form of photoelicitation as a method that "promises a particularly apt alternative; a model for collaborative research" (p. 36). Researchers Caroline Wang & Mary Ann Burris (1997) gave cameras to their research participants and asked them to take photographs. These researchers through the use of photography gave their participants a voice in describing the social structure of their community with an eye toward identifying areas for change. Thus they coined the term "photovoice" to describe this type of data collection. Archival photographs may be used in much the same way as researcher or participant generated photographs serving as prompts to enhance the memories of participants.
Image-based Research in Science Education

Over the decades photography has served an integral role in the documentation of evidence related to scientific discoveries. The camera was used to provide conclusive evidence to support scientific evidence, such as new species of animals, phenomena such as tornadoes, and hurricanes, as well as archeological findings. Despite a long history of the use of photography in science, there is little reference in the literature on the use of photography as a tool in science education research. Nichols & Tippins (2000), utilized photoessays as a tool to explore the views held by preservice elementary teachers in regard to teaching and learning science. They asked the preservice teachers to take photographs and develop oral narratives describing the significance of the photographs.

For my study, I chose to enlist my participants as photographers. I asked them to photograph scenes, people, objects, etc. of science significance; alternatively, some used archival photographs selected from personal collections. The combination of participant’s photographs and the accompanying spoken and written elicitation can be used to create photoessays (Sampson-Cordle, 2000). For this study participants created photoessays by selecting a series of photographs of significance to their science life story and then writing a written description of the significance of the photographs.

Supporting Data Sources

Historical timeline

A modification of autobiography is the historical timeline; a technique in which a person represents the major events in their life in diagrammatic form. This form of autobiography, since it relies on diagrams, has the advantage of showing chronological relationships between events in a way that is easier to understand. Nonverbal means of
depicting life events has a long tradition, dating back to prehistory. For eons before the written word people communicated with drawings/symbols, i.e., petroglyphs used by Native Americans in the Southwest United States, the totems of the Northwestern Native American, and the cave paintings found in Europe. These drawings/symbols told stories for later generations – the family histories, traditions, clan history, etc. In the absence of written language these symbolic representations were key to the preservation of that group of people. The historical timeline is a modern day extension of these graphic stories.

Use of Timelines in Science Education

For most studies autobiographical information has focused on the written word; Nichols & Tippins (2000) explored the utility of using diagrams or drawings to express personal beliefs and Nichols et al. (1997) investigated drawings as a method to display life experiences. A historical timeline is another use of diagrams to represent major events in a person's life. A person might draw pictures presenting significant events in their life and include a brief description of the drawings while others might write a description of their significant events and place them along a timeline.

In this study the historical timeline was used as an adjunct to a written autobiography. The historical timeline visually depicted significant events, memorable experiences, and important experiences related to science teaching and learning that took place in each participant's life; it was used to facilitate inquiry concerning the relationships among the major events in the lives of the participants.
Metaphors

Personal metaphors served as a supporting datum source; they represent a third type of personal document utilized in this study. Personal metaphors provided information concerning the beliefs that these teachers held in regard to science teaching and learning. Teachers bring their own belief systems to the classroom; these personal frameworks concerning the role of teacher are shaped, in part, by classroom and teaching experiences. These assumptions can affect the teacher's actions in the classrooms and thus affect student learning (Marshall, 1990). The actions that a teacher takes in the classroom are guided by their understanding of what has worked in the past under similar conditions. These decisions are usually made at the subconscious level and evidence suggests that teaching metaphors play a significant role in guiding the actions teachers take (Tobin & Ulerick, 1989 as cited by Tobin et al., 1994).

In the early 1900's John Dewey promoted the idea of being a reflective thinker. According to Dewey we reflect in order to gain an accurate and full appreciation of the significance of our experiences. Dewey's ideas on reflective thinking and learning naturally link with Schon's (1987) ideas of knowing-in-action, reflection-in-action, and reflection-on-action. The term knowing-in-action refers to the performance of tasks one does well intuitively with little conscious thought. The process of reflection-in-action involves the rethinking and evaluation of some part of an activity that may help shape future actions. Schon (1983) discussed a related thought process he terms reflection-on-action in which past actions are recalled and evaluated. One might puzzle over an event many times and then suddenly "see" that event in a different way and be able to solve that particular problem; this is what Schon referred to as "reframing". Mumby & Russell
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(1990) have tied together the ideas of metaphor and reframing in a study of 13 inservice teachers. In their research on the development of teachers' professional knowledge, Mumby & Russell described how analysis of teaching metaphors can reveal aspects of one's professional knowledge and are a necessary part of reflection and reframing.

Metaphors are one way to gather knowledge that teachers have gained through the act of teaching. Mumby & Russell (1990) believed that such knowledge is constructed through the use of metaphors and that examining personal metaphors is one way to understand how teachers view their profession and professional activities. Bullough (1991), working with preservice teachers, used metaphors to encourage self-reflection upon deeply held assumptions concerning the role of a teacher and found metaphors to be a useful tool for exploring beliefs concerning teaching and learning. Bullough & Stokes (1994) studied preservice teachers and the use of metaphors to encourage professional development. They found that not only did analysis of personal teaching metaphors help beginning teachers to reflect on their deeply held assumptions regarding themselves as teachers but also to embrace new concepts of teaching and thereby encourage them to be more conducive to professional development and change. Provenzo, McCloskey, Kottkamp, & Cohn (1989) suggested that "exploration of teacher metaphors ... can lead to the identification of critical events in teaching and how the teacher experiences them" (p. 571). Not only are metaphors helpful in guiding teacher reflection, they can help teachers understand their own concept of the role of a teacher. Bullough (1991) stated that "metaphors represent teachers' understanding about teaching and their conceptions about themselves as teachers..." (p. 43-44). In summary, the metaphors teachers hold concerning teaching and learning are one means by which to understand how teachers
view themselves as teachers, methods for helping teachers reflect on their assumptions regarding themselves as teachers, and a way to promote professional development and teacher change.

**Metaphors in Science Education**

Many researchers have explored the use of metaphors to effect teacher change in science education; some studies focused on preservice science teachers while others focused on in-service teachers (Briscoe, 1991; Nichols et al., 1997; Tobin, 1990; Tobin & LaMaster, 1995; Tobin & Tippins, 1996; Tobin et al., 1993; et al.). Tobin (1990) described metaphors as a "master switch" for changing teacher practices; i.e., metaphor change can initiate changes in science teaching beliefs and practices. Briscoe (1991) in a case study of a high school chemistry teacher explored the role of metaphor in teacher change. The results of this study supported previous research that suggested that teaching metaphors have an impact on teaching practices. Further, teaching metaphors play a role in determining the manner in which curriculum modifications are adapted and implemented. Tobin & Tippins (1996) discussed how metaphors are similar to analogies in that they help teachers see situations in a new way. Teachers use analogies to help teach a new concept by comparing it to something already known. This helps students learn a new concept; for instance, an atom is like a tiny solar system. A teaching metaphor represents a similar type of comparison that helps identify aspects of teaching that are difficult to describe literally. For instance, one might compare her/his teaching role to that of a gardener or a policeman; each metaphor would imply certain beliefs concerning science teaching and learning. The metaphor serves as a link between well understood experiences and new, poorly conceptualized experiences thus promoting
understanding of the new experience, i.e., the known is compared with the unknown (Nichols et al., 1997). A study by Tobin & LaMaster (1995) described the professional development of a first year science teacher and documented the relationship between reflection and metaphor in the process of change. Through the process of active reflection, i.e., writing in a journal, the participant came to believe that she needed to change the way she taught and she needed help in making positive changes. Through the process of metaphor analysis she was able to view her role of a teacher in a new and different light and, therefore, changed her beliefs concerning science teaching and learning. This change in beliefs, facilitated by the analysis of metaphors, altered the way she conducted her classes.

For this study, metaphors were used to explore the teaching beliefs of three second career science teachers. Participants were asked to write three metaphors describing: themselves as a science teacher, the ideal science teacher, and their understanding of a science curriculum that best meets the students’ needs. In the construction of these documents the participants were instructed to focus on their feelings, emotions, and beliefs.

Journals and their use in Science Education

A fourth type of personal document that served as a supporting datum source for this study was participants' personal journals. Journals are yet another form of widely used autobiographical data; used so frequently that Nichols et al. (1997) regarded journals as a primary tool used for teacher education. Maas (1991) in a preservice elementary teacher program used journals to gather personal experiences from the students specific to teaching and as a stimulus for class discussions. Volkmann &
Anderson (1998) used journaling to explore the development of personal identity as a science teacher of a novice chemistry teacher. Stuart & Thurlow (2000) utilized journal writing in an elementary science and mathematics methods class to explore the beliefs held by preservice teachers concerning teaching and learning. Clandinin & Connelly (1994) described journals as an effective way for individuals to relate their personal experiences. Journals can be used as an aid to reflection since writing about one's experiences causes that person to relive and rethink those experiences (Cortazzi, 1993). As a teacher writes in her/his journal, they are reliving that experience; later, as they reread and reflect upon that experience, different meanings may be constructed. The act of writing down experiences is one way to see what happened in a different light, to understand the events in a different way, and perhaps speculate on changes in behavior that might promote a more positive outcome when faced with similar events in the future. Nichols et al. (1997) described three forms of journals used in teacher education: the personal journal, the dialogue journal, the roving journal. A personal journal is meant for that writer's personal reflection. The other two types of journals are meant to be shared: the dialogue journal is exchanged between two or three writers over time – like a conversation. Written dialogue journals prompt reflection by providing teachers the opportunity to relive and learn about what they know, feel, do, how they do it, and why they do it (Maas). A personal journal can become a dialogue journal as in the Volkmann & Anderson study; what started as a personal journal for the participant grew into a dialogue journal as she shared it with her supervising teacher. This prompted the supervising teacher to reflect back on his own first year of teaching and thereby prompting journal dialogue. A roving journal is randomly exchanged between a larger
group of people. Black & Halliwell (2000) used journals to record reflections regarding their "group conversations" and to write about situations that were of concern to them. These journal reflections were used to guide group discussions.

In summary, journals have been used in teacher education programs and by teachers as logs or diaries, as conversations, and as a method of reflection. The written journals allow teachers to describe their experiences and provide the opportunity to explore their remembrances with the goal of creating an alternative, more productive experience in the future. Journals provide an opportunity for teachers to discover how they view themselves as science educators and their set of beliefs concerning science teaching and learning.

For the collection of these data, participants were instructed to write journal entries once or twice a week for 18 weeks. These journals consisted of both semi-structured and unstructured entries and were used to contribute information concerning the participants' personal reflections upon their teaching experiences, their beliefs concerning science teaching and learning, their remembrances of the role science has played in their lives and their recollections of the journey into the world of school science. Each week one or two questions were provided to focus their writing. Their journal entries consisted of a written response to a question as well as a reflection upon classroom experiences during that week. Some teachers thought of journals as diaries or logs in which to write accounts of their daily experiences.

Life Learning Maps and Science Education

Life learning maps served as the final datum source for this study. Learning maps are one of the tools used to help teachers critically reflect upon their science teaching
beliefs in relation to their historical, social, and cultural life history (Nichols et al., 1997). A learning map is a graphic representation of events in a person's life, similar to an autobiography, except the goal is not to outline chronology of the events depicted in the map, but to depict connections between events making the map more like a web (Nichols et al. 1997). Often teachers base their learning map on a teaching metaphor and write a reflection on the drawing.

I used the concept of a learning map in a similar way but have expanded it to include not just teaching experiences but also life experiences; for this reason, I have termed these documents "life learning maps". For collection of these data, participants were instructed to represent their life experiences as a science learner as a metaphor; this metaphor was represented graphically with a drawing and notations. Further, they were asked to write a short description of what they drew and why and to reflect upon the impact of these experiences on their learning. The life learning map represented an alternative method of accessing a person's life history.

Procedures

Participants

As I began this project, I knew I wanted participants who had had a previous science career before they started science teaching. This rather narrow research focus influenced the method of sampling that I used and dictated that I use a purposeful sampling method which was described earlier in this chapter. Earlier in this chapter there was a brief introduction of the participants; I would like to now describe the selection process used to enlist the participants in this study. Since I am more familiar with high school teaching I preferred the participants to be high school teachers but I was open to
other grade levels if needed. From other activities related to my education classes, I had accumulated a list of people who had prior careers, one was an elementary teacher, two were in middle school, six were in the local high school. My next step was to determine which of these educators had a previous science related career. My list was narrowed to one middle school teacher and six high school teachers. Since I was more interested in drawing comparisons between teachers with differing amounts of experience, I used a stratified purposeful approach as described by (Patton, 1990). Patton described stratified purposeful sampling as a strategy that involves selection of cases that are average, above average, and below average based on some characteristic. For my study, the sample was stratified by years of experience. I wished to have teachers in three specific groupings: novice (less than five years science teaching), mid-career (six - twelve years science teaching), and experienced (more than twelve years science teaching). Next I asked these people who would be willing to participate in this study. Two mid-career science teachers agreed and one experienced science teacher agreed. To get a novice science teacher, I had to look in other nearby systems. About three weeks into the study, one mid-career teacher dropped out citing that she had too many other demands on her time. Thus the study participants consisted of three second career teachers.

Research Setting

The participants taught in large high schools south of Atlanta. Both were in a semi-rural setting. Two participants, Rosalind and Dave taught in a high school with roughly 1500+ students in grades 9 - 12. Rosalind and Dave's school was located in a town approximately 40 miles south of Atlanta; this town has been referred to as a “mill town”. Until recent times the main industry and employer in the town was a series of
textile factories. In recent years there has been some influx of new industry, however, a significant number of the citizens are still tied to the textile factories. Daffodil taught in a school with 1900 + students in grades 9 - 12. The school in which Daffodil taught is located in a south metro Atlanta county which had been a rural county until recently experiencing overwhelming growth in both industry and population.

Data Collection

Data collection occurred over one school year from preplanning to postplanning during the school year 1999 - 2000. The purpose of this study was to explore how prior career and life experiences mediated the teaching beliefs of three second career science teachers. Specifically, the research questions informing this study were:

1) What are the life stories of second career science teachers?
2) Where is science in their life stories?
3) What beliefs do second career science teachers hold with regard to science teaching and learning?
4) What professional, cultural, and societal borders did these second career science teachers have to negotiate to enter the world of school science?

The process of data collection

As described earlier in this chapter, my study involved collection of multiple layers of data. During preplanning of the 1999 - 2000 school year, participants were asked to write an autobiography and construct a historical timeline. Once the school year had started, the first of four semi-structured interviews took place; the purpose of this first interview was to gather general background information from the participants. Each interview was audiotaped and ranged in length from 1/2 hour to 2 hours in length. Each
Table 2

Data Sources for each Research Question

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Historical Timelines</th>
<th>Auto-Biography</th>
<th>Semi-structured Interviews</th>
<th>Teaching Metaphors</th>
<th>Journals</th>
<th>Case Narrative Stories</th>
<th>Photo-Essay</th>
<th>Life Learning Maps</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the life stories of second career science teachers?</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Where is science in their life stories?</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>What beliefs do second career science teachers hold with regard to science teaching and learning?</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>What professional, cultural, and societal borders did these second career science teachers have to negotiate to enter the world of school science?</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Table 3

Timeline of Data Collection

<table>
<thead>
<tr>
<th></th>
<th>Auto-biography</th>
<th>Historical timelines</th>
<th>Interview 1</th>
<th>Journal writing</th>
<th>Case Narrative Story</th>
<th>Photo-essay</th>
<th>Metaphors</th>
<th>Interview 2</th>
<th>Life Learning Map</th>
<th>Interview 3</th>
<th>Interview 4</th>
</tr>
</thead>
</table>
interview was guided by a set of questions prepared in advance (See Appendix A); however, all interviews deviated from the prepared protocol and became more conversational in nature. Each interview was transcribed and a copy of the text given to the participant as a member check. Also their journal writing began near the start of the school year; the journal writing lasted approximately 20 weeks. Journals were checked at approximately four week intervals to provide an opportunity for me to read through the journals and form additional interview questions as well to monitor the participants' progress and address any issues related to the journal entries. Participants were given general instructions (See Appendix B) and weekly questions (See Appendix B) with which to focus their thoughts; they were also asked to reflect upon the week that had just ended and comment on any issue related to science teaching and learning. Information gleaned from the first interview was used to formulate later journal questions as well as additional interview questions. Near the middle of the fall semester they were asked to write their case narrative story. Each participant was provided instructions (See Appendix C) and the opportunity to read examples. Towards the end of the first semester, teachers were asked to begin their photoessays. Instructions (See Appendix D) regarding photoessays were given and an example was available for participants to study. One teacher, Daffodil, did not participate in this datum source saying that it was too painful. Regardless of how much I questioned her, Daffodil would not consider completing a photoessay, nor would she say why she would not. Near the beginning of the second semester the participants were asked to write their teaching metaphors. Each participant was given instructions (See Appendix E) and several metaphors written by other teachers were available for the participants to view. The second interview was conducted around
the same time. The second interview focused on science legacies, academic influences and connections between prior career and science teaching. As data were received from the participants they were analyzed and reviewed and used to inform later data collections. In the spring of the second semester participants were asked to complete their life learning maps, with instructions (See Appendix F) as well as an example being provided to participants. The third interview was conducted in the spring of that year; this interview focused on their beliefs. The fourth interview was completed at the end of the school year and focused on reflections of life experiences that led to the world of school science, borders negotiated during the career transition, and beliefs.

Data Analysis

A ton of crude ore is dug from a mine. The next step is to separate, by some process, the valuable metal from the ore. In much the same way data analysis is the process of gleaning valuable meaning from mountains of raw data. Bogdan & Biklen (1998) described data analysis as a way to understand the data. Data analysis is also defined as the process of making sense of the data (Schwandt, 1997) much like a detective would analyze a crime scene and make sense of the clues present. Marshall & Rossman (1995), described data collection as the process of bringing order, structure and meaning to the data again, much as detectives would strive to do. For me, data analysis was much like panning for gold; the pan was loaded with lots of raw material, within which may or may not reside valuable gems and gold. The miner's job is then to wash away the dross to reveal the valuable materials. In a qualitative study such as mine there were generated large amounts of data within which is lodged meaningful information. The role of the data analysis is to reduce and rearrange the data so the meaning rises to
the top. In my study, data analysis began while the collection of data was ongoing. While transcribing the audiotapes of the first interview and reviewing information gleaned from participants' autobiographies and historical timelines, I made notes of my initial understandings or interpretations. From these notes other journal questions were developed as well as interview questions. I shared these ideas with the participants as a member check.

After completing data collection, I began data analysis using the three steps described by Miles & Huberman (1994); these steps are: 1) data reduction, 2) data display, and 3) conclusion drawing and verification. Data reduction involved coding of the data and the elucidation of themes present within the data. This was accomplished through reading journal texts, interview transcripts, photoessays, metaphors, case narrative stories, autobiographies, historical timelines, and life learning maps and making a list of coding categories. During this stage of analysis, groups of data from multiple sources were placed into categories that related to the research questions and in which all data share a commonality. This is referred to as first level coding by Miles & Huberman and by Merriam (1998) as "the constant comparative method of data analysis". The coding categories were then collapsed into a smaller number of themes that connect two or more categories in some meaningful way. This process, known as pattern coding by Miles & Huberman, united larger blocks of data into more meaningful analytical units known as themes that were emergent within the data. The data were displayed graphically in an organized fashion which facilitated the formation of conclusions. The third phase of analysis, conclusion drawing and verification, involved the process of constructing meaning by making note of patterns present from the data. The processes of
data reduction, display, and conclusion drawing facilitated both within-case analysis and cross-case analysis of the data. This analysis began with the construction of a case record for each case. The case record for each participant consisted of a complete set of all data collected during the study. The case record, as Patton (1990) stated "pulls together and organizes voluminous case data into a comprehensive, primary resource package" (p. 386). For my study, I first completed a within-case analysis for each participant by constructing a detailed description of the case, analyzing themes and tensions present across the data for that case, and providing an interpretation for the themes across the data. The analysis for each participant was completed before constructing a cross-case analysis for each participant because, as Patton stated "trying to both individual case studies and cross-case analysis by issue at the same time will likely lead to confusion" (p. 377). The next stage of analysis was the cross-case analysis in which analysis of themes common across the cases were examined and interpreted.

Role of the Researcher

How did I view my role as a researcher in this study? As I reflect back on the study it seemed to have been like an expedition in which the participants and I searched for treasure in the form of knowledge gleaned from the participants’ experiences. To guide us on this journey, we had a map – the research questions; to uncover the treasure we sought, we had various tools – the data sources. My job was director of the journey – using the map for guidance and directing use of the tools. The participants and I acted as a team to uncover the treasure (data) revealed in this study. One of my roles as researcher in this study was to serve as an active instrument for data collection.
I came to this study with a science background; tools were objects to be used to make measurements. My undergraduate degree was in entomology and I had taught high school science (mainly biology) for 18 years before beginning the doctoral program. The world of science, as I understood it, was positivistic, quantitative, and experimental. It was not until I had entered the doctoral program that I realized there was another paradigm for investigating phenomena – one that is interested in people, how they view their world, and how they construct meaning from their experiences (Merriam 1998). The search for such data required a more intimate collaborative relationship between researcher and the participant; a relationship built on mutual interest, trust, and dedication to the project. My role was as expedition leader in an exploration of the life experiences of the participants.

There was an enormous quantity of data through which to sift in the search for research findings with which to construct meaning. Much as a detective starts with bits of information and no clear picture in mind of the significance of the clues, I had no clear picture of what the results would be as I began analysis of the data. The research findings became clearer as data were analyzed. The findings then had to be written in a form that would be meaningful to other people. A third role that I played in this study was that of a detective/author.

Summary and Preview

In this chapter I have presented the methodological frameworks that grounded the study. A qualitative design that incorporates case study and oral history was most appropriate since this study represented an attempt to create a rich description of the life histories and teaching beliefs of three second career science teachers. The goal of the
study was to explore the beliefs concerning science teaching and learning held by three second career science teachers and to examine the effect of prior career experiences on their teaching beliefs. Specifically, the research questions informing this study were:

1) What are the life stories of second career science teachers?
2) Where is science in their life stories?
3) What beliefs do second career science teachers hold with regard to science teaching and learning?
4) What professional, cultural, and societal borders did these second career science teachers have to negotiate to successfully participate in the world of school science?

Data concerning the participant's life history and life experiences related to science teaching and learning as well as their beliefs concerning science teaching and learning were collected utilizing a variety of oral, written, and visual methods. The primary data sources were autobiographies, interviews, case narrative stories, and photoessays and the supporting data sources were historical timelines, metaphors, journals, and life learning maps. Data were analyzed using the three stage process outlined by Miles & Huberman (1994). Both within-case and cross-case analyses were completed.

Next, I discussed my view of the researcher's role in this study. I discussed the three-fold role I played in the research, i.e., the role of data collection instrument, expedition leader, and detective/author. I explained how each of these roles represented an expansion in my view of how research could be conducted; this could be described as a paradigm shift in my way of thinking about research in general.
In the next chapter, a within-case analysis involving each participant is presented. In this chapter the school settings, educational background of the participants, and their life stories will be more fully discussed. The role of science in their life stories and their careers will be explored as well as the impact of their first career on their science teaching career. Finally, their beliefs concerning science teaching and learning will be presented as well as the impact of their science background upon their beliefs.
CHAPTER 4

PORTRAITS OF THE PARTICIPANTS:

WITH-IN CASE FINDINGS

The purpose of this study was to explore how prior career and life experiences mediate the teaching beliefs of three second career science teachers. Three second career science teachers were chosen for the study using purposeful sampling. The researcher selected an experienced science teacher (having more than 12 years in the classroom), a novice science teacher (with less than five years of classroom experience) and a mid-career science teacher as study participants. A variety of primary and supporting data collection methods were used in this study to gather information through oral, written, and visual means. Oral data were collected using a series of semi-structured interviews; written data were collected through autobiographies, case narrative stories, journals and teaching metaphors; visual data were collected through photoessays, life learning maps, and historical timelines.

Through these methods, participants shared meaningful, often intimate, recollections and deeply held beliefs concerning their lives, their careers, and their crafts. This chapter presents a with-in case analysis of data to identify unifying themes present across the data sources which shed light on each participant’s response with respect to the questions of interest to this study.

The first research question, "What are the life stories of second career science teachers?" sought to understand what life experiences may have impacted each
participant and led them to a second career as a science teacher. The next question, "Where is science in their life stories?" explored the role science as a discipline and as a way of understanding the world has played in their lives and how their careers in science may impact their conception of science teaching and learning. The third question, "What beliefs do second career science teachers hold with regard to science teaching and learning?" explored the personal understandings of the participants with regard to the process of science teaching and learning.

**My use of the term "teacher belief" in this study**

What teachers believe has been the focus of many studies in science education. Numerous topics related to what teachers believe concerning science teaching and learning have been explored. Several researchers, Agne et al., 1994; Greenwood, Olejnik, & Parkay, 1990, examined teachers' beliefs in regard to their ability to positively affect student learning. Other researchers, Cronin-Jones, 1991; Czerniak, Lumpe, & Haney, 1999; Eisenhart et al., 1990; Haney, Czerniak, & Lumpe, 1996, examined teacher's beliefs regarding policy and implementation of curriculum. Other researchers, such as Hasweh (1996) studied teachers' epistemological beliefs. Weinstein (1989) and Schmidt & Kennedy (1990) explored teachers' beliefs concerning the responsibilities of teaching. The role of metaphors in helping teachers realize and modify their beliefs concerning science teaching and learning were studied by Tobin & LaMaster (1995) and Briscoe (1991).

Whereas these researchers were examining specific beliefs held by teachers, the focus of this study was somewhat different. The participants in this study were asked nonspecific questions concerning their beliefs with regards to science teaching and
learning. What emerged through the data, rather than reflecting the participants' responses with regards to specific beliefs was the more personal perspectives with which the participants approached science teaching and learning. While throughout this document the term beliefs was used to label the understandings that emerged through analysis of the data, these understandings more correctly represented the personal perspectives or frameworks of the participants from which they entered the field of science education. These frameworks give some idea of how the participants view science teaching and learning.

The fourth question, "What professional, cultural, and societal borders did these second career science teachers have to negotiate to successfully participate in the world of school science?" explored each participant's journey into the world of school science including certification, family, financial, and professional issues confronted along the path. What follows is the presentation of each participant's life story represented as a complex multi-colored image created through data analysis and interpretation. My goal in this chapter was not to present a linear explanation or expose on each research question, but rather, to present the complex story that represents each participant’s life experiences in ways which explore responses to the research questions. To that end, what follows is each participant's life tapestry woven from themes present in the data and representing a convergence of data threads assembled in ways which have meaning for both researcher and participant. Participants are presented in the order of teaching experience: novice, mid-career, and experienced. For each participant the relationship between each theme and the relevant research question is presented in the following data tables.
Table 4: Themes for Question 1

**Question 1:** "What are the life stories of second career science teachers?"

<table>
<thead>
<tr>
<th></th>
<th>Daffodil</th>
<th>Dave</th>
<th>Rosalind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return to roots</td>
<td>Grafting the branches</td>
<td>The rebel returns to her roots</td>
<td></td>
</tr>
<tr>
<td>Voyage to collegium</td>
<td>Influence of heroes</td>
<td>On the shoulders of giants</td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Themes for Question 2

**Question 2:** "Where is science in their life stories?"

<table>
<thead>
<tr>
<th></th>
<th>Daffodil</th>
<th>Dave</th>
<th>Rosalind</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is science but life?</td>
<td>Science defines life</td>
<td>Combining loves</td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Themes for Question 3

**Question # 3:** "What beliefs do second career science teachers hold with regard to science teaching and learning?"

<table>
<thead>
<tr>
<th></th>
<th>Daffodil</th>
<th>Dave</th>
<th>Rosalind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing the torch</td>
<td>Kindling the fire</td>
<td>Sharing the passion</td>
<td></td>
</tr>
<tr>
<td>Learning to do, learning to teach</td>
<td>Teaching with blinders on</td>
<td>Bringing the lab to the classroom</td>
<td></td>
</tr>
<tr>
<td>Adjusting the vision</td>
<td></td>
<td>Preparing for the 21st century</td>
<td></td>
</tr>
</tbody>
</table>
Table 7: Themes for Question 4

Question 4: "What professional, cultural, and societal borders did these second career science teachers have to negotiate to successfully participate in the world of school science?"

<table>
<thead>
<tr>
<th>Daffodil</th>
<th>Dave</th>
<th>Rosalind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing in midstream</td>
<td>Certification: Spinning my wheels</td>
<td>Hurdles</td>
</tr>
</tbody>
</table>

Daffodil: A chemist in the classroom

>To me, science is any endeavor that seeks to uncover the basic truths about our physical universe and to organize those truths so we can see an order which leads to an understanding and appreciation of that universe. (Daffodil, Journal entry 3)

Daffodil is a novice teacher, in her first year of teaching. She is a second career science teacher, wife, and mother of two teenage daughters. Her husband is also an educator at a local community college. Daffodil has a strong background in science having earned bachelor's and master's degrees in chemistry and lacks only completion of her dissertation to earn a doctoral degree in chemistry. She came to the world of school science after a career in the military where she commanded a chemical unit in charge of water decontamination. In this section, you will learn more about Daffodil, her life story, a synopsis of her career path, how she became interested in science teaching and science, how science has impacted her life history, her beliefs concerning science teaching and
learning, and the professional, societal, and cultural borders she negotiated in her journey to the world of school science.

In Daffodil's discussion of her beliefs regarding teaching and learning, two themes emerged with reference to the tension she perceives between her personal beliefs concerning the process of science and the school science curriculum she is required to follow, and the tension produced by the importance she places upon science and the apathy of many of her students. When remembering her science career and the borders she negotiated to enter the world of school science, two themes were evident, one concerning gender issues she faced and the other concerning challenges with regard to teacher certification. With regards to her life story and the role science has played in this story, three themes came to light which present a picture of Daffodil as a life long devotee of science and learning and reveal Daffodil's journey to the world of school science as the convergence of her devotion to science and learning.

Question 1: "What are the life stories of second career science teachers?"

Daffodil was born in Buffalo, New York, into a family where knowledge and education were highly valued; her father was a tool and die maker and an amateur inventor. "...he never invented anything that got him anywhere but he had all these little gadgets and he designed and built his own house" (Interview 3/24/00). Daffodil's mother wanted to pursue a medical career as a nurse but was unable to obtain the education required to fulfill this dream. Daffodil has two younger sisters; one is a nurse, the other is a lab technician. Daffodil learned to read at the age of three or four; her mother took her to the library frequently so that she could read books about things that interested her. At home, to feed her curiosity, Daffodil would read the encyclopedia "starting with [Vol.]
A and working through [the set]" (Interview 3/24/2000) especially enjoying the overlays of how living organisms, objects, and devices were put together. In Daffodil's home, academic achievement was expected and highly valued. Her parents set strict guidelines for Daffodil and her two sisters concerning academic performance and achievement. Daffodil did well in school, demonstrating high academic ability at a young age, participating, while in the fifth and sixth grades, in pilot gifted classes at her school. When Daffodil was in high school, she began to feel a desire to tell other people about the things she had learned. In her neighborhood she set up science day camps for other children and conducted these impromptu science classes for all that were interested. It was during these neighborhood science camps that Daffodil realized how much she enjoyed sharing her knowledge of nature with others. She was excited about the things she had learned and wanted others to share in her excitement.

Daffodil's interest in science investigations led her to pursue an undergraduate degree in chemistry and biology. Her interest in chemistry continued and led her to continue her college education in that field. While a graduate student, she conducted research on the biochemistry of albumen and hemoglobin and later worked in a lab studying the enzyme cytochrome C in spinach. She earned a master's degree in Chemistry and completed all requirements, with the exception of the dissertation, for a Ph.D. in Chemistry. Daffodil had the unfortunate experience of her thesis advisor leaving the college at which she was conducting her research; no other professor would pick up a student at this stage of their doctoral program. Daffodil was told, to complete her dissertation, she would be required to begin and complete a new research project. She elected not to pursue the dissertation. After college she joined her husband in the
military. During her twenty year career in the Army, she commanded a chemical unit in charge of decontamination procedures. During this time, she and her husband began raising their family – two daughters. After her husband's retirement from the military, the family moved to a suburb of Atlanta where he accepted a professorship in the Department of History at a local community college. This was when Daffodil returned to college once again – this time to obtain a science teaching certificate and return to sharing her love of science with others.

**Theme 1: Return to roots.** Daffodil's journey to the world of school science seems to reflect a return to three things she loved as a child: 1) a love of science, 2) a love of academics, and 3) a love of sharing with others. As a young person, she was curious about nature and that lead her to seek out more and more information about the scientific explanations that underlied her observations. As a child, science emerged as one of the three great interests in her life.

*I also remember liking to explore the world around me...I walked everywhere, and could tell you about every plant, animal, and rock along the route, and every constellation in the night sky.*  (Autobiography)

*I had a kitchen chemistry set and I fiddled with it. I did a little kitchen chemistry; mixed the baking soda with vinegar and let’s see what happens...*  (Interview 3/24/00)

Perhaps the second great influence in her life, the love of academics, sprang from the emphasis her parents placed upon learning and achievement; this love of learning has resulted in Daffodil's lifelong record of high achievement.
...homework was a priority and that, uh, teachers were to be respected...and, even, even, teachers who were not good teachers. They deserved our respect; our encouragement... My parents were, I think, were intellectually curious; but didn't have the wherewithall to pursue this curiosity and so it was important to them that we get far in school...and while in school it was different for each of us. I, I was supposed to have straight A's. There was not question. My middle sister struggles academically and got, she got alot of C's but failures were acceptable for her. My younger sister was supposed to be straight A's again....And while they couldn't do alot to help us, they certainly made sure that whatever support we needed was available to us. They did what they could to help us....they encouraged us to do academic stuff. (Interview 3/24/00)

Daffodil's desire to enter the science classroom perhaps had its roots in the neighborhood science camps she organized while in high school. She would lead the children in science investigations and teach them some of what she had learned about nature. At this time she realized she enjoyed sharing her knowledge and experiences with others.

*When we moved to the suburbs while I was in high school, I thought it might be fun to share some of what I knew, so I set up a science day camp for the neighborhood kids. We made water-drop magnifying lenses and looked at pond scum. We collected rocks and used a field guide to identify them. We even stayed up late to do some star-gazing, I probably could have made a fortune that summer, but I didn't even think about charging*
for what I was doing. All I wanted to do was share what I knew and maybe ignite a passion for knowledge in one of those kids. I found that I enjoyed teaching and had a knack for it.... (Autobiography)

After high school, Daffodil entered Wells College in New York State, continued to pursue her interest in science, and graduated with a BA in Chemistry. Her graduation was especially important to her since she was the first person in her family to earn a college degree. After graduating with her BA, she worked as a laboratory technician at Georgetown University as she pursued a graduate degree in biochemistry. Her academic career also took her to the University of Michigan where she worked as a research technician in the field of immunology and to the University of Louisville where she began work on her doctorate in chemistry. Unfortunately, her major professor later moved out of state and there was no one willing to take up a graduate student in her particular field of research.

I actually got to the point of writing, but my advisor left and the department decided that I would need to complete a new research project, so I quit instead. I loved the research, but wanted to get on with other things. (Autobiography)

She then enlisted as a Chemical Laboratory Technician in the US Army Reserves. Throughout her graduate career, as she pursued advanced studies in chemistry, Daffodil also had the opportunity to utilize her love of sharing information as a graduate assistant at the various universities she attended; for example, Daffodil taught laboratory classes and held tutoring sessions. "I rediscovered my love of teaching during grad school and wanted to develop that interest" (Autobiography).
While in the army Daffodil commanded a chemical decontamination unit. Again she found opportunities to combine science and her love of teaching as she instructed recruits in the procedures to carry out their missions.

*I think pretty much everything I've done ...you have knowledge that needs to be shared and what is teaching but sharing knowledge. And I can't think of a job that didn't involve teaching.... when you're out there in the field in the military, you look around for the best way to do something and then try to teach as many people as you can how to do it that way...*

(Interview 3/24/00)

When the time came in her life to consider a second career, teaching was the obvious choice. It seems the choice of science teacher reflected a return to what she had first loved as a child, i.e., science, academics, and the sharing of her science knowledge. In her life, there have been repeated instances in which Daffodil combined her love of science with her love of teaching both formally and informally. First as a child in her neighborhood science camps, later in graduate school where she taught and supervised laboratory classes, and eventually in the army where she taught the troops under her command the processes and procedures needed to complete the tasks required.

*I had taught chemistry, physical science, and computers at a community in Kansas for a while, and pursued my military career I started in Kentucky accepting my second command of a chemical detachment and teaching chemical defense. I never lost my interest in science and kept current now and then and remaining active in the American Chemical Society. It finally struck me that perhaps I should combine my love of*
teaching with my love of science and become a high school science teacher.  (Autobiography)

Theme 2:  Voyage to collegium.  As Daffodil has pursued her scientific curiosity through graduate school and her chemical career in the army there have been challenges related to gender.  Despite her intelligence, academic achievement, and her chemical experience, her professional career has, in some ways, reflected a voyage to collegium – a journey of acceptance into the often male dominated world of science; a quest to attain the status of colleague in the true sense of the word – equal in standing and in respect.  The gender related issues Daffodil has faced range from faulty assumptions based on gender to verbal, overt, sexual harassment.  Through these episodes Daffodil has "kept her cool", has not been distracted from her career goals, and has retained her love of science and curiosity about the natural world.  One episode occurred when she was applying for a chemistry position.

Once I got my degree and started looking for a job, um, this was the late sixties and early seventies, I have an ACS certified degree in chemistry, I had some ungodly number of hours in chemistry, and I went to interview with this one company; he told me, "I'm sorry dear, there's no openings in our steno pool!"  They gave group interviews; and I was the only woman in this group of five; I had a BA in chemistry, because the college I went to did not give a Bachelor of Science, only a Bachelor of Arts; but I had more chemistry courses than any other prospective employees in that group; and the other four got jobs.  (Interview 3/24/00)
This brush with unfair hiring practices did not deter Daffodil from her career goals; in fact, the episode served only to strengthen her resolve to pursue her career. Daffodil continues her description of the above incident: "So at that point, I thought, being the person I am, if someone says, 'I'm sorry, you can't do that', I'm going to say, 'Oh, yeah? Watch me!'" (Interview 3/24/00).

Another instance Daffodil related occurred when she was a graduate student teaching a Physical Chemistry laboratory. "I had one student who was from Sierra Leone who thought that women just don't, are not smart enough to be able to teach and therefore, I couldn't teach him...He failed my lab...." (Interview 3/24/00). This student was black and the issue of race was also raised after the student received a failing grade. Daffodil continues to relate the tale: "He failed my lab and the student went to the Dean and complained that I failed him because he was black and I was prejudiced....But his attitude was I was a women and I couldn't, couldn't do anything, be anything" (Interview 3/24/00). The Dean investigated the student's charges and found them to be without merit.

A third incident Daffodil related occurred while she was in the army. Some of the men in her field command attempted to embarrass her and thereby undermine her authority and ability to lead the group. She relates the story: "They got an issue of Playboy and walked up and [said], 'Hey, what do you think about that?' You know. Right in [my] face. Well I'm sure the typical reaction is 'How dare you?' They do it to me and I say, 'Ah, no, I’ve already seen that one. Got anything more recent?'" (Interview 3/24/00).
Daffodil related these stories and others with a degree of humor. It is obvious that these unfortunate episodes did not deter Daffodil from her life's work. In each instance Daffodil seemed to be able to use her innate intelligence to turn the situation around and embarrass the instigator. While episodes such as these represent significant events in Daffodil's life story, due to the way Daffodil responded, they have not had a significant effect on her career.

...I don't pay attention to that kind of stuff [gender issues]; so it may have been there and I just didn't see it; but everything that I wanted to to do I've been able to do. The things I haven't been able to do have not been because I'm female. It’s just because other circumstances were, were in the way. (Interview 3/24/00)

Question 2: "Where is science in their life stories?"

Theme 1: What is science but life? In contrast to other's understanding of science as a means to explain phenomena and address problems through a systematic research process, Daffodil's understanding of science seems to be a much broader, almost religious belief in obtaining knowledge and furthering one's understanding of the universe. To her, science appears to be a total explanation of the universe and a means for understanding and explaining events that occur. Science is the "lens" through which Daffodil views the world and almost approaches the realm of religion for her in terms of producing meaning for her existence. Her life demonstrates a passion for learning – especially about science. Her interest in nature goes back to childhood as does her desire to learn more and more about her world. Daffodil's life is a celebration of how to understand, through science, the world around her.
We can't exist without biology, chemistry, and physics; and the questions these disciplines bring are what breathe life into the mind and soul. The search for truth and understanding is what it's all about (for me, anyway). How can a person go through life without asking questions and then exploring, experimenting, to find some answers? That's science!! and without it, there is no life. (Journal entry 5)

She has passionately pursued her love of science throughout her life. In her early years, the world around her, nature, was the focus of her interest. She was interested in the world around her and made it a point to ask questions and seek out information about her world. She learned to identify plants, animals, rocks, and constellations. Daffodil continued to pursue her love of science in college where she majored in biology and chemistry. Her choice of a career as a chemist reflected her desire to investigate and better understand the world. Daffodil's curiosity burns bright even today. She states, "if I had to get up in the morning with the thought that I was not going to learn anything today, I wouldn't get out of bed" (Interview 3/24/00). Further, she relates her curiosity to her science teaching. She said, "...science is a way of life kind of thing; if you're not interested in learning then you can't teach. Teaching and learning are two sides of the same coin..." (Interview 3/24/00).

In view of Daffodil's education and military career, it is perhaps not surprising that she considers chemistry to be an integral part of her entire life. Her life learning map, depicting her life as a flask sitting on a ring stand over a Bunsen burner, graphically illustrates her understanding of the connections between science and her life. There is, perhaps, no more recognizable symbol of chemistry than the flask and the Bunsen burner.
and the fact that Daffodil chose the flask to represent and contain her life experiences suggests the integral part science, chemistry in particular, has played in her life. Daffodil has described how human existence, for her, is intimately bound up with the love of knowledge and the desire to continue the active pursuit of greater understandings; this pursuit, for her, is carried out with and through the processes of scientific investigation. It is further illustrative of this point that Daffodil, in her life learning map (See Appendix J), places the flask of her life over the Bunsen burner of truth and knowledge to be heated with the light of understanding.

In my life map, the Bunsen burner, its fuel, and the flame represent the external factors that are the basis for every life. The ring and stand are the other entities that support me and give my life meaning apart from myself. The flask holds my unfolding life. Each bubble holds an important event, whose significance changes as it rises toward the top and whose true significance depends on how it interacts with experiences already in the cloud that has been distilled so far. My cloud mingles and mixes with those of others and it is this mixing that produces true understanding. (Life learning map)

Question #3: "What beliefs do second career science teachers hold with regard to science teaching and learning?"

Theme 1: Passing the torch. One of Daffodil's deeply held beliefs concerning science teaching and learning relates to the legacy we leave our students. Passing the torch conjures up a vision of Olympic runners relaying the Olympic torch from Athens, Greece, to the location of that year's games. For Daffodil, the torch to be relayed to her
students is the light of scientific curiosity. In addition to, perhaps in preference to, a collection of scientific facts and data, Daffodil believes the primary gift we can bestow on our students is the love of science and a deep curiosity about the world. By encouraging curiosity among her students, Daffodil hopes to ignite a lifelong flame of scientific investigation. When speaking of what she desires for her students, Daffodil stated:

*I would like them ask questions...to objectively subject themselves asking themselves why, wondering about the world around us. The main thing I want them to do is to ask questions...to ask questions and then pursue the answers.* (Interview 3/24/00)

This type of scientific curiosity represents what Daffodil considers the most important legacy we can leave for our students. As a science educator Daffodil is concerned with teaching the things she perceives students need to be successful in the 21st century. Rather than a list of facts and figures, Daffodil believes students most need a passionate curiosity for learning and the skills to pursue those questions. She said:

*I think students need the same thing for the 21st century as they needed for every preceding century (and will need for every century to come), that is, a thirst for knowledge and a knack for asking interesting questions. That is science. They need to know how to use whatever tools they have at their disposal (that's technology), but we need to remember that the most important tool is the curious mind. If they know how to work that one, they can figure the rest out.* (Journal entry 16)
Theme 2: Learning to do, learning to teach. Daffodil realizes her prior training and career as a chemist greatly enhances the educational opportunities she can provide her students. Science, to Daffodil, is a "doing" kind of subject rather than simply volumes of information to be regurgitated on tests. She understands science as a way of life, a way of understanding the world, and a process by which to understand the world more completely. In this regard, science is a process of gaining understanding and Daffodil's prior career has given her practical experience in utilizing the process of science. Daffodil's career experiences offer a wealth of practical application and illustrations of concepts taught in the classroom that breathe life into what might otherwise be a dry subject. As she reflected on her educational experiences and career in the Army, she saw ties in three areas between these life experiences and her teaching that enhanced the educational experiences she could provide for her students.

First, from her experiences doing laboratory research, she can breathe life into the often tedious and remote subject of laboratory safety. Often times, students find it difficult to consider such information significant because the situations and cautions discussed are not real for them; they have never worked in a lab and, therefore, they have never experienced laboratory accidents and believe that "it can't happen to me". Daffodil has several anecdotal stories that she shares. When discussing Bunsen burner safety, Daffodil related the story of a freshman chemistry student who decided to remove the rubber band from his shoulder-length hair. In the course of lab work his hair flopped right into the Bunsen burner and he "had a mohawk back when it was not fashionable" (Interview 3/24/00). Another story related to a student who was burned when a beaker of benzene was spilled and set on fire by a Bunsen burner. A third incident related to the
discussion of the gas laws; Daffodil has a story relating to gas pressure that adds realism to the discussion. It seems that an oxygen canister was knocked over and the pressure gauge broke off. The force of the oxygen leaving the tank sent the tank flying "through three cinder block walls...until it stopped about three inches from the head of a graduate student working in his office down the hall" (Interview 3/24/00).

Secondly, Daffodil's education and prior career give her a vast body of knowledge from which to draw when guiding her students in the science classroom. This knowledge allows her to bring to the discussion of each topic more information than what is presented in the textbook. She believes her prior career adds greatly to the explanation and discussion she can give to each topic.

...if you have nothing to go on...you really don't know more than what the book has. If all you know is one way to do something then you can’t teach it six different ways. So that leaves you more boxed in; you really don't have the options that someone that has the background has. People who have real-world experiences, ...bring a broader perspective; you can cover the subject from more directions, I think that makes it more interesting... (Interview 5/19/00)

Daffodil believes her experience in graduate school as a research chemist provides her with a knowledge base that allows her to more effectively guide students to find the answers to their own questions.

It's very difficult for a person to know chemistry as an education major; that person probably has had three courses in chemistry. And now you're teaching chemistry and you don't really understand the mechanics of
chemistry, so how in the world, when a student asks an interesting
question and you haven't had the courses in inorganic....first of all, you're
not going to recognize it as an interesting question and second you're not
going to have the background or the skills you need to really get students
to pursue that question. (Interview 2/25/00)

Thirdly, Daffodil's chemistry career in the army provided her experience in
leading a diverse group toward a common goal. From Daffodil's perspective, a military
unit is not unlike a science classroom; there is a group of individuals of various
backgrounds and abilities with varying levels of motivation that must be brought together
as a cohesive unit and taught to effectively achieve a goal or complete its mission. In the
science classroom, students bring differing strengths and weaknesses as well as different
degrees of motivation with them. The class must be brought together into a cohesive unit
so that each student can achieve the goal – learning science. In reflecting on her military
responsibilities, Daffodil said:

I think pretty much everything I've done, um, no, every place you go you
have knowledge that needs to be shared and what is teaching but sharing
knowledge. And I can't think of a job that didn't involved teaching, um,
you know, when you're out there in the field in the military, uh, you know,
you look around for the best way to do something and then try to teach as
many people as you can how to do it that way and, and you continue to
look for things that improve the process, and you're willing to take ideas
from whoever gives them, regardless of who they are...And, um, so it's the
same way in teaching and, uh, any other job that you have; I'm not sure
that, that science teaching is any different from any other kind of teaching.

*It's just sharing knowledge.* (Interview 3/24/00)

**Theme 3: Adjusting the vision.** As Daffodil made the move from science researcher into the world of school science one challenge she faced was the differing focus given to science in each field. She has experienced science as a field of inquiry, as a process of learning new information, and as a process of asking and then answering questions concerning the underlying principles that govern nature. Daffodil's threefold experience of science has produced, for her, a vision of science focused on research and the uncovering of new understandings. Daffodil wrote, "To me, science is any endeavor that seeks to uncover the basic truths about our physical universe and to organize those truths so we can see an order which leads to an understanding and appreciation of that universe" (Journal entry 3). Now as a science educator, her emphasis has shifted to science teaching and learning. Through this vision of science, instead of uncovering new facts, she has assumed the task of teaching existing knowledge to students and training her students to effectively use the skills they will need to conduct their own investigations. In many instances, she is given the task of teaching the students enough facts so that they will perform well on tests. Daffodil explained, "There’s so much emphasis on passing tests ..., that we forget that our job is to educate the child" (Journal entry 3). The shift in focus from investigation to student preparation has forced Daffodil to adjust her vision of science and represents a border she continues to negotiate.

Daffodil's education and career also led to some areas of tension in her teaching. For example, she feels the way the scientific method is presented in the science textbooks
and is presented in the classroom does not reflect the process of discovery the scientists
utilize in practice. She said:

*It's the way we teach science; think about the way we teach the scientific
method. And what's the first step? The step is to ask a question. And the
second step is to form a hypothesis and make a guess about what the
answer to that question is. Before you even explore the question. When I
was in the lab doing science, that's not the way we did it. We asked the
question; most of the time we found two. It wasn't that it happened if....We
did that to see what would happen if....There was never a hypothesis for
our sake; if we do this, this is what we're going to get. And for the time I
was involved in research that was done that way (the way the scientific
method is presented in the text) it was very uncomfortable for me. What
happened is the results then tend to be skewed towards the hypothesis until
after he's gotten, that doesn't mean he doesn't go out and do background
research, but if you see what other people have done you're still
answering the question, I wonder what would happen if... and it's different
if they want to participate in science, they have to have a hypothesis. They
ask a question and make a prediction and then they do their experiment.
And that to me is wrong. They make a prediction and they gather and
analyze their data, then make a prediction and you do the next experiment
to confirm your hypothesis. And if I tried to tell my students, I know this
because I worked with it; I've done it that way. I know that's what
happens. But if I try to tell my students, OK when you do science, the
scientific method is ask the question, design your experiment to answer your question, collect the data, analyze the data, then form a hypothesis.

Well, guess what, they're all going to fail the high school graduation test because that's not the way, that's not the approved scientific method.

(Interview 2/25/00)

Daffodil perceives there to be a rigidity in school science which is counterproductive and inconsistent with her role as a research scientist. "We have, um, we have this insistence that science is a cold, unidimensional, rigid discipline; and when in fact, it's really, almost a religious search for truth" (Interview 2/25/00). For Daffodil, the process of science, rather than being one of following process, is more of an expedition of understanding. True scientific method, for Daffodil, is more the following of one's curiosity than a set guideline of steps. This belief is illustrated by her metaphor of the ideal science teacher.

Ideally, a teacher of high school science should be the leader of an expeditionary force. She trains her team members in the basics, sparking their curiosity about the world around them, and then takes them out to explore new territory. Even though she's been through the area before, each new team brings its own perspective and the landscape changes with every visit. Ultimately, the goal is for the team members to become capable leaders or solo explorers in their own right. (Metaphor # 1)

Daffodil's concern is twofold: she is afraid that we are not teaching students "real world" science process skills, and second, that this rigid structure is dousing the flame of their scientific curiosity.
So we are trying to force science into much too rigid a framework and uh, our science skills cry from it and not just the students who go on and become Nobel laureates because the underlying principles....and you're looking for the right answer instead of the interesting data; you're looking for the right answer. And when I tell my students, those in the lab, and I say "OK, well, let's do it and see what happens". And they say, well "Mrs. D., this is what happened. Is that right?" I say, "Is it what you observed? If it's what you observed then it's right". "But is it the right answer? I didn't get the same thing as Jimmy got." "Well, but that's OK. Did you do exactly the same experiment as Jimmy did? Did you follow Jimmy step by step around the room"? "Well no, of course not". "Well, why would you expect that your results would be the same as his?" I think we are making a mistake and the reason that we're falling behind in science is that the people who are teaching it don't understand it and we're forcing on those who of us do understand it as a rigidity that really does not need to be there. That really hurts. (Interview 2/25/00)

In these respects, Daffodil is concerned that the way we teach the scientific method is doing more harm than good to our students. The tension Daffodil feels in the presentation of the scientific method is illustrated in her second metaphor. This metaphor describes what Daffodil perceives as the reality of teaching high school science.

*In reality, I feel like I have been given the job of leading an exploratory group, but I have to do it while driving the bus. My team must learn to be capable explorers, but we must stay on the prescribed route, in*
the ruts left by all the other buses that have departed before us. Before the bus can leave the terminal, I have to be sure it's mechanically sound and ready to roll. But if there is a problem, materials to repair the bus are unavailable. I can't fix it, but I'm still responsible for its safety. We can't pull out until the whole team is on the bus, but I haven't been given the authority to make them get on. If we actually do get on the road, it turns out that the farthest afield we go is in a loop around the terminal. The team has a great time on the trip, but refuses to look out the window or get off the bus to explore. (Metaphor # 2)

The tension experienced by Daffodil suggests at least two issues for science educators: firstly, perhaps we need to re-think how the process of scientific exploration is presented and, secondly, perhaps the program of teacher preparation offered second career science teachers could be amended to offer more opportunities for issues such as this to be resolved. These issues will be discussed in more depth in the implications sections of this document. It may well be that the Daffodil's concerns result more from the arrangement of priorities than from fundamental differences in philosophy. Daffodil, in her first metaphor acknowledges the need to train her team members in the basics. It seems that Daffodil's discomfort may stem from what she perceives to be an excess emphasis on drilling the procedure into the student's heads and less opportunities for students to utilize the scientific process, even if they get the steps wrong, to follow their curiosity and gain understanding about the world. These types of issues would be well suited for inclusion in teacher preparation courses offered to prospective second career science teachers.
Question 4: "What professional, cultural, and societal borders did these second career science teachers have to negotiate to successfully participate in the world of school science?"

Aikenhead (1998) described two subcultures of Western or Euro-American culture, science and school science. While the two cultural arenas are related, each is composed of a unique body of knowledge and procedures, set of beliefs and goals, array of social norms and behavioral expectations. Daffodil's career move from the world of research scientist to the world of science educator represented the negotiation of the cultural border between the two careers. This research question explores challenges Daffodil faced as she negotiated these borders.

Theme 1: Crossing in mid-stream. While the move to school science involved making family changes, Daffodil did not speak extensively of the borders or challenges she faced when entering the world of school science. She did mention family constraints related to finances and time away from her family, but did not consider them to have been a major difficulty. At the time Daffodil entered a program to obtain her teaching certificate, she had retired from the army, her husband had taken a professorship at a local community college, and both of her daughters were in school. Her family situation was an ameliorating influence upon financial and family time issues. While Daffodil observed that many of the students in her certification classes had significant financial difficulties, she did not consider finances to be a particular hardship on her family. At the time Daffodil obtained her certification, she was not the sole provider for her family, so any loss of income was not felt as deeply as it might have been. While the time required to complete the certification took her away from her family, she did not consider that to
be a particular hardship. Both Daffodil's and her husband's military careers had impacted their family life for their entire married life, forcing them, on occasion, to be apart for long periods of time; thus, time away from family was not, for Daffodil, a unique experience. Therefore, for Daffodil, financial and loss of family "together time" were not significant borders.

With reference to epistemological borders, Daffodil talked at some length about the courses she was required to complete in order to earn the right to teach. What represented the greatest and most challenging border for Daffodil was the "reluctance of the college to accept my background as sufficient" (Interview 7/20/00). Daffodil entered the certification program with a strong background as a research chemist and some experience teaching; she felt competent to teach the subject and did not feel like she needed to learn the mechanics of teaching. Throughout Daffodil's educational and professional career she had acquired new knowledge and understanding through classroom lectures and laboratory investigations; a continuing challenge she faces is to appreciate the fact that different epistemological processes might play an integral role in student learning. She felt, and continues to feel, that efficiency in teaching relates mostly to content knowledge. Her idea of competence continues to center on content knowledge of the subject.

...the attitude is that education courses are more important than the content courses and that once you know the process, the content comes. Which, to me, you have to know the content, the process will come....But you have to know something about science to be able to teach it...I don't think education courses address that issue. (Interview 7/20/00).
Daffodil's background was not considered sufficient by the regulating agencies to qualify her to be able to teach chemistry at the high school level; this was a source of tension for Daffodil since she was not only well trained as a chemist, but had taught both formally and informally on numerous occasions throughout her life. She entered her education coursework with perhaps a jaded opinion of the benefit of these courses; as a result, the benefits she gained from these courses may have been limited. In her past, Daffodil had taught chemistry at community colleges and, as a graduate student, had taught chemistry lab courses. She considered herself a chemist and felt qualified to teach chemistry without further courses in the process of teaching.

The tension Daffodil felt with reference to her background and her precertification coursework raises an issue of how education coursework may be better presented to prospective second career science teachers. Daffodil entered her certification program with some teaching background and a firm belief that she knew how to teach. Her attitude may have restricted the benefits she might have otherwise received from the education methods courses. Some mechanism by which to demonstrate to second career science teachers the need and benefit of developing teaching skills applicable to the science education classroom would further enhance the effectiveness of science career professionals who enter the classroom convinced they can teach because they know the subject.

Dave: A forester turned teacher

*Only a truly enlightened person can be aware enough of their surroundings to truly enjoy them.* (Journal entry 12/4/99)
Dave is in the middle of his teaching career with 10 years of teaching experience. He is a husband and the father of two teenage boys. He teaches physics and geology at a large south metro Atlanta high school and has previously taught biology, physical science, ecology, and horticulture. He enjoys running and is the coach of the boys and girls cross country team at his high school. Dave has a degree in Forestry from a large northeastern university. His wife is a professor of entomology with an emphasis on research. Dave comes to the world of school science after a 12 year career in forestry. In this section, you will learn more about Dave, his life story, a synopsis of his prior career, how he became interested in teaching science, and where he is now in his teaching career.

With reference to research question # 1, Dave's discussion of his life story revealed two themes that were evident across the data. One involved Dave's two life long loves – nature and academics and how his move to the world of school science reflected a convergence of these two life influences. A second theme concerned the ways in which Dave's career path was influenced by individuals whom he greatly admired. With reference to research question # 2 concerning the role of science in his life story, a single theme emerged relating the ways in which Dave's life has been defined by the field of scientific endeavor. In his responses related to research question # 3, his beliefs with regards to science teaching and learning, two themes presented themselves in the data. One dealt with the tension he feels between the interest and excitement with which he approaches science and the apathy toward the subject displayed by many of his students. The other theme concerns his beliefs concerning what he should be teaching and the tension he feels when the requirements of established curriculum (the QCC objectives) prohibit him from teaching in that manner. In regard to research question # 4 two themes
emerged regarding his move to school science. One involved his certification process and the other involved family challenges.

Question 1: "What are the life stories of second career science teachers?"

Dave was raised "all over", living in at least four states. His father was a forester and one of his earliest memories was "riding Dad's shoulders through the woods...being with Dad in the forest and around nature" (Timeline). His mother was a homemaker and full time mother.

Dave always enjoyed school and did well academically. In the third grade Dave won a science fair award and while in middle school he won a writing competition which earned him a subscription to a nature magazine. During this period of his life, his father changed careers and began teaching; this career change moved the family back to New York state. It was during his high school years that Dave became interested in science and nature as a career. He was accepted into the Forestry School at the State University of New York at Syracuse. Dave recalls his acceptance with pride because, as Dave states, "the standards were the highest in the nation and I had made it" (Autobiography). While at SUNY at Syracuse, he met and fell in love with his wife. After graduation he managed a Christmas tree farm and nursery in northern Indiana for two years.

I did, uh, I ran a Christmas tree operation. Uh, I was the manager of a large farm in northern Indiana for two years and there I was in charge of different work crews, uh, we raised Christmas trees and sold them and we also, uh, created nursery stock in a large tree nursery and I was responsible for planting and harvesting and tending all the different stock in the nursery and the Christmas trees. And I also did forestry at the
University of Kentucky in the Forestry Department. And there I was in charge of a research lab that did tree physiology work that environment (unintelligible)... I did forestry things for about 12 years. (Interview 9/23/00)

During this time his wife got a job at the University of Kentucky thus putting 300 miles between them. As a result, Dave followed her there and had several jobs while at the University of Kentucky, the last one in the Forestry Department as a research analyst. During this time Dave was becoming more and more dissatisfied with his job; it was not fulfilling emotionally or financially and he considered a career change.

I wanted to be a forester. I wanted to work in the woods; I wanted to do forestry types of things. Foresters no longer do that; technicians do. And professional foresters, uh, are in charge of running a business.... That's what the technicians, uh, lab, uh, uh, lower level persons... they do that... the outdoor the fun type stuff. Whereas the foresters used to do that and now they have someone else that does that.... If it had been available I would liked to have been uh, just a "forestry teacher". Or an outdoor education teacher. But that's a very specialized thing and I would have to go search that out. Uh, my wife, being a professor here, I decided to coordinate what I wanted to do with what she was doing and find the easiest way for me to pursue that. I've always enjoyed science and found it very, uh, I don't want to say easy, but, uh, very interesting. And the most fascinating thing to me about everything around me operates and to me it just seems so natural and to everyone else it's very hard to understand.
So, I thought maybe I was a little bit more understanding and I could help students understand science better, easier. (Interview 9/23/00)

Theme 1: Grafting the branches. Dave's life story is much like a forest filled with different species of trees. A forest is made of different types of trees, each filling a different niche in the forest environment. In much the same way Dave's life has been influenced by many different experiences and relationships which together form the "forest" of his life. In relating his life story, Dave emphasizes two species of "trees" that represent major life influences: his love of nature and his love of academics. Dave's move to the world of school science, in many ways, mirrors the process of grafting used by foresters to create more desirable plants. This process involves selecting individual plants with desirable qualities (for example fruits) and joining those plants with others who have strong qualities in other areas (for example, roots). In much the same way Dave has combined two major life influences into his career as a teacher of school science.

Dave spoke of being interested in nature from an early age mostly through the influence of his father.

[My] earliest memories are all about nature and how involved my Dad was with protecting it and loving it. Dad would walk through the woods with us and know the names of not just the trees but everything....Nature was the always the most important thing in our house. (Autobiography)

Dave related two events in his early life which he described as "defining moments" of his life – both related to experiences in nature. He talked about walks
through the woods, riding on his father's shoulders, looking at the plant life and listening to his father describe and name the various plants they passed. "Dad would walk through the woods with us and know the names of not just all the trees but everything" (Historical timeline). The second defining moment described by Dave relates to catching a small fish and being so impressed with the beauty of the animal. Dave recalled, "I vividly recall catching a beautiful trout in a stream in Washington state. It was a huge, beautiful fish and I keep [sic] dropping it in the dust and crying" (Journal entry 1/7/00). These early experiences seem to have set the stage for Dave's love of nature and his interest in science as a way to understand nature. Dave described his personal involvement in nature:

As a child of the 60's I feel always like an environmental scientist first. I think we're all in this together and since we all share the same address whatever we can all do to improve the planet needs to be done. As a scientist I can not only understand this but explain it. (Journal 12/4/99)

Dave maintained this love of nature and desire to understand and improve our environment throughout his school years. This led him to pursue a career as a forester.

The second great defining love of Dave's childhood was academic achievement and school. Dave always did well in school and was encouraged consistently by his parents.

....I was told from the earliest that I can remember – "you can do it if you just apply yourself. You're smart – it's easy for you". Academics to me was always a matter of pride. I enjoyed doing well and wanted the
teacher to be pleased with my efforts. I did well at school but always had
to work at whatever I did. (Autobiography)

As Dave became dissatisfied with his forestry career and began to consider other possible career paths his love of academics came back to the forefront of his consciousness. Where else but in the science classroom could he combine the two great loves of his intellectual life – science and learning; the decision to enter the field of science education was a natural move for Dave and he took the leap with enthusiasm.

...my desires have always been to help others learn about nature and it's always been something that was easy for me to communicate. I begin
taking classes part time. (Historical timeline)

Theme 2: Influence of heroes. As Dave reflected upon his life and career paths, he emphasized the influence that certain individuals have exerted on his life. The set of role models that have had the greatest influence in his life have connections to science and to the teaching field and Dave acknowledges their effect in helping steer him to the science classroom.

I think back through my formative years and realize that my role models and my most admired individuals were my teachers; at home and at school. I spent enormous amounts of time talking with my Dad, Mother-in-law, and sisters, who were all teachers. They all loved their work and thought it worth-while. I thought they were great and truly admired them and this is perhaps the real underlying reason for my desire to teach. So that I could be that person for someone else. (Autobiography)
Dave described the influence of three individuals in particular as being elemental in his life and career goals. He included two teachers and his father as the three heroes who helped lead him to the classroom and a second career as a science educator. The first and foremost influence for Dave is his father. In many ways, Dave's father has been the primary guiding influence for his life; he was, and still is, a significant role model, mentor, confidant, encourager, and advisor in his life. A hero can be defined as an ideal, or a role model; in this sense of the word, Dave's father has been a hero for him throughout his life, continuing to the present day.

And always I can see that image in the back of my mind – My daddy – hard hat, big boots, chain saw and double-bit axe [sic] and me just a little guy. It always left an impression – still does – I wanted to be the same thing and still do. (Journal entry 12/4/99)

Dave spoke of how closely his career path has followed the same pattern as that of his father. Dave's career path has mirrored his father's almost exactly without design. Dave's father attended SUNY's School of Forestry and worked as a forester for 15 years before changing careers and pursuing teaching as a second career. Dave attended the same university, earned a degree in forestry, worked as a forester for 12 years, and pursued science teaching as a second career. Dave, in an interview, spoke of the uncanny similarity between his dad and himself:

Uh, I followed him almost exactly…. Just one of those things. Where you, I tried not emulate and ended up doing it anyway. Laughs. Uh, I went to the same college he went to, got the same degrees he did, and ended up
Dave became a forester because he loved nature and wanted to work outside in the woods, being with plants and animals. As the field of forestry underwent a change in the duties required of professional foresters, Dave became dissatisfied with the field of forestry. His duties as a forester were increasingly removed from what he enjoyed most about the field. As Dave began to feel the need to change careers he began to seriously consider the idea of science teaching as a second career.

I wanted to be a forester. I wanted to work in the woods; I wanted to do forestry types of things. Foresters no longer do that; technicians do. And professional foresters, uh, are in charge of running a business....

That's what the technicians, uh, lab, uh, uh, lower level persons...they do that...the outdoor the fun type stuff. Whereas the foresters used to do that and now they have someone else that does that. (Interview 9/23/99)

The teaching profession had an appeal for Dave through the influence of his father and his family as well.

My dad ...went into teaching and I grew up around that. And saw the benefits of it. And grandmother was a teacher, uh, I have two sisters that are teachers, my mother-in-law was a teacher and my wife is a teacher.

So I was surrounded by it. (Interview 9/23/99)

The influence of family and his father planted a seed of interest in teaching which sprouted as early as high school years. This seed of interest, while dormant for many years, was evident to one of Dave's high school coaches. This was revealed to Dave
during a visit he had to his hometown. He had the opportunity to talk with this coach; the coach was very interested to learn that Dave was thinking of becoming a science teacher and made the comment that he remembered Dave saying he might like to teach when he grew up.

After ten years in the forestry profession, Dave made the decision to leave the forestry field. At this point in his life his father's influence and encouragement again exerted a strong effect on his career decision to enter the world of school science. 

*My dad says – go ahead – you'll do great! I was afraid of going back to school after 12 years. He said they'll have to keep up with me – he was right and also he said – don't listen to everyone it's a great way to make a living and that I wouldn't regret it. He also said the the money sucked but that is was getting better.* (Journal entry 12/4/99)

Dave's father seems to have been a guiding influence for him throughout his life and to have played a major role in Dave's career path and move to the world of school science. Dave repeatedly makes references to his father across all data sources and consistently stresses the importance of his father's influence. Up until he actually started his career change, Dave's father led by example. Dave looked up to his father and observed his career; it was not until after Dave changed careers that he realized how much his father had influenced his life. During Dave's career change, his father was a source of guidance and advice that steered Dave toward the science classroom as a second career. So the seeds of Dave's career as a science teacher were both sown and nurtured, in large part, by his father until those seeds came to fruition when Dave earned his science teaching certification and moved to the world of school science.
Other influences that occupy places of prominence in Dave's life have been former teachers. He described two high school science teachers who were especially important in guiding his selection of science as the teaching area he wished to pursue. With his background, Dave could have pursued outdoor education or forestry education; instead, through the influence of these two teachers, he chose to be a high school science teacher.

*There were 2 individuals that were enormously important in my selection of science as an area. I had two incredible science teachers in high school. Mr. S. – 9th grade biology and 12th grade advanced science and Mr. C. – 10th grade chemistry and 11th grade physics. These 2 men were without a doubt my hardest teachers in school – but they helped mold a real love for science. They expected the very best from me and would be disappointed with anything less.* (Journal entry 1/7/00)

It is apparent that, as Dave reflected on his life story, his career path has been shaped by the influence of these men who were heroes for Dave. The path he followed to the world of school science was cleared, smoothed, and prepared through the influence of these heroes.

**Question 2: Where is science in their life stories?**

**Theme 1: Science defines life.**

*My dad was a forest man and I grew up learning all about nature, uh, sort of at his knees you know and all of our surroundings and everyday life had to with nature and forestry, and ... that was a real learning experience.*

(Interview 9/23/99)
Dave's earliest memories always involve nature so it could be said that the seeds of
Dave's science related career path were sown by his father as he and Dave enjoyed nature
together. The seeds of this life-long love of science were nurtured by his mother as she
allowed Dave to have pet snakes and birds in the home. While his mother was not a
"science person" she encouraged Dave to pursue things in which he was interested. The
flames of Dave's curiosity about science were fanned in elementary school by classroom
lab activities and by the active role Dave's father took in his science classes. Dave's dad
would often bring in examples from his job to present to Dave's class.

Science was always my favorite subject in school and one in which I
excelled. In junior high and senior high I became very interested in alot
of the things my father was doing which his classes – identifying trees,
identifying animals, doing forestry – operating heavy equipment.

(Remembrances)

As part of the reflective process for this project, Dave was asked to draw a life
learning map. (See Appendix J.) This map graphically represented Dave's life
experiences as a learner through a visual metaphor. Dave represented his life as a pine
tree with various life events depicted as branches off of the main trunk. In view of
Dave's life reflections it is perhaps not surprising that he would choose a tree to represent
his life. Pine trees usually have a strong upright growth with one strong main trunk. In
the diagram, the main trunk represents his love of nature, his father's influence, and his
family relationships. The influence of science in Dave's life is suggested by the location
in which he has placed nature and science on the central trunk of his life. At the base of
the tree, perhaps even the roots, Dave said "that he always grew and learned close to
nature” (Life learning map). In a later journal entry, Dave avers "Science in the truest sense defines my life. On a personal level it has [provided me] with a means for making a living. As a child of the 60's I feel always like an environmental scientist first" (Journal entry 12/4/99).

In these ways Dave's life has been guided and defined by scientific curiosity. His early childhood interest in nature kindled his scientific curiosity. Through his school years this fire was further fueled by his family, most notably his father, and several influential teachers, most notably Mr. S. and Mr. C. This interest in nature led him to a science related career in forestry and to a second career in school science.

Question 3: "What beliefs do second career science teachers hold with regard to science teaching and learning?"

Theme 1: Kindling the fire. Dave feels strongly about the science legacy he would wish to leave his students. From his youth, Dave has had a passionate interest and curiosity about nature and the scientific underpinnings of natural phenomena. The fire of this passion for science has burned bright throughout Dave's life. The science legacy he would wish to leave for his students would be for this fire of interest in science to burn bright in them as well. This could be described as one of the great loves of his life. Dave also has a great passion concerning the importance of academic achievement in students' lives. This is evident in his own educational and career background. Dave described his vision of school science in this way:

At the least (lowest) level I view our teaching of science as an explanation of the world around us and how and why it works and the way it does.
In the larger frame of reference science is the basis for all technical and scientific careers. We are their first introduction to perhaps their live's [sic] work... (Journal 10/15/99)

Many of Dave's students do not share his passion for learning and his curiosity about scientific knowledge; this results in a significant tension for Dave. Dave would like to share his passions with his students but many times his students are not willing, interested, or motivated to follow Dave. In this respect Dave feels frustration; while he would like to be fanning the flames of their scientific curiosity, he feels as if he is simply kindling a fire that has been extinguished, if it ever existed at all, in his students. In his case narrative story, Dave describes student indifference as a significant challenge as he teaches science. This narrative, presented below, highlights Dave's frustrations with regard to student indifference.

**Challenge encountered while teaching science.**

*Indifference of the students to learning science information which they view as unimportant anyway!*

*The teacher is a white male, 44 years old – married with 2 children*

*Sons: 15 & 12.*

*I was formally educated at the SUNY in Syracuse, NY & have a BS in resources management. I worked several years in industry and then 8 years at a University. I’ve since then gone to work as a science teacher and have spent the last 10 years teaching science.*
Students:

Let my [sic] give you an idea! We start with approx. 1200 8th graders from 3 middle schools.

By the 10th grade we’re down to 800 and by 12th grade there's only about 400 left.

Many just drop out and get a GED – many just drop out and go to work – low or no pay.

Most of the kids are going to be rich and live the easy life but have no way of accomplishing this. When the going got tough – they quit! Now they have no background and no education and find themselves in none paying jobs.

Schools and community:

Our school is an enormous sprawling affair. It covers over 7 ½ acres and is larger than many small colleges. The buildings, grounds, and equipment [sic] are costly and well maintained.

The community – here lies the source of all the problems. Our community is mainly low middle class. The vast number of founding father's [sic], so to speak, worked mill jobs and similar low pay – low skill jobs.

Our town has not, as a whole, seen the benefits of having an education, because one wasn't really necessary to get a job and settle down.
All of a sudden this has changed and everything has become highly technical. Most of this involves math and science. Now everything runs by computer.

Teacher's feelings:

My students are primarily indifferent to the learning process – just give me the grade.

We're riding high on the crest of technology and science as the wave of the future. I explain this to all of my kids (what they're learning does make a difference.) What they learn could help them get jobs or determine a future course of study.

I can teach anyone that is willing to learn. But the indifference that I must fight through is often overwhelming. Over ½ my classes feel they have to take science – they didn't sign up for it, these students also see no point in the classes.

My intentions: through teaching and probing at the students [sic] thoughts, etc. is to make as many as possible aware of what's going on around them. Much of this involves science and learning.

I use real life examples and set up scenarios which include issues that affect their lives.

I became aware fairly early in teaching that I couldn't save them all but, but, but I could save some and this does make it worth while.
Relevant individuals:

My peers: – without my science buddies – I'd go crazy. They our [sic] my sounding board.

Parents aren't much help w/this challenge because primarily they're the source of the problem.

Since our main concern seems to be test scores I feel that the best course of action with administration is to keep low and not make too many waves. If I explain that my students are indifferent and uninterested – administration will point out that it must be the way I teach and what could I do differently?

Theories:

My theory is that with lowered standards you get lower results. I need to maintain my standards and push the kids to meet them. While doing this I'll try to make it clearer to them how important science is to their everyday life.

Examples from the news – personal experience, current events, etc. are all good sources of information.

Real dialogue/meaningful experiences.

I've recently had 2 former students that were complete washouts who came back and thanked me.

I had made a difference, they were listening and they heard – I never would have expected it of them.

You never know who you touch and how it will affect them.
The only solution to the indifference is to continue to fight on and maybe in the future we'll begin to be heard once more.

As a closing note – If I could ask one thing it would be for the parents to return to their positions of responsibility in their own homes – it would make helping their sons and daughters learn and understand science a lot easier. And also if Mom and Dad believed it was important so would their kids. (Case narrative story)

Dave's deeply held beliefs concerning science teaching and learning are further elucidated by his teaching metaphors. His metaphor of the ideal teacher is that of an orchestra leader.

Well, ideally I would love to be in a teaching situation with this metaphor in force; where I am the conductor and everything revolves around me and yet as... expert musicians in an orchestra, these people are already taught; I don't have to teach them how to play their trombone; they already know how. All I have to do is cue them as to when they’re gonna do this, fine tune it a little bit. That in my mind is what a teacher [does]...I have the knowledge, I have the resources, I have the time on a daily basis, now let's do it. (Interview 4/20/00)

For Dave, the ideal teaching scenario involves motivated students who have a passion for learning and the dedication to put forth the effort required to learn new concepts; the teacher's job is to facilitate the learning process. In this metaphor the flame of scientific curiosity burns bright and Dave’s task is to maintain the flame and keep it fueled. On some days, Dave does experience this type of science teaching and learning:
Sometimes; sometimes. Maybe once a week even in those classes [physics]. It doesn’t happen much and when it does you really know it’s goin’ on. You really know everything’s clicking and they’re being receptive and learning something and ... it is a good feeling. That to me seems like what teaching may have been like thirty years ago. Any way it was a really nice thing to do then. But now, it just seems like, at times, a constant [struggle]. (Interview 4/20/00)

While rewarding teaching experiences occur, Dave often feels as if he can not be the ideal science teacher due to student apathy and disruption in the classroom. Dave feels as if he must assume the role of a policeman or babysitter before he can be a science teacher. In his personal teaching metaphor, he described it this way:

As I teach science, I feel that I am like a policeman or a babysitter.

The students are a crowd at a sporting event and I'm working crowd control. My ultimate goal is to help everyone get to the finish of the event safely....As a babysitter I have the responsibility of overseeing the care of the students in my room. I can do nothing for them except to make sure that they don’t injure themselves or others. (Metaphor)

This tension between what he would like to do in the classroom and what he is required to do is further illustrated in his photoessay. (See Figures 1 & 2.)

While the tension Dave feels with regard to student apathy is a significant discomfort in his teaching experience he does express the belief that his teaching does make a difference and the hope that he will continue to make a difference in students' lives.
I've recently had 2 former students that were complete washouts who came back and thanked me.

I had made a difference, they were listening and they heard – I never would have expected it of them.

The Greenhouse:

I thought this would be great. We could grow things and set up experiments. One thing I forgot was – I teach chemistry and physics as well.

I have no one to take care of the greenhouse. Anything that needs doing I must do with no outside help. This would be okay but one-third of the kids will pay attention and participate and the other two-thirds screw around, get in trouble or pay no attention at all. (Photoessay)

Figure 1.

Excerpt from Dave's Photoessay – The Greenhouse
Garden plots – another good thing gone bad. We have a garden
plot available but the kids won’t work in it – even under threat. They
might get dirt on their shoes or hands. This gets frustrating. So many
chances to excel and I keep getting shot out of the saddle. But I continue
to try with the hope that I’ll eventually get that class that clicks.

(Photoessay)

Figure 2.

Excerpt from Dave's Photoessay – Garden Plots

You never know who you touch and how it will affect them. The only
solution to the indifference is to continue to fight on and maybe in the
future we'll begin to be heard once more. (Case narrative story)

Theme 2: Teaching with blinders on. Dave's lifelong love of nature and curiosity
about the underlying science are reflected in his beliefs about the role science teaching
and learning should play in the intellectual development of his students. Dave views science as the most effective method by which to develop understanding and knowledge of the natural world. He views his job as science teacher as much more than just a facilitator to help students acquire facts. He very much wants to share his passion for nature and for discovery with his students. Dave wishes for all of his students to develop the skills needed to ask meaningful questions, logically pursue the answers, and critically evaluate the information received. Dave further defines his vision for science teaching and learning is this way:

*I see science as the quest for knowledge! The answers to questions that can only be answered by the properly trained individual... School science is the first step along this direction. We (science teachers) are the first individuals to guide and direct the next generation of students. It's not so much the content of what we teach them (although we like to think differently), it's the molding and structuring of some of their basic thought processes.* (Journal entry 11/4/99)

Dave sums up his beliefs concerning school science in this way: "science is the acquisition of knowledge; school science is learning how to learn about science" (Journal entry 11/4/99). In contrast to the vision Dave has for school science he often finds his hands tied by various curriculum and testing restraints; this results in tension for Dave that impacts his teaching. Much like a horse pulling a buggy has its vision restricted by the use of blinders, Dave feels as if his vision for science teaching and learning is restricted by these external factors. With Dave's background in science he feels competent to determine the needs of his science students as well plan educational
experiences which will help the students acquire the knowledge and skills necessary to meet those needs. Consequently, Dave takes a somewhat negative view of science curricula and state mandated QCC objectives. In his mind, and in the minds of many teachers, the terms science curriculum and state mandated QCC objectives are synonymous.

Well, I see the science curriculum and the QCC's as dictated by the state. I see signs of dictator type politics; in other words, I, as a physics teacher, have a better idea of what's necessary for beginning students in physics and what they can comprehend than you; as a biology teacher, you have a better idea than somebody that wrote these standards....I think what's dictated to us by our curriculum and our QCC's is confusion; to say it's a guideline for us to cover is kind of laughable; there's no way we can do everything the QCC or a school curriculum [states]....there's no way. (Interview 4/20/00)

Time pressure often prevents Dave from planning learning experiences that he feels would promote student interest and achievement in science. These time pressures are yet another tension Dave feels while teaching science. He feels like he is pushed to cover all the QCC's and pushed to prepare the students for the exit exam; instead of a voyage of discovery, his science classroom has become a test preparation center. Dave appears to be somewhat uncertain concerning what he believes an ideal science curriculum should be. Nevertheless, he expresses strong opinions concerning the science curriculum as it exists.
...A metaphor for a curriculum. (Pause) Irrelevant? (Pause) This is what we talked about yesterday in our meeting with how we're going to go to this science standards stuff and we're going to key our curriculum to our test so now we're finally worked around in the past 15 years to the point where we're now teaching the test. And we're gonna, the next step, we're gonna realign our curriculum for the test. So now, what we teach across the board – math, science, english, and so on, not just science, is dictated by what's on the test; to me that's wrong. Education is, education is, especially at the level of high school, is education for (unintelligible). These are untrained minds. And somehow people have now gotten in mind that if they pass quote this special test, that makes them better. And if they have the basic knowledge to pass these tests, that you learn from years of study, then that determines you have a certain amount of knowledge to be able to walk from that school after you obtained that amount of knowledge. (Interview 4/20/00)

In spite of these tensions or constraints, Dave continues to bring the perseverance learned from his athletic training to his teaching. While in high school, Dave earned 10 athletic letters; the lessons he learned through athletics included keeping site of the goal, never give up, and to do your best. These tenets have stayed with Dave and serve to keep him focused on the goals he has for his students. While Dave is buffeted by these external forces or tensions which cause him a great deal of frustration, he is anchored to the goal of helping his students acquire the knowledge they need to become productive citizens that contribute significantly to 21st century society.
Question 4: "What professional, cultural, and societal borders did these second career science teachers have to negotiate to enter the world of school science?"

Dave, as he moved from forester to science teacher, completed a successful transition between the world of science and the world of school science. The transition between these sub-cultures involved the negotiation of the cultural border that separates the two careers. The purpose of question 4 is to explore the challenges Dave faced as he made the move to the world of school science.

Theme 1: Certification: Spinning my wheels. Dave thought that with his science background, becoming a science teacher would not be a difficult task; he was, however, proven wrong. Dave entered the certification process confident of his science background and confident of his ability to teach young people. He graduated from a major university with a degree in forestry and in the process of earning his degree had completed a variety of upper level science courses. Dave had managed a Christmas tree farm with numerous employees who required instruction in the proper procedures used in the management of the trees.

My first career in science was as an assistant manager of a Christmas tree farm and tree nursery.

This job in many ways was like being a science teacher. During the Christmas season we collected, trimmed, wrapped, stacked, and shipped the Christmas trees. I had groups of 20 - 40 workers at any time that I was in charge of. I had to instruct these individuals in small groups and set them all to different tasks.
This very closely resembled a classroom where students are given a demonstration and then set to doing the task themselves. Monitored by the instructor (boss) to make sure that the task is properly completed.

During the so called off season – inventory was taken and then our volumes of paperwork was begun – this would greatly resemble lesson plans and preplanning. In effect I was actually training for my current job long before I was aware of it. (Journal entry 11/15/99)

Dave entered the certification process thinking he would only need a few education courses. Instead, the certification process was an arduous task containing numerous repetitive science courses as well as the education courses. Dave's remembrances of this process are jaded as reflected below:

Uh, the process for me to become certified in Georgia was not a pleasant one. I did that 11 years ago. And at that point certification for a nonGeorgia resident with a nonGeorgia degree was very hard. Now it's alot easier as I understand it. They sent me back to school and I took a year's worth of, basically, prerequisite courses to what I had. And I was not real pleased with that... I actually went through enormously complex science and math classes and they sent me back to prerequisite courses for what I'd already had. [So you had to take education and science classes?]

Exactly. And, uh, it, uh, I went to school full time at night and full time during the day. I went to school for about a year because I wanted to get 'em all out of the way. I just wanted to get it over with. Uhm, if you'd asked me then and you ask me now, then I was real upset with it and
probably would not have done it if you looked at it now, it's over and
done... [Were the classes beneficial?] The coursework? No. Nothing
was, nothing that I took was beneficial. Not the education nor the science.
I'd had most of it. I'd had it and on beyond what I took. So was it
beneficial to me? Not really. Just hoops to jump through...so that I could
be certified.  (Interview 9/23/99)

Dave persevered and obtained his science certification. Dave's unfortunate certification
experiences seem to have their roots in several factors. First, Dave believes he gained
little useful information from his education courses; perhaps this is partly because Dave
believes that he was teaching while employed as a forester. Second, science courses he
had taken out of state were not recognized by the state certification board. Third, he was
going to school day and night and was, perhaps, a little overwhelmed by the volume of
coursework required. Dave's experiences raise several issues for the certification of
second career science teachers. It would be helpful if there was a mechanism by which
science courses completed at an out-of-state university could be accepted and counted
toward the requirements for certification. Perhaps there is some mechanism by which
students could be made more aware of the need for these courses; this will be explored in
depth in the implications section of this document.

Theme 2: Transition: Bumps in the road. Dave's path from forester to science
educator was not without some challenges – bumps in the road. These challenges might
be described as borders that Dave had to negotiate as he moved from the science world of
forestry to the world of school science. These borders fell into two categories: 1)
financial and 2) professional. When Dave's wife accepted a professorship and the family
moved to Georgia, the time was ripe for him to leave forestry and obtain his science certification. His family, consisting of himself, his wife, and two boys, went from two paychecks to one paycheck resulting in some financial hardship.

*I took, my grandmother actually gave me a loan; the rest of my family didn't know about it; but K and I paid it back. I had to travel to get certified. And instead of getting a part-time job and doing this and that while I was going to school, I borrowed a couple thousand dollars and had gas money, a little bit of food money, stuff like that. Another monetary consideration was I had just moved to the state so I had to pay for all my schooling and, this was a highly sought after area, certification even so, because I wasn't a resident, I didn't get any help....First I went to no salary for about a year and a half and then I went to a, actually a better salary. ...after I'd been teaching for two or three years I was making quite a bit more than I had been in forestry. That was one of the considerations. I was making decent money as a forester but there was no automatic raises, step up increases, very small monetary raises.*

(Interview 6/16/00)

A second border Dave negotiated was cultural in nature and involved changes in status as he changed careers. He went from being a professional forester to a student and from a student to a novice teacher. While working at the Christmas tree farm, one of Dave's responsibilities was to teach others the knowledge and skills they would need to perform their jobs. He was the expert and considered himself a professional scientist. The move to the world of school science required Dave to set aside his professional status
and assume the role of a student – a role Dave perceived as being a "true unprofessional" (Journal entry 1/30/00). Another issue for Dave was the lack of earning ability while he was attending school to obtain his certification. A third issue for Dave was his perception of his status as a novice teacher. He felt that he knew as much science, if not more, than the other teachers, yet he was given the "worst" students and was considered as the low man on the totem pole. These perceptions, perhaps, shed some light on Dave's deeply held beliefs concerning the importance of content knowledge versus pedagogical knowledge and may suggest a reason why Dave did not feel that he got very much benefit from his education classes.

I was a research analyst and lab technician in a university setting.

I had a professional forestry degree and was operating in a setting where my expert opinion and my qualifications gave me a lot of freedom as far as decision making, etc...

We left Kentucky and move [sic] to Georgia and I quit my job. I went from a working professional to a house husband for a brief period.

At this point I took a huge step and became a true unprofessional - I went back to school full time. This was perhaps the hardest time for me – I had worked for over 12 years and all of a sudden – with two small sons – no job, no money, and no real respect. I was just another student. (Journal entry 1/30/00)

I finally became a teacher at the age of 34 and here I was starting all over – no real experience at this new endeavor. I'd accomplished so much – graduating from the best forestry program in the country and
finally getting work in my field and now I've got to ask 22 year olds how to do things. (Journal entry 1/30/00)

Rosalind: Test tubes to teaching

I can not imagine my life without my love for science specifically BIOLOGY. It has been a life long passion and the more I know the more I want to know. (Journal entry 12/4/99)

Rosalind is near the end of her teaching career with 28 years of teaching experience. Rosalind is a middle age, single female and is the primary caretaker for her elderly mother. Rosalind has taught science in both Texas and Georgia. She has taught earth science, life science, biology, physical science, human physiology, gifted biology, and gifted physical science; she is also a homebound teacher. She is very active in professional organizations and enjoys attending conferences. Prior to entering the world of school science, Rosalind earned a degree in Biology/Psychology; after graduation she took the training to become a microbiologist. She worked as a microbiologist for seven years until she became convinced that she "needed to be working with teens and not test tubes" (Timeline).

Question 1: "What are the life stories of second career science teachers?"

Rosalind was raised in a family that placed a high value on education. Her mother was a teacher and her father was a college professor.

I suppose my first firm recollection of influence was the very academic aura of my entire family. Not just my immediate family, but aunts, uncles,
and grandparents. I always had a sense of academia and its importance in our lives. My parents' only rule was "my sister and I would get a college diploma before we did anything else in our lives".

(Autobiography)

Rosalind grew up "everywhere" – Texas, Ohio, Indiana, and Georgia – living in rural, urban, and suburban areas. She attended public school where she did well and was always interested in science and nature. She remembers that "it was always a source of pride for me that I was the rare female that loved studying and learning all things science" (Autobiography). During her high school years her love of science continued and she took all the science courses possible. After graduation, she attended Texas Christian University where she earned a BA in Biology/Psychology. After graduation she chose to pursue a career in science taking additional training to become a microbiologist. She enjoyed the science and the lab work, but was bothered by the politics involved in the job.

...it was interesting while I was in the lab; but, the politics, I didn't like the politics involved. But I enjoyed the lab work and I enjoyed the friends and I [liked] working in the lab...I worked for a female and that was a mistake. I thought that would be a good positive thing but it wasn't...She was so dominating, she wanted to have her hand in everything, she didn't leave us to do our own thing, properly or accurately. She stood over our shoulders all the time. (Interview # 1)

While working in the lab Rosalind was also involved in a local sorority, Kappa Delta, and enjoyed working with the students. "I'd go around and inspect different
chapters which meant that I dealt with freshman college age.....and I really liked working with them and that led me to be informed that I really ought to be working with people and not Petri dishes" (Interview 9/28/99). After she made the decision to change careers, the natural step was to combine her love of science with her love of working with students and pursue a career as a science educator. This she did with great diligence, taking courses at night and finally quitting her job in the lab to pursue her dream full time. She returned to TCU to obtain her teaching certification. After obtaining her teaching certificate, she was hired by the Fort Worth City Schools to teach inner city children earth science, life science, and general science. After teaching in Texas for 11 years, Rosalind moved to Georgia. In Georgia, she has taught at the high school level for 17 years. In this section, you will learn more about Rosalind, her life story, a synopsis of her prior career, how she became interested in teaching and science, and where she is now in her teaching career.

**Theme 1: The rebel returns to her roots.** Rosalind often refers to herself, rather proudly, as a rebel.

*When I attended public schools (back when the earth was cooling!) in the 50's, it was always a source of pride for me that I was the rare female that loved studying and learning all things science. I relished walking to a different beat as I do now and will continue to do the rest of my days.*

(Autobiography)

She was raised in a family that had no particular science background, but had a very strong academic and teaching background. Her mother and father were both teachers as were her grandparents. Initially, Rosalind's interest was not teaching; in fact, she had no
intention of pursuing a career in education. Rosalind very definitely wanted to pursue her interest in science.

As far back as I can remember, education has been emphasized in my family. Not only my immediate family but my relatives as well. Seems that many were teachers, on my mother's side. (I was closest to these family members.) My mother and father were both teachers. Mom – 2nd grade and Dad in college – TCU. Both my grandparents (Mom's parents were teachers.) All of this is to say education was valued highly when I was growing up – I was never encouraged to be a teacher – as a matter of fact – since I was 6 or 7 it was more or less a foregone conclusion that I would do something in science.

Indeed, the rebel in me, would not hear of getting a teacher's certificate anymore [sic] than she would hear of getting her MRS. degree while at TCU. This was what was expected of female students and I would hear nothing of it! (Journal entry 1/10/00)

Rosalind's family accepted her interest in science and encouraged her to pursue her scientific curiosity. In the 7th grade, Rosalind remembers helping her science teacher set up equipment in preparation for laboratory activities. "I clearly remember being so enthusiastically drawn to my second floor science room with Miss L. I appointed myself her personal assistant..." (Journal entry 1/3/00). In high school she took as many science courses as she could in preparation for a science degree and career.

While I remained a rebel (still am for that matter) and somewhat outside the realm of our familial expectations (they didn't know what to do
about my love of science!) I nevertheless felt and still fell a great deal of encouragement from my family. (Journal entry 1/10/99)

The one hard and fast rule, cut in stone, unchangeable, immutable in her family was that she and her sister get college degrees before they do anything else. Rosalind honored her parent's request and followed the inner call she felt towards science graduating with a degree in Biology/Psychology from TCU. After graduating, she took additional training to become a group therapist; after graduation she chose not to pursue this avenue, but instead, took additional courses to become a microbiologist. Her training as a microbiologist landed her a job in a laboratory; for seven years she immersed herself in

Figure 3.

Excerpt from Rosalind's Photoessay – R.
this field of science. At the same time, Rosalind also began working with young adults. She worked with members of the Kappa Delta sorority in a supervisory role. This work with young ladies reawakened the strong educational background she received from her family. Among the friends who noticed Rosalind's interest in people was her roommate, R. (See Figures 3 & 4.) It was R. who first convinced Rosalind that she should be working with people and not Petri dishes. When asked what lead her to pursue a teaching career rather than another science related field, Rosalind responds:

Well, um, my interest at the time was in social sororities and I was a member of Kappa Delta and I enjoyed working with the kids. I'd go around and inspect different chapters which meant that I dealt with
freshman college age and some would be in ... and I really liked working with them and I let that lead me to be informed that I ought to be working with people and not petri dishes. And so I thought "that's probably true". And that was the main thing, enjoyment. (Interview 9/28/99)

In Rosalind's life learning map (See Appendix J), the influence of science in her life and career is depicted graphically in the image of a flower she uses for her life. She refers to herself as a zygote which has blossomed into a many petaled flower. The melding of science and science education that has characterized her life is shown as petals developing from the zygote. The roots of "the zygote" have been depicted by Rosalind as "love of teaching, kindness and gentleness, brains, respect and love for academics and learning" (Life learning map). Just as the roots of a plant anchor the plant, provide stability against the elements, and serve as a means of obtaining nourishment, Rosalind's academic roots have served as an anchor point and source of strength for her development as a science educator. Throughout her life, her roots have not only anchored and nourished her but have served to lead and guide her to the classroom. In these respects, Rosalind's life story reflects a return to her roots.

Theme 2: On the shoulders of giants. Rosalind's life and career path seem to be impacted by the influence of several individuals. In discussing her life story, she mentions several individuals as having particular influence on her. Her father was a minister and a college professor and her mother was an elementary teacher. Rosalind describes their influence:

Dad was communication, that's how I got that, [now] communicate arts. Mother's was elementary; wasn't secondary at all. But she was
strong in elementary. Mainly she was good without the kids and that, that's a good legacy to remember that we teach young people first and teach the subject second. That's the legacy I got from my mother.

(Interview 1/28/00)

On her life learning map, Rosalind's mother and father occupy an elemental position. The influence of her mother is described as "love for teaching, any kindness and gentleness" and the influence of her father is described as "brains, respect and love for academics and learning" (Life learning map). These two elemental influences are depicted as the roots of the plant. The roots of a plant anchor it to the solid earth and allow the plant to absorb the moisture and minerals necessary for sustaining the life of the plant. The placement of parental influences as the roots of her life seem to reflect the importance Rosalind places upon the influence of her parents. Rosalind seems to be suggesting that their abiding influence has served as a solid foundation upon which she has built and sustained her life and career.

A second influence that Rosalind describes as particularly influencing in her life was her 7th grade science teacher, Miss L. This teacher encouraged Rosalind to pursue her interest in science. Rosalind describes how this teacher encouraged her in the following narrative:

Well, she gave me some positive strokes. I set up a demonstration. She couldn't figure out how to set things up for PTA at Open House and I processed it some way, on an elementary level, to make a suggestion and she just had a fit. It was just a positive thing and I was an answer to a
science teacher's prayers...I remember that statement from 7th grade. So that must have had a really big impact. (Interview 1/28/00)

Miss L., seemed to have an enormous effect on Rosalind since she is mentioned numerous times in various personal documents. Rosalind’s historical timeline (See Appendix I) describes her as "[my] all time fave teacher" and again states that [she is the] science teacher [who] gave me the label of ‘answer to a teacher’s prayers’." (Historical timeline). In another journal entry Rosalind states

I always went to 206(?) [sic] during the day because I felt at home, welcomed, and needed. There were always things to do in the science room and Miss L. was always lab/activity oriented. I remember working with prisms down at the end of the hall in the stairwell – guess we were looking for sun rays. We did weather charts that I found fascinating. I'm sure 7th grade then (1950’s) for science was general science because I remember helping Miss L. set up a glassware exhibit in front of a poster with the names and pictures of pieces of physics-type labs, leads me to remember the 7th grade as an introductory physical science level.

(Journal entry 1/3/00)

There was another group of individuals, mentioned by Rosalind several times, who were among the giants upon whom she built her teaching career; these were her colleagues at her first teaching position in Fort Worth, Texas. They were mentors who firmly established Rosalind's foundation in the science teaching field. These individuals figure prominently in her autobiography and her photoessay. Mr. W., who was Rosalind's first science consultant helped her obtain her first science teaching position;
Rosalind states, "Mr. W. took a particularly strong role in helping me get my teaching job ahead of some others who did not have my lab experiences" (Autobiography). Mrs. A. was Rosalind's first supervising teacher who gave Rosalind the mantra she still teaches by today: "I am teaching young people first and then I'm teaching them a subject" (Autobiography). In her journal Rosalind was asked to comment upon the question, "Do you see yourself as a scientist who teaches or as a teacher of science?". In the spirit of Mrs. A., Rosalind stated unequivocally,

\[
I \text{ see myself as a teacher who teaches young people science rather than a scientist who teaches young people science. My students are the most important of this equation and I only want to see myself as a facilitator.}
\]

\[
\text{Another reason I want to remind myself that I teach young people first and then I teach them a subject is that if I hang on to being a scientist who teaches, I think that I would not be able to communicate as well as I need to direct the learning of these young people.} \quad (\text{Journal entry 11/1/99})
\]

Two elements have brought Rosalind to a point in her professional career in which she is content in her role as a science educator, excited about her opportunities to work with students and share her passion for science, and committed to the task of helping students acquire science skills and knowledge. These two elements were her love of science and the mentors with whom she has worked.

\[
\text{On a personal level, being a teacher of science, has certainly added to the quality and substance of my life in so far as adding a sense of fulfillment. I am proud that I have continued in this profession and really proud that this month I celebrate 30 years in teaching.} \quad (\text{Journal entry 2/14/00})
\]
Question 2: "Where is science in their life stories?"

I can't think of a time or place that didn't contribute to my interest in science – Breathing contributed/contributes to my interest. (Journal entry 1/3/00)

Theme 1: Combining loves. Rosalind's entire life reflects a passionate curiosity about science, particularly anything related to life science. She has been interested in science for as long as she can remember. This is interesting because she was raised in a family that was very academically oriented but not particularly science oriented. Rosalind has an explanation for the genesis for her science interests; as she describes it:

I think I was born with a love of science gene – they may be mapping it even as we speak. Unlike others who may have had a particular incident or series of incidents trigger something – I have a feeling that I emerged from the uterus naming the parts of the reproductive system. (Timeline)

Rosalind's love of science has been a consistent controlling factor for her entire life. Even today, as she approaches retirement age, she brings a childlike enthusiasm to any discussion of a science related topic.

I cannot imagine my life without science – nor would I want to. I think that my choice of science for my first career and then teaching science for my second career has allowed for many positive avenues. (Journal entry 10/25/99)

Rosalind's love affair with science led her to consider a career in science; there seems to have hardly been any other options that she would consider at the time. The
opportunities available to her led her to her first science career, which she pursued for seven years. She became dissatisfied with this position due to the politics involved with the job and the personal interactions with her boss and began searching for an alternative career; two factors exerted an influence on her: the first was the academic experiences of her childhood and the second was her work with a local sorority. Through her work with the Kappa Delta sorority, she found that she enjoyed working with young people. These factors, along with the encouragement of her friends who said she was good in working with young people, led her to consider combining her love of science with her new found love of working with young people into a second career as a science teacher. Rosalind's move to the science classroom, in this way, reflected the combining of loves – her first love, the love of science, and a newly rediscovered interest of working with the education of young people. This melding of passions seems to have been a perfect amalgam for her career path.

*I am able to share my passion for my subject with my students. I think this is a good thing. I tell them up front that they don't have to love biology because I [sic] love is enough for all of them put together. As I look back over my life (which I do frequently as I approach retirement) I think I am so lucky to love what I teach and teach what I love. I know that I teach children first but to think that I have been able to teach them what I love the most for 28 years and the other 7 years I was doing biology!* (Journal entry 10/25/99)
Question 3: "What beliefs do second career science teachers hold with regard to science teaching and learning?"

I have continued to study so that I could "thoroughly" understand and be able to communicate to my students the true nature of science. This is why I usually tell my students that the most important ideas I can share with them come during a brief excursion into the origin and essence of science. (Autobiography)

Theme 1: Sharing the passion. When reading through Rosalind's data as she describes her life and career, the one word that comes to mind as she describes the relationship to science and the commitment to her students is the word passion. Passion describes her curiosity toward investigations, toward learning, and toward scientific advances in all fields (but particularly in the field of biology – as Rosalind will quickly point out).

I can not imagine my life without my love for science specifically BIOLOGY. It has been a life long passion and the more I know the more I want to know. I'm sure other teachers in other areas are passionate about their topics or subjects but I don't see how any area could be anywhere near as exciting as science. (Journal entry 12/4/99)

Passionate commitment to the education of her students as well as their preparation for college, career, and for life in the 21st century is an integral component of Rosalind's inner being. To say that Rosalind enjoys science teaching and wants to share her passion for her subject with her students is an understatement. As Rosalind elaborates on her passion for teaching, the image of a religious evangelist fervently
spreading the gospel, trying to save the masses comes to mind; Rosalind brings this aspect of deep commitment to her teaching. She deeply cares about her students and wishes to help prepare them for success in later life; these desires lie at the core of Rosalind's beliefs concerning science teaching and learning. That Rosalind has maintained her passion despite the challenges and disappointments all teachers face, over her 28 year career in the classroom is exceptional. Perhaps it is her curiosity and passion for learning that have sustained her passion for teaching.

I think it's [love of learning] the very basis, to continue in this area.

Contrary however, to what a local science teacher said at the 9th grade level, science never changes, scientists never have to go back to school.

That couldn't be further from the truth; you have to continue to go to school to learn, but you've got to keep current. Your kids deserve that. I don't think anybody ought to continue teaching if they don't try to stay current. (Interview 1/28/00)

Theme 2: Bringing the lab to the classroom.

...I think the kids have to have hands on stuff; I hate to say hands on but...labs, they've got to do it; there's no, it's no, alternative for doing science than doing it; that's just it; you do science. (Interview 3/30/00)

Rosalind views science as a participation activity. Her role, she feels, is that of a facilitator – a guide to help students as they learn science by doing science. Perhaps because of her laboratory background, she strongly believes that students need to be in the laboratory conducting learning activities. It was her work in the lab that Rosalind believes prepared her the most for science teaching. Rosalind stated, "I think my 7 years
as a microbiologist [best prepared me]; I draw on that frequently for labs" (Interview 9/28/99).

Rosalind's belief that science is best taught in the laboratory as students actively participate in the learning process also has its roots in her lab experience. In her journal, when reflecting on links that might exist between her two careers, she wrote:

*I would say that I brought my 7 years experience as a microbiologist and youthful enthusiasm to teaching. Additionally I brought an appreciation for "doing" science, real world science, an appreciation for the scientific method.* (Journal entry 3/13/00)

When her students enter the laboratory for instruction Rosalind is excited for this is the time she feels she is really teaching. "When I can walk around and teach individually – I feel GREAT!...Anytime I can work individually at the scopes I can actually TEACH!" (Journal entry 9/29/99). She envisions a Biology course that would last one and a half or two years instead of the one year course as it is now taught; the additional time would be used to incorporate more labs. In addition to the use of laboratory work for the development and refinement of science process skills, Rosalind prefers to use a small group lab setting for presenting content information to her students. Rosalind does not lecture very often; she stated, "I'd rather do to small groups in the lab and do my lecturing or teaching that way" (Interview 9/28/99).

Rosalind summed up her beliefs with regards to use of the laboratory in the teaching of science in this way: "I don't think that being involved in lab work necessarily means that one will involve the students in it. I felt then as I still do that lab is the heart and soul of science" (Historical timeline elaboration).
Rosalind also believes that teachers of science must be careful not to use the same activities over and over each year. Science teachers who take this shortcut run the risk of falling into a rut which may rob the students of the science knowledge they need to succeed and will rob the teacher of any joy in their teaching. One of Rosalind's teaching metaphors she wrote for this study was titled "Teaching as Organic Gardening". An important aspect described is the need to rotate crops which Rosalind associates with the use of different teaching techniques. Rosalind stated that crop rotation is important "because if the same crops are planted in the same place their growth might be stunted" (Metaphor). Rosalind was referring to the detrimental effect on student learning that might occur if a science teacher uses the same activities over and over again. Rosalind felt that her background in microbiology helped prepare her to be more willing to try new and different activities and believed that those with a science background would be more willing to try new things because they were more confident with their subject knowledge. She stated:

[I'm a] big time risk-taker. I just, I think that that keeps it alive for me and for the kids. I try things new; and so what if it doesn't work, you can go back and, you can always go back on your old tried and true; if you have to. Although I do attempt to follow a curriculum, I, I still go in, um, new, uh, dry labs and new activities for the kids to [do] while covering the material, I hope. I've never done a study; but, I have to think those more comfortable with doing science and being in science would be more willing to branch out and take risks and try untried things and we know that if they don't work, you throw them away; that's what happens in
science; if it doesn't fit and if it doesn't work then it needs to be thrown out. And not accepted as part of the scientific method or whatever. So I think there would be a direct correlation; I would be interested in knowing if it holds true for those who have done science prior to teaching, maybe we take more risks. That's all they know is what was done in the classroom; they don't know that people experiment a little bit with this test and they teach it here and teach it there and of course experience does nothing to substitute for that, um, experience in teaching, or in the profession you're in, uh, to help you realize that you takes more risks as you go along. (Interview 3/30/00)

Rosalind's belief that "labs are the heart and soul of science" (Historical timeline) is also evident in her photoessay. She devoted three pages of her essay to her teaching; these pages are filled with photographs of her students in a lab setting "doing" science. Perhaps these photographs (see Figure 5) point to a deeply held belief that science, rather than representing knowledge gained by a solitary researcher in an isolated laboratory, is a human activity best advanced in a collaborative and cooperative atmosphere.

Theme 3: Preparing for 21st century.

I don't think we can "give" them the "science" that they need. I suppose the most important science "thing" that we must teach our students is the scientific method – we just must teach them why the scientific method is so special and that it is this method that makes "science" what it is. (Journal entry 3/6/00)

As Rosalind considers the science knowledge her students need for successful careers in the 21st century, she believes it to be impossible for any teacher to give her/his
students this body of knowledge; students must be taught the process of acquiring knowledge through investigation. Rosalind emphasized that as the body of scientific knowledge becomes ever deeper, it will become increasingly futile to attempt to stay current by rote memorization. Students will need to become proficient in investigation and information acquisition through the scientific method. Rather than science class as a large and ever expanding array of facts to learn, Rosalind views science class as a process training lab in which students master the skills needed to objectively investigate and evaluate phenomena using the scientific method. Rosalind does not discount the need to know facts, she just acknowledges the futility of memorizing information when the knowledge base is expanding at such a great rate. She views technology as an important tool in the process of accessing knowledge. Computer technology has greatly streamlined the process of learning information and gathering facts, this is a blessing in that it frees up science teachers to concentrate on the processes of science.

_Because we no longer need to be required to teach them facts and that's been gone for a long time; but, we sure can't be teaching them facts now._

_I know [many people do this]... But they're goin' to be able to go to their computer and find the facts; we've got to teach them the scientific method, what steps are taken, um, what's required, the thinking involved, how to get information, how to acquire information through technology so they can vote on irradiated foods, or cloning, or whatever it is that they're goin' to have to be involved with; uh, they'll need to know about making...but they need to be able to find out about how irradiated foods can affect their lives, if indeed it does, so they'll need to tap technology to
Oh yes... teaching...

Labs, always the emphasis on labs...
Figure 5.

Excerpts from Rosalind's Photoessay
find information. If we teach them the importance of acquiring
information and being, um, informed so they make a decision, and what's
good science and what's bad science and the steps involved in the good
science, and what to look for. Maybe that will help 'em more in the 21st
century and with this technology...we've gotta, it has to be interwoven, I
think, in what we do. (Interview3/30/0)

The belief that students must be taught the skills needed to acquire new knowledge
appears to be, for Rosalind, a core belief with regards to science teaching and learning
because she reiterated this belief across many of her data sources. The tenet that school
science must involve something more than student memorizing of facts forms the
foundation of her science teaching. She believes that students gain understanding
through active involvement. Her beliefs are in concert with the National Science
Education Standards which state "…students develop an understanding of the natural
world when they are actively engaged in scientific inquiry – alone and with others"
(NSTA, 1996, p. 29). Although, for Rosalind, the teaching of science as a verb –
something that is done instead of memorized – is central to her concept of her role in the
science classroom, she acknowledges there are factors that limit the class time she can
devote to inquiry skills development. Rosalind identified two factors that tend to shift
science education away from process and more toward facts. One issue involved teachers
trained in traditional techniques that include minimal emphasis on process skills and a
second issue involved the renewed interest in student testing to access student
achievement. Rosalind addressed these issues in the following interview segment:
Uh, I think by us old time teachers being open to suggestions. (Laughs).
Ways we can do things differently. I don't see how to get around all those tests you have to take. The whole world revolves around testing. Um, I see the value in that, because that's what society wants but then such problems because you've got to teach them facts, have them memorize facts, just to pass a test. Um, when that's not really the important area that they need to be preparing themselves for. And I place my values on investigating their world more. (Interview 1/28/00)

In summary, Rosalind's beliefs concerning science teaching and learning center on her passion for scientific investigation. Her personal precept that laboratory activities lie at the core of effective science teaching and her strong conviction that students need to be taught the process of science to best prepare them for success in the 21st century undergird and direct her teaching philosophy. Rosalind's passion for science teaching and concern that the young people of today get the knowledge they need for the 21st century is evident throughout this study.

Before this treatist [sic] gets too long, I'll end by saying that I have endeavored to continue my life-long learning and attempts to share my passion for my subject. I can only hope that my teaching translates to a meaningful component in the lives of these young people. I realize the importance of my subject to our present and future world and I want to share this with my students in a way that will ignite their desire to be life-long learners. (Autobiography)
Question 4: "What professional, cultural, and societal borders did these second career science teachers have to negotiate to enter the world of school science?"

Theme 1: Hurdles. Rosalind's journey to the world of school science was not without challenges. When she writes of this time in her life, she speaks of this being the most frightening time in her life. While she was convinced of her need to change careers and certain that the move to school science was the correct direction for her career to take, the misgivings she experienced represented significant hurdles which she had to negotiate to effect her career change. These apprehensions centered in three areas: the fear of running out of money and not having a job, loneliness during the transition, and the anxiety related to talking in front of a lot of people. The fear of running out of money is mentioned in several data sources. In one example she talked about how frightening this time of career change was for her.

*I worked in a city lab as a microbiologist for seven years, until friends and sorority work convinced me I needed to be working with teens and not test tubes. I took all of the education courses I could take at night and then quite [sic] my day-job to return to school full time. This was one of the most frightening things I have done in my life... I had two years worth of money to support myself while returning to TCU full time to get my certification. Ft. Worth ISD, one week before my rent (that I could not pay) was due, hired me. Whee! (Historical timeline elaboration)*

Rosalind's concerns about finances were very real. She had been supporting herself and was not receiving any monetary help; therefore, the decision to quit her job and go back
to school would mean a total lack of income and she would have use to her savings to get
her through this time of nonemployment.

As I said before, I was my sole means of support so I had to figure to the
dollar what I would need to live on (rent, food, etc.) and pay for classes at
TCU. All of this assumed that I would be hired by Ft. Worth Ind. School
District when I finished student teaching. Big chance on risk. (Journal
entry 11/15/99)

This time of career change was a lonely time for Rosalind; she had left her friends
in the laboratory and was going out on her own – to a new world, that of school science.
Although career change was frightening and she felt lonely, Rosalind addressed and
overcame these fears by keeping her focus firmly on her goal of becoming a science
teacher and immersing herself totally in her studies.

As far as planning the money and timing to be able to support myself and
do my student teaching. I remember the time as a scary, lonely time. I
really felt very much alone and I think I had to really submerge myself in
my education classes to reduce my anxiety. (Journal entry 1/24/00)

Figure 6.

Turtle Drawing from Rosalind's Photoessay.
Rosalind's photoessay also shed some light on her focus during career change. Included in her photoessay is a sticker of a turtle and the statement "behold the turtle: he makes progress only when he sticks his neck out" (Photoessay).

Another challenge Rosalind faced was her inherent shyness. The thought of standing in front of a group of students and talking to them was very uncomfortable to her. She was used to working in a laboratory with limited contact with people. "The biggest challenge was my timidness and trepedation [sic] about dealing with people instead of petri dishes" (Journal entry 3/13/00).

Summary and Preview

In this chapter, the threads of the lives of Daffodil, Dave, and Rosalind have been presented as a tapestry woven through the remembrances of their life experiences. Participants have shared deeply personal, often intimate, recollections of their lives and beliefs concerning science teaching and learning. Responses for Question 1: "What are the life stories of second career science teachers?" revealed themes that centered on a lifelong love of academics, science, the influence of others, and the move to school science as a convergence of lifelong passions. The life story of Daffodil was organized around the themes of "Return to roots" and "Voyage to collegium"; the life story of Dave revolved around the themes "Grafting the branches" and "The influence of heroes"; Rosalind's life story centered on the themes "The rebel returns to her roots" and "On the shoulders of giants". Both the convergence and divergence between themes across the cases are presented in the next chapter.

The second research question, "Where is science in their life stories?" generated responses that revealed the central role science has played in the participants' view of the
world and their place in it. Daffodil's understanding of the centrality of science as the basis for all existence was expressed in the theme "What is science but life?". Dave's science-oriented world view, emergent from his data, was described by the theme "Science defines life". Rosalind's life long love affair with science was expressed in the theme "Combining loves". Similarities and differences between these themes will be discussed in the next chapter.

The third research question, "What beliefs do second career science teachers hold with regard to science teaching and learning?" elicited a variety of responses that were organized in this manner: for Daffodil, "Passing the torch", "Learning to do, learning to teach", and "Adjusting the vision" were significant themes; for Dave, the significant themes were: "Kindling the fire" and "Teaching with blinders on"; for Rosalind, "Sharing the passion", "Bringing the lab to the classroom", and "Preparing for the 21st century" were significant themes. Areas of convergence and divergence between the beliefs of these three second career science teachers are explored in the next chapter.

The final research question, "What professional, cultural, and societal borders did these second career science teachers have to negotiate to enter the world of school science?" elicited insights into challenges faced by the participants as they made the move to the world of school science; data, again, were organized into inherent themes. The challenges faced by Daffodil as she made the move to the world of school science were summarized in the theme, "Crossing in mid-stream". The frustrations experienced by Dave as he came to the world of school science were summarized by the themes: "Certification: Spinning my wheels" and "Transition: Bumps in the road". Rosalind also experienced challenges in her move to school science; her experiences are summarized
by the theme "Hurdles". Similarities and differences between these themes are presented in the next chapter.

Chapter 5 presents a cross-case analysis of the participants' responses to the research questions. This chapter explores themes common to more than one participant as well as themes specific to one individual. Threads from each participant will be woven into a common tapestry illustrating the lives, beliefs, and career challenges faced by these three second career science teachers.
CHAPTER 5

FAMILY PORTRAIT:
CROSS-CASE ANALYSIS

Introduction

In Chapter 4 the life stories of three second career science teachers as depicted by within-case analyses of each participant were presented. This chapter presents a cross-case analysis of the three participants that focuses on themes gleaned from the data that are common to more than one individual. Miles & Huberman (1994) state that one goal for cross-case analysis is to deepen and enhance "understanding and explanation" (p.173). The present study sought to build understanding concerning the beliefs of second career science teachers with reference to science teaching and learning as they related to their life stories and career experiences. Therefore, an analysis of themes present in the data across the three cases will, in addition to providing insight into each participant, promote understanding of this subset of science teachers that represent second career science teachers. The examination of multiple cases through cross-case analysis, according to Miles & Huberman allows the researcher to enhance the description of a phenomenon through "examination of similarities and differences across cases" (p. 173). In this chapter, the similarities and differences between the participants of this study will be examined through a description of the themes present in the data that are shared by multiple participants.
As in Chapter 4, the themes are organized around the research questions. Specifically, the research questions informing this study were:

1) What are the life stories of second career science teachers?

2) Where is science in their life stories?

3) What beliefs do second career science teachers hold with regard to science teaching and learning?

4) What professional, cultural, and societal borders did these second career science teachers have to negotiate to successfully participate in the world of school science?

### Table 8

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The theme common across the data of the three teachers with regard to research question # 1 was "Completing the portrait". With respect to research question # 2, the theme "Sci-
evangelists", was common across the participants. Participant responses to research question # 3 revealed the common themes: "Adding to the passion", "Finding my center", and "To know is to teach/content is king". "The crossing" emerged as a common theme gleaned from responses to research question # 4. The response variation among participants will be explored later as a part of the discussion of each theme in this chapter.

Question # 1: "What are the life stories of second career science teachers?"

Theme 1: Completing the portrait. The life stories of these second career science teachers can be thought of as murals composed of a series of images that depict life experiences and that connect the important relationships, beliefs, goals, and dreams of each person. The career path of each of the three participants reflected a multi-faceted image composed of work experiences related to science as well as school science. The lives of these participants represented, in large part, a life long interest in science as a method of explaining the world and a deep appreciation of science teaching and learning, born of a record of high academic achievement throughout their student careers. Their move to the world of school science reflects the completion of the portrait of their careers to this point and represented the joining of two strong life long influences, namely, science and academia.

It is probable that their lifelong interest in science was a product of a number of experiences that guided their interest; however, in reflecting on their life stories, each participant related a critical experience or described a key person whom they perceived as instrumental in shaping the science world view that has so defined their lives. It is probable that other experiences, which the participants either did not remember or were
unwilling to share, exerted a significant influence on them; it is, however, interesting that these individuals, in the middle stages of their lives, would recount incidences that occurred in their childhood and characterize them as pivotal in the development of their interest in science. The fact that these, often brief experiences, are remembered so vividly after a number of years have passed suggests that these events played an important role in the lives of the participants and is consistent with participants’ own evaluation of their remembrances.

For Daffodil, her natural curiosity played a large role in the genesis of her interest in science. Her parents seemed to have played an integral role in the development of her scientific curiosity by encouraging her to pursue her interests. Daffodil stated, "...anytime we expressed an interest, they made sure that they provided an opportunity to learn about what we were interested in. I was fortunate to have parents who were always there for us" (Interview 3/24/00). When reflecting on her childhood interest in science several sets of experiences came to her mind in which she had the opportunity to nurture her interest in nature. She recalled walking in her neighborhood, observing plants, animals, rocks, and stars, being curious about them and reading books to learn the names of each. Daffodil remembered seeing the northern lights, lying on blankets watching a lunar eclipse, and traveling to Dismal Swamp in South Carolina to observe a total solar eclipse. She also recalled a trip to a science museum where she observed a Foucault pendulum. Daffodil remembered her desire to tell others about the information she had learned; this desire led her to conduct science camps for younger children in her neighborhood. Daffodil's life long interest in science seems to have its roots in these
childhood science experiences where her interest in nature led her to seek out scientific explanations for the phenomena she observed.

As Dave reflected upon the genesis of his love of science, he related several images that came vividly into his mind. The images that Dave recalled revolved around interactions with his father and the beginnings of Dave's commitment to science seemed to lie in how he looked up to his father who was a "science person". He spoke of being with his father in the woods and of riding on his father's shoulders while his father told him the names of all the trees. He remembered fishing and "catching a large trout – with my hands in a stream in Washington State. It was a huge beautiful fish and I kept dropping it in the dust and crying – it was a defining moment." (Journal entry 1/7/00). A third series of images that Dave related involved the trips his father made to his school classes to bring specimens and talk about nature. For Dave, his deep appreciation for nature and his devotion to science seemed to have their roots in his early childhood interactions with his father.

Rosalind can not remember a particular series of experiences which led to her interest in science; instead, she believes that she must have been born with a "love of science gene" (Elaboration on historical timeline) because she always remembers being interested in nature. While the genesis of Rosalind's scientific curiosity occurred early in life with details that remain unclear, her interest in science was encouraged by two experiences. As a young child she remembered that her mother described her as a "budding naturalist before she was ten" (Timeline) and she recalled that Ms. L., a junior high school teacher, referred to her as an "answer to a teacher's prayers" (Timeline). For
Rosalind, it seemed, her life-long love of science began early in life and was fostered and encouraged by positive interactions with individuals who were important to her.

The first image that composed the career path in the life stories of these second career science teachers centered on curiosity about the world and the love of science as a means of explaining their world. Whether engendered by the childlike curiosity described by Daffodil, the strong father figure and role model described by Dave, or by the "science gene" described by Rosalind, a love of science continues to play a defining role in their lives and careers. The selection of school science as a second career represented the continuing evolution and expression of that lifelong love of science.

The second image that formed the career path for all participants is a deep appreciation for academics. In much the same way as their science interest went back to childhood experiences, appreciation for academics seems to have had its roots in strong family expectations and in early childhood school experiences. Daffodil remembered her parents setting strict academic requirements for herself and her sisters. Teachers were to be respected and homework was to be completed nightly; academics came first, other activities were second. Daffodil learned to read at a very early age and seemed to crave knowledge from books – reading everything she could find in the public library concerning subjects that interested her as well as reading the encyclopedia. She was a good student and a member of the pilot gifted class at her elementary school.

Dave came from a family of educators – his father and grandmother were teachers. Academic achievement was expected and required. Dave recalled being told by his parents from an early age "you can do it if you just apply yourself…you're smart – it's easy for you" (Autobiography). The encouragement of his parents resulted in a desire
for high academic achievement. Dave recalled that "academics was [sic] to me a matter of pride. I enjoyed doing well and I wanted the teachers to be pleased with my efforts" (Autobiography).

Rosalind also came from a family of educators; her father, mother, grandparents, and various aunts and uncles were all educators; there was a high appreciation for academic achievement in the family. "As far back as I can remember, education has been emphasized in my family" (Journal entry 1/10/2000).

For all three participants, an appreciation of the importance of academic achievement was developed in childhood through strong family influences and has remained, along with a love of science, a guiding influence in their life stories and career development. For all three of these second career science teachers, the selection of school science as a second career represented a continuing appreciation for academic achievement coupled with their continuing love of science. In this way the career paths of the participants reflected the joining of science and academic achievement into an ever evolving image that united these lifelong passions.

Question 2: "Where is science in their life stories?"

Theme 1: Sci-evangelists. Upon looking at the data across the three participants, it was clear that each participant brought a passionate interest to the science classroom. Each developed an interest in science at an early age and this interest developed into a lens through which to view, understand, and evaluate their worlds; in this respect, interest in science has developed into a science-centered world view for these participants. Each participant spoke of science as integral to human existence and an essential component of a student's education. Each participant served as a strong advocate for the importance of
science achievement to every student's life and career. Rosalind spoke of her desire to share her passion for science with her students. Rosalind went on to state "I realize the importance of my subject to our present and future world and I want to share this with my students in a way that will ignite their desire to be lifelong learners" (Autobiography). It seemed that the participants have retained their childlike enthusiasm for science as a field of study and body of knowledge and have brought with them the passionate curiosity for the natural world that launched their own lifelong odyssey of scientific investigation. Among their primary goals for the science classroom was the infusion of passionate love of scientific inquiry into their students; they wish to share their love of science with their students and feel frustration when students are unable or unwilling to share their zeal. Daffodil expressed her wishes in the following way, "Maybe I'm being unrealistic, but I want my students' minds to blaze with a passion for learning; I want them to have a sense of wonder when they look at what's around them and have the curiosity to explore and the willingness to investigate what they don't understand. So far, all they seem to want is good grades on the tests and for everything to be easy" (Journal entry 1). Dave expressed a similar thought; while he would like to share his passion for science with his students, "the indifference that I must fight through is almost overwhelming. Over half of my classes feel they have to take science – they didn't sign up for it, these students also see no point in these classes" (Case narrative story). In contrast, Rosalind did not seem to see as much indifference among her students as Daffodil and Dave; this was due, perhaps, to the fact that she taught upper level senior science classes and gifted sophomore science classes. She felt that students wanted the information but did not want to work to obtain the information. This was a tension for her because she strongly felt an obligation to
"teach these young people a state curriculum that includes certain topics. Also I must remember this rigorous regimen can only help them when they go to college" (Case narrative story).

Through the process of sharing their passion for science and portraying the importance of science in the lives of their students, these second career science teachers reminded one of the religious evangelists seen on television. They had good news to share that would make their students' lives more rewarding and productive and they were diligently seeking to gain as many science converts as they could. When teaching their classes, these sci-evangelists attempted to lead their students to the promised land of scientific understanding where solid careers and meaningful life experiences are to be found.

The sci-evangelists viewed the world through the lens of science; they viewed science as the way to understand the universe (and one's place in it) and as an array of significant and productive career paths through which one could make a positive impact upon society. This set of beliefs comprised a significant component of the world view possessed by the participants. Proper, Wideen, and Ivanny (1988) stated "a world view is a person's set of beliefs held consciously or subconsciously, about the basic nature of reality and how one comes to know about it" (p. 547). Cobern (1991) described world view as "a culturally dependent, generally subconscious, fundamental organization of the mind. This conceptual organization manifests itself as a set of presuppositions which predispose one to feel, think, and act in predictable patterns" (p. 16). The science oriented world view held by the participants, built upon the experiences from their first careers, was so closely and deeply held that the sci-evangelists had difficulty in
understanding and appreciating the variety of alternative world views that students brought to the science classroom. One goal for preservice teacher training may be to enhance second career science teachers' ability to empathize and bridge the gap that may exist between their and their students’ understanding of the world.

Question 3: "What beliefs do second career teachers hold with regard to science teaching and learning?"

Theme 1: Adding to the Passion. As described above in the theme "Sci-Evangelist" each of the three participants brought with them to the science classroom a passionate interest and love for science. Each participant possessed the strong desire to share their enthusiasm with their students as they sought to instill the love of science in their students. These second career science teachers, while strongly committed to the importance of science, presented evidence of a somewhat vague understanding of the philosophy and nature of science and the scientific process. In contrast to the "gospel-like" quality and inherent value assigned to scientific explanations by the belief structures of the sci-evangelists, philosophers of science speak of the discipline as one that seeks to develop theoretical understandings about the world through a process of problem solving that consists of conjecture, observation, and experimentation. Popper (Thornton,1997), Kuhn (1970), Lakatos (Motterlini,1999), and Laudan (1977) emphasized the impermanence and correctability of scientific knowledge and stressed the conviction that the value of scientific research lies firmly in the ability of that research to solve problems or to make useful predictions concerning natural phenomena that are corroborated by observations. Imre Lakatos (Motterlini, 1999) described science as a series of theories that are connected together in what he terms scientific research programs and that a
research program is progressive if it continues to make successful predictions about phenomena present in nature. Lakatos wrote, "...my standards apply to series of theories (research programmes) and not individual theories... I term 'progressive' any program which predicts events confirmed by subsequent research, thereby leading to the discovery of 'new' facts." (Lakatos quoted in Motterlini, 1999, pg. 2). Karl Popper described science, at its most basic level, as a process of problem solving (Thornton, 1997). Laudan (1978) echoed Popper with his statement "science is essentially a problem-solving activity" (p.11). Laudan stated, "if problems are the focal point of scientific thought, theories are its end result...the first and essential acid test for any theory is whether it provides acceptable answers to interesting questions: whether, in other words, it provides satisfactory solutions to important problems." (p. 13). Thomas Kuhn described science as a process of puzzle solving as scientists seek to expand existing understanding (Pajares, 1992). Kuhn (1970) described the progress of science as occurring in two ways: normal science and revolutionary science. Normal science is research that has its basis in past scientific discoveries; he referred to revolutionary science as the unexpected discoveries that do not fit existing scientific frameworks and force the revolutionizing of scientific understanding (Kuhn). Kuhn went on to state that "bringing a normal research problem to a conclusion...requires the solution of all sorts of complex instrumental, conceptual, and mathematical puzzles. The man who succeeds proves himself an expert puzzle-solver, and the challenge of the puzzle is an important part of what usually drives him on" (p. 36). The ideas of these philosophers might be summed up by the words impermanence and usefulness. The process of science represents the attempt to understand and explain the world through logic and observation.
Scientific knowledge reflects a work in progress in which explanations and understandings are modified as ideas change in light of new discoveries. The goal of science is one of useful problem-solving and prediction-making; science, more than being a "neat" way to gain knowledge, is oriented toward solving real world problems. The participants tended to describe science in broader, more general terms; the passion of their interest was more grounded in scientific explanations of natural phenomena than in the sometimes uncertain process by which these explanations were developed. When responding to questions concerning the nature of science, each participant responded in broad generalities of how scientific knowledge is both an interesting and essential body of knowledge concerning the natural world. In describing their beliefs regarding science, the participants expressed a range of beliefs that, in some instances, approached more accepted ideas concerning the philosophy of science, but on other occasions varied greatly from the writings of Popper, Kuhn, and Laudan.

Daffodil, in describing her beliefs concerning science, presented a more global understanding of scientific knowledge; she viewed science and life as interchangeable components of one another. She stated, "…life is science. We can't exist without biology, chemistry, physics; and all the questions these disciplines bring are what breathe life into the mind and soul. The search for truth and understanding is what it's all about (for me any way)" (Journal entry # 5). Daffodil's interest in science grew out of her curiosity concerning nature which began for her in early childhood. In another journal entry she seemed to reflect back to these childhood passions as she linked the process of science with curiosity about nature; she wrote, "… a thirst for knowledge and a knack for asking interesting questions. That is science" (Journal entry 16). Another aspect of
Daffodil's beliefs with regard to science was a sense of permanence or absoluteness. Rather than writing of science as a process of developing theories that make predictions or solve problems, she referred to science as a search for ultimate truths about nature. The word truth, which Daffodil applies to scientific knowledge, seemed to imply an absoluteness or permanence to scientific explanations. She stated, "Somehow we have a skewed view of what science really is. We have this insistence that science is a cold, uni-dimensional, rigid discipline; and when in fact, it's really, it's almost a religious search for truth" (Interview 2/25/2000). In other writings, she revealed a more process oriented understanding of science when she wrote, "To me, science is any endeavor that seeks to uncover the basic truths about our universe and to organize those truths so we can see an order which leads to an understanding and appreciation of that universe" (Journal entry #5). Daffodil, it appears, had a somewhat nebulous understanding of the nature and philosophy of science that was centered on curiosity about nature and the search for ultimate truths about the universe.

In much the same way as Daffodil, Dave's interest in science began at an early age with curiosity about nature and, like Daffodil, Dave expressed an "all-inclusive" understanding of scientific knowledge. Dave also conveyed a deep seated connection with science as he stated:

*Science in the truest sense defines my life. On a personal level it has provided me with a means of making a living. As a child of the 60's I feel always like an environmental scientist first. I think we are all in this together and since we all share the same address, whatever we can all do to improve the planet needs to be done. As a scientist I can not only*
understand this but explain it. Only a truly enlightened person can be
aware enough of their surroundings to truely [sic] enjoy them. My life is
constantly enriched by the marvelous complexity of nature and the ability
to comprehend the actual simplicity with which it works. (Journal entry
12/4/1999)

Dave viewed science as a body of knowledge with which to understand the workings of
the universe. His beliefs with regard to science seemed to venture toward explanations of
natural phenomena that could be described as numinous or religious as he wrote:

Instead of science as a puzzle, I've always viewed science as the answer to many
mysteries. Not that I know the answers to all the questions, but instead of things
being totally unexplainable I've always found the world more understandable
because of science. (Journal entry 10/28/1999)

I see science as the quest for knowledge. In the purest since it's knowledge for

Therefore Dave, in much the same way as Daffodil, expressed beliefs concerning science
that are somewhat loosely defined and simplistic. His beliefs did not appear to reflect
understanding and appreciation for currently accepted ideas of the philosophy and nature
of science and seemed to be related to his deep seated curiosity and concern for nature.

Rosalind, when writing of her beliefs concerning science, wrote about her love of
science, "I cannot imagine my life without my love for science, specifically Biology. It
has been a lifelong passion and the more I know the more I want to know. I'm sure other
teachers in their areas are passionate about their topics or subject but I don't see how any
area could be anywhere near as exciting as science" (Journal entry 12/4/1999). Rosalind,
in addition to her passion for science, expressed, more than Daffodil or Dave, an understanding of science as a process. Her ideas were more in concert with accepted ideas of the nature and philosophy of science. Her beliefs were revealed as she wrote of the importance of the scientific method in her journal:

*I suppose the most important science "thing" we must teach our students is the scientific method. We must teach them why the scientific method is so special and that it is this method that makes science what it is. We must share that all so-called discoveries in science are subject to scrutiny – all are subject to review and replication. (Journal entry 3/6/2000)*

Therefore, for all three of these second career science teachers there exists a need to enhance their understanding of the subject they love so much. In the face of their love for science, there appears to be a need to sharpen and enhance their understanding with regard to the philosophy, goals, and aims of science. The educational experience the participants can offer their students can be enhanced by adding understanding to the passion.

**Theme 2: Finding My Center.** Beliefs among educators concerning the most effective strategies for students’ learning in a science classroom vary from totally teacher centered, in which the teacher presents all the information to the students, to totally student centered, in which students, through learning activities, create their own knowledge. The data from this study suggested that a degree of tension existed within participants' belief structures concerning the issue of teacher centered versus student centered teaching and learning. This tension was most apparent in the data for Daffodil and Dave. Both Daffodil and Dave expressed their belief in the importance of student
involvement in laboratory activities to the science learning process and viewed science as a "doing" subject; at the same time, they viewed science learning as a teacher led process of discovery.

Daffodil, in her teaching metaphor, expressed her beliefs in this manner:

_Ideally, a teacher of high school science should be the leader of an expeditionary force. She trains her team members in the basics, sparking curiosity about the world about them, and then takes them out to explore new territory. Even though she's been through the area before, each new team brings its own perspective and the landscape changes with every visit. Ultimately, the goal is for the team members to become capable leaders or solo explorers in their own right._ (Teaching metaphor)

For Daffodil, it seemed that students can be in charge of their own explorations after they have been led and taught by the teacher. She expressed her belief in the benefit of student centered learning but under the direction and instruction of the teacher. The science learning process, ideally, for Daffodil, intimately involves the student but is led by the teacher. When describing a meaningful science teaching experience, Daffodil related an experience that reminds one of Aristotle leading his students in a learning dialogue. She wrote:

_If there's no learning, there's no teaching!! It's a two way street and requires an exchange of ideas. Both the students and I should come away with something to think about. Unfortunately, most days I feel like I give my lessons in an empty classroom. Even though most of my students are physically present, I don't feel like we connect, and no real exchange of_
ideas occurs. I try to engage them in a dialogue that will lead them to
discoveries about the world, but all they want is the "right" answers for
questions that will be on the test. (Teaching metaphor)

In this passage Daffodil expressed her belief in and desire for student involvement
in science learning while at the same time her belief in the need for teacher directed
learning in her science classroom. So, it seemed, Daffodil's beliefs with regard to science
teaching and learning represented a mixture of student centered and teacher centered
philosophies.

Dave, when describing a meaningful teaching experience, wrote of his
Horticulture class, "An experience when I felt like I was really teaching was in
Horticulture class. I was teaching how to plant seeds and take care of them. The hand's
on approach to identifying plants and trees is much easier for the kids to understand"
(Journal entry 10/2/99). Dave provided insights into his belief in the value of a teacher
centered classroom as well as the importance of student centered learning in his teaching
metaphor written to describe the ideal science teacher. He wrote:

I view the ideal science teacher as a conductor of a great
orchestra. Each student is a talent in their own right but unless they have
the proper guidance they will never achieve that which they are capable
of. As you practice daily you become better at anything – this is true with
my classroom orchestra. The students will continue to need your guidance
but you will eventually reach a point where your orchestra will operate
itself. They will continually need your help for new information and new
works but once you have trained them how to learn then they can truly

*teach themselves.* (Teaching metaphor).

Dave seemed to feel that students can learn autonomously but only when the teacher guides them. His ideal class is an orchestra that requires direction. He stated that the members of the orchestra, after they have learned how to learn, can teach themselves, but, they will need his leadership to master new concepts. The passage also implied that the orchestra members rely on the leader for instruction in the process of learning how to learn. Dave's ideal class, therefore, relies on the leader for mastery of new information and for mastery of the skills needed for student centered learning; in both situations, the teacher is the focus of instruction. Once new material has been mastered and once the orchestra members have mastered the ability for self learning, then students can assume control of their learning through repetition and practice with the concepts presented by the teacher; this philosophy represents what might be referred to as pseudo-student centered learning in that the students are not given the focus for investigating new concepts but are put in control of committing the concepts to memory through drill and practice. Dave summed up the description of his metaphor with the following statement, "That in my mind is what a teacher [does], I have the knowledge, I have the resources, I have the time on a daily basis, now let's do it" (Interview, 4/20/2000). Therefore, it seems that additional instruction in current methods of student centered learning in the science classroom might help Dave clarify and update his belief structure concerning student learning.

In contrast to the beliefs of both Daffodil and Dave concerning science teaching and learning, Rosalind expressed a much more student centered philosophy of student
learning. She seemed to view her role as more of a guide to assist students as they discover and learn new material. Like Dave, Rosalind in her teaching metaphor described science teaching in terms of being the leader of a band or and orchestra. However, careful reading of her metaphor revealed a very different focus than that expressed by Dave. For Rosalind, the leader of the musical group served as a facilitator to help the individual players improve their playing technique. Rosalind wrote:

During practice for the band or orchestra, as in practice in the classroom, there may be certain sections of the class that need extra work on difficult parts. As the leader, I would call for additional practice sessions. If there were classes or students who needed additional work on microscope technique or preparing wet mounts, I would set up additional labs to practice this technique. Unlike the band director who would be going for an overall improvement of sound, I would need to work with individual, small groups to improve their technique. I think the same thing would apply to classwork i.e. Punnett square work for increased understanding of genetic crosses, interpretation of cartoons and other illustrations to understand translation and transcription. (Teaching metaphor)

In this metaphor, the band director's responsibility to each band member is to help each of them improve their playing technique. The emphasis is on the player to improve her/his playing; the director's role is to help each member grow and develop to the best of her/his ability. By the same token, in the science classroom the major responsibility for learning lies with the student; the role of the teacher is to assist the student – to help
her/him to learn effectively. Through this metaphor Rosalind stated her belief in student-centered science learning. In her journal Rosalind described an experience when she felt she was teaching effectively in this way, "When I can walk around and teach individually – I feel GREAT. Anytime I can work individually at the scopes I can actually teach!"

Rosalind summed up her personal philosophy of science teaching in this affirmation, "I would rather be a guide on the side than a sage on the stage" (Personal communication). For Rosalind, the teacher was not the center of attraction. The teacher was not the possessor and disseminator of knowledge; instead, the teacher was a guide and an instrument through which students could gain knowledge that was important to them. When asked if she considers herself a scientist with expertise to share with her students or a teacher who helps her students learn science, she stated:

I see myself more as a teacher who teaches young people science rather than a scientist who teaches young people science.

I guess I have been away from the lab for so long and since teaching is my chosen profession I feel I need to rechoose it every year. My rechoosing also encourages me to validate my choice and reaffirm my position and my students.

My students are the most important part of this equation and I only want to see myself as a facilitator. Another reason I want to remind myself that I teach young people first and then I teach them a subject. If I could or would hang onto being a scientist who teaches, I think that I would not be able to communicate as well as I need to to direct the learning of these young people.
Theme 3: To know is to teach/Content is king. Daffodil and Dave were confident in their knowledge of the subject; therefore, they considered themselves the possessors of the information and their role as teachers was to pass on their knowledge to their students. Therefore, since the knowledge resided with them, the teachers, they must meet the students and pass on the knowledge and direct their learning. Rosalind, on the other hand, while confident of her knowledge of science, did not consider herself the center of knowledge for her classroom; she considered her role of teacher to be more of a guide – to assist students as they acquired the science knowledge and skills they needed. These divergent sets of beliefs seemed to have their roots in the educational and professional experiences of the three participants. While each of the participants had somewhat similar learning and work experiences, the result has been divergent opinions concerning their role as science teacher. What follows is a discussion of their beliefs with regard to the importance of content knowledge and their perceived teaching ability and how those beliefs have impacted their teaching styles.

When in college, the learning experiences of both Daffodil and Dave revolved around lectures conducted by a professor and laboratory sessions conducted by graduate assistants. This was the usual method for instruction; in both lecture and lab, the instructor "possessed" the knowledge and passed it on to the students. In their first careers, both Daffodil and Dave instructed and supervised workers. When Daffodil was in graduate school part of her job was to instruct students under her; when she was in
command of an army chemical decontamination unit, part of her job was to instruct the
troops under her command with an emphasis on proper procedures to be followed.
Daffodil had the knowledge and part of her job was to pass on the knowledge. She
wrote, "In each job I've had in science with an educational institution there has always
been a 'teaching' aspect. Even as a research technician, you have knowledge that has to
be shared, which is what teaching really is. In fact, I think that any job requires one to
teach at some point" (Journal entry 7). In describing her army experiences, she wrote:

I think pretty much...everything I've done, um, no, every place you
go you have knowledge that needs to be shared and what is teaching but
sharing knowledge. And I can't think of a job that didn't involve teaching,
um, you know, when you're out there in the field in the military, uh, you
know, you look around for the best way to do something and then try to
teach as many people as you can how to do it that way and, and you
continue to look for things that improve the process and you're willing to
take ideas from whoever gives them, regardless of who they are...it's a
good idea and you can take it and you use it. And, um, so it's the same
way in teaching and, uh, and any other job that you have; I'm not sure
that, that science teaching is any different from any other kind of teaching.
It's just sharing knowledge. (Interview 3/24/00)

Daffodil entered the field of science education confident in her ability to teach
due to her educational background and teaching experiences while in graduate school and
while in the army. She remained confident with the depth of her content knowledge and
believed this knowledge gave her the ability to teach science. She described her beliefs in this way:

*Um, but, you know, the attitude is that the education courses are more important than the content courses and that once you know the process, the content comes. Which, to me, you have to know the content, then the process will come. I think you need to know the content then the process...You have to know something, like science, well in order to teach it.* (Interview 7/20/00)

In addition to her educational background and depth of her content knowledge, Daffodil credited her preservice teaching experience with helping prepare her for her career in science education. As previously described, Daffodil had a number of educational and work experiences in which she performed a teaching function; most notably, she taught laboratory courses and supervised other graduate students while in graduate school and she performed teaching duties as commander of a chemical clean-up unit while in the Army. In each of these experiences she was teaching, so it was, perhaps, natural for her to consider herself an experienced and capable science educator.

Dave, while managing a Christmas tree farm, had to instruct his work team on the proper procedures they must follow for the farm to be a success; from Dave's perspective, he possessed the knowledge and part of his job was to pass on that knowledge to his workers. When describing his work at the Christmas tree farm he wrote:

*This job in many ways was like being a science teacher. During the Christmas season we collected, trimmed, wrapped, stacked, and shipped the Christmas trees. I had groups of 20 – 40 workers at any time*
that I was in charge of. I had to instruct these individuals in small groups and set them all to different tasks.

This closely resembles a classroom where students are given a demonstration and then set to doing the tasks themselves. Monitored [sic] by the instructor (boss) to make sure that the task is properly completed.

During the so called off season – inventory was taken and then our volumes of paperwork was begun – this would greatly resemble lesson plans and preplanning. In effect I was actually training for my current job long before I was aware of it. There was one big difference though – if my workers didn’t perform I could just fire them, if only could happen with students. (Journal entry 11/15/99)

Dave entered the field of science education also confident of his ability to teach; his confidence was based on his educational and career background. He had a strong science background, felt well grounded in content knowledge and had work experiences that involved instruction of employees; therefore, he felt little need for courses in educational methods. Dave described the most important things that prepared him for teaching in this way:

[The] most important thing would be my formal education. I have a background to draw from. My formal and my informal. My work. I have what many people never have which is a working background. In other words, my work from years in industry and the university. Uh, I know what is necessary in a job situation; I know what it’s like to have twenty or thirty people working for me... that to me is more valuable than any,
anything I might have learned in "teaching" university... you can't teach classroom monitoring, classroom activities, you have to get in there and do it. I don't think you can learn how to teach, I think you have to be shown how to teach. (Interview 9/23/99)

In light of Daffodil's and Dave's educational and career experiences, it was, perhaps, not surprising that they possessed a belief in a teacher centered process of learning. While Rosalind was also confident in her knowledge of science and believed content knowledge was important for a science teacher, she preferred to allow students to work on their own to acquire the skills and knowledge they needed while she provided guidance and stood ready to help if needed. Rosalind's teaching and learning experiences in college and in her first career were similar to those of Daffodil and Dave; she also recalled learning in college through a combination of lecture and lab and assuming the role of teacher to complete duties that were part of her first career. While her first career in the lab did not involve supervising employees, it did contain elements of teaching. Rosalind described some of those teaching opportunities:

During my seven years as a microbiologist I spent many times acting both as a teacher and as a student. There would be times when a group and/or individuals would tour the lab and we had to take them around to each section and explain what we did in that section... I would be sent to Austin to the big state lab to learn new techniques. This was always fun for me because I would get to learn some thing new – and then I would come back to my home lab and teach the others... From time to time we got new
lab techs. I would instruct them in the separate parts of our work.

(Journal entry 11/8/99)

Rosalind's educational and work experiences did not seem to be significantly different from Daffodil's and Dave's; the difference in learning philosophy that existed between Rosalind and the other two participants may have centered on their respective beliefs with regards to their ability to teach and their willingness to accept new ideas. In brief, both Daffodil and Dave came to the world of school science believing they were already competent teachers and did not believe that teacher education courses would be of any value to them. In fact, they both stated in several data sources that their teacher preparation courses were of little value to them. Rosalind, on the other hand, entered the world of school science not at all confident in her ability to teach and was very receptive to educational methods courses; she remains to this day very receptive to new ideas concerning educational methods. This divergence of opinions may have had its roots in two sets of core beliefs: beliefs concerning student learning and beliefs concerning the nature of science. Rosalind approached the role of teaching, much more than Daffodil or Dave, as a process of learning. In other words, Rosalind saw her science teaching career as a process through which to develop more effective means to help students discover meaningful science concepts. Rosalind felt the drive to meet the students where they were to help them learn the science they needed, while Daffodil and Dave considered themselves to be "possessors" of the science concepts; students must come to them to learn the material. The participants also viewed the nature of science differently; Daffodil and Dave both viewed science as a way to effectively understand the world,
while Rosalind viewed science as more of a process of discovery. When asked about teacher preparation courses for second career science teachers, Rosalind stated:

[The course preparation] needs to be every bit as traditional because if you go into one career then...I need to get out, um, [take all the] pedagogical background I can because I don't know anything about that. I'm goin' from a lab with test tubes and petri dishes into a classroom full of kids and I need everything, I need every class I ever had in education from Texas to here in Georgia and they all helped in some way. (Interview 6/12/00)

Perhaps the receptiveness of Rosalind paved the way for her to accept new ideas concerning science teaching and student centered learning.

My science teaching experiences have been varied to say the least. I'm sure I had preservice expectations but maybe I don't remember what they were.

I had a VERY STRONG, VERY excellent certification program at TCU – I did not find it lacking in any area! I have not been disappointed in ANY education course at the undergrad. level in Texas nor at the graduate level in Georgia. Perhaps this has more to do with my expectations – I always expect to learn something and interestingly enough I always do learn! (Journal entry 3/19/00)

In concert with their beliefs concerning student learning, the participants all emphasized the importance of teacher content knowledge to effective science teaching and learning. Daffodil and Dave, and, to a lesser extent, Rosalind, seemed to suggest that,
to the science educator, content was the most important aspect of teacher preparation. They believed that content knowledge was king and allowed them to be effective teachers. The belief in the pre-eminence of content knowledge to science educators expressed by Daffodil and Dave appeared to be related to their educational background and may well have explained their teacher focused philosophy of science teaching and learning. While Rosalind exhibited a more student centered philosophy of student learning, she also expressed the belief that content knowledge was critical to effective science teaching.

Daffodil and Dave expressed a similar set of beliefs concerning science teaching and learning: the science teacher must be well versed in the discipline she/he is teaching and have a deep understanding of the content to lead students to explore and learn new science concepts. Daffodil believed that knowledge resided with the teacher and the role of the teacher was to direct and guide the students as they mastered new material. Daffodil shed light on her beliefs in this regard when discussing the benefits science teachers realize through earning a science degree; she wrote:

If all you know is one way how to do something then you can't teach it six different ways. So that leaves you more boxed in; you really don't have the options that someone who has the background has. People who have real world experiences,...I think bring a broader perspective; you can cover the subject from more directions, I think that makes it more interesting...(Interview 5/19/00)

Implicit in the passage above are the ideas that the teacher must lead the students as they learn new material and the teacher must have an understanding of the content that
is deep and rich enough to allow them to effectively lead their students. In other words, the learning in a science classroom centers on the teacher who possesses the knowledge and is charged with helping students learn the concepts they need; this reflects a very teacher centered view of science teaching and learning.

When responding to the question of what traits are most important for a science teacher, Daffodil’s reply reflected her belief in the pre-eminence of content knowledge as well as the importance of teacher led science teaching and learning. She responded in the following way:

*Pedagogical knowledge definitely goes. Gee, I think if you have passion for the subject, you're going to have content knowledge. You can't have a passion for the subject and not have content knowledge. Those two are the same thing. Um, passion for student learning, um, if you have a passion for the subject, you want everybody to know! So, I think, you know, that's kind of redundant. Definitely passion for the subject has got to be the most important.* (Interview 5/19/00)

In this passage Daffodil again expressed her belief in the importance of content knowledge to effective science teaching as well as her low opinion of pedagogical training. Her belief that pedagogical knowledge was of minor importance to science teaching and learning is perhaps not surprising in light of her faith in content knowledge.

Much like Daffodil, Dave also felt that content knowledge was the most important trait needed to be a good science teacher. He considered himself to be the possessor of the knowledge in the classroom and his job was to present the science information students needed and to help them learn it. Dave considered himself a scientist that is now
charged with the task of presenting science to high school students. Dave described his feelings in this way:

I view myself as a scientist who teaches; but I don't view the two as exclusive. I find myself in an interesting position. I've been trained as a scientist – hard math and science and very analytical procedure. I started out primarily as a scientist who teaches but unless you constantly refresh your perspective I feel that eventually I shift over to a teacher of science. Even so, I find I can draw from my experience as a scientist to help my teaching or illustrate examples for my classes. (Journal entry, 11/4/99)

As a scientist in a science classroom, for Dave, it followed that the teaching and learning centered around him since he had the knowledge and the experience. His belief in the importance of content knowledge to the art of teaching was further defined by his assessment of the traits that were most important for a teacher. When asked to describe the most important traits for a science teacher, Dave responded:

Passion for the subject, content, and passion for the student. Um, pedagogical knowledge, you can just throw that out. Um, if you don't have content knowledge you should know teaching; with a science teaching degree you're much less versed in science content and if you don't have the content it's obvious to the kids instantly. And that would probably be the most important. And then passion for student learning and passion for the subject. If you have the content knowledge quite often you have passion. And I think content plus passion for student learning. (Interview, 4/20/00)
In summary, for Dave, science teaching involved primarily the transfer of science knowledge to students and the training of students in the methods of science. In Dave's view, science teachers need to be well versed in science information and scientific methods and the process of science teaching is centered on science teachers who have the knowledge that students need to learn. This passage also suggested the low opinion Dave has in the value of pedagogical training. This belief was perhaps not surprising when viewed in light of Dave's beliefs in the importance of content knowledge to effective science teaching.

It is interesting to note that the third participant, Rosalind, expressed a much stronger belief in student centered learning and less emphasis on the teacher as the center of learning in the classroom while, at the same time, she recognized the importance of content knowledge. "One of my favorite things is just to sit and study biology or any science. I think that I would dry up totally if I had to stop that behavior" (Autobiography). While Rosalind felt confident in her content knowledge, she acknowledged her need to learn how to teach. She was an active member of several professional organizations; "...but NABT is absolutely THE VERY BEST I can not imagine my teaching life without this association, the doors it has opened and the knowledge I have gained" (Autobiography). In contrast, Daffodil and Dave had little to say with regard to the benefits they received from professional organizations dedicated to the promotion of science education. Daffodil did discuss her membership in the American Chemical Society but had nothing to say about science teacher organizations; perhaps this reflects the connection she felt with her career as a chemist and suggests the need to help Daffodil build similar bonds in her career as a science educator. Dave, also,
briefly mentioned membership in professional forestry organizations and made no mention of involvement in professional science education organizations; the need also exists to help Dave build bonds within the science education profession.

Rosalind saw herself as a facilitator and expressed her belief that the best teaching she did was "at the microscope" when guiding students in their lab work.

Lab situations afford many opportunities – not the least of which is to teach on a 1:1, 1:2:3 basis.

When I can walk around and teach individually – I feel GREAT!
This week with my seniors I could experience them relearning all things about cells. I would love to try different teaching techniques with 10th grade about cells and then design an evaluation/assessment [using the microscopes] to actually test what they remember. Anytime I can work individually at the scopes I can actually TEACH! (Journal entry 9/29/99)

Question 4: "What professional, cultural, and societal borders did these second career science teachers have to negotiate to successfully participate in the world of school science?"

Theme 1: Misgivings on the passage. Daffodil had little to say concerning psychological borders she faced during the transition to school science. In contrast, when responding to questions concerning any borders they had to negotiate along their passage from the world of the professional scientist to the world of school science, both Dave and Rosalind spoke of psychological issues that served as borders and exerted a negative influence upon them during this time of transition. Dave was uncomfortable with the status of student he had to assume during his preservice coursework. He had graduated
with a degree in Forestry and had been employed as a professional forester for several years and was now forced to re-enter the classroom as a student to complete the courses needed for certification. Dave wrote of the difficulty he had with this new role on several occasions:

In moving from one career to another I did encounter some unusual boundaries. I was a research analyst and lab technision[sic] in a university setting. I had a professional forestry degree and was operating in a setting where my expert opinion and my qualifications gave me a lot of freedom as far as decision making etc.

We left Kentucky and moved to Georgia and I quit my job. I went from a working professional to a house husband for a brief period.

At this point I took a huge step and became a true unprofessional – I went back to school full time. This was perhaps the hardest time for me – I had worked for over 12 years and all of a sudden – with 2 small sons – no job, no money, and no real respect – I was just another student.

(Journal entry 1/20/00)

...being very much a professional in one respect, in forestry, having graduated from one of the top forestry schools in the nation, and being told I'm not qualified even when I've had this experience, being sent back to school for several years for several classes and most of this by people that I was more qualified than and more intelligent...it was a hard pill to swallow because you've got this desire to do this thing, and you will put up
with a lot because eventually what you want to do is to teach. And to do
that you just have to do things that are ridiculous... (Interview 6/16/00)

When Dave completed his certification and began teaching he then assumed the role of
novice teacher.

_ I finally became a teacher at the age of 34 and here I was starting all over_
– no real experience at this new endeavor. _I'd accomplished so much –_
graduating from the best forestry program in the country and finally_
getting work in my field and now I've got to ask 22 year olds how to do_
things. _ (Journal entry 1/20/00)_

This was uncomfortable for him since he was an experienced forester.

Rosalind related a different type of psychological border she faced and negotiated
as she prepared to enter the world of school science. She related that her biggest
difficulty was her inherent shyness. She felt very unsure of herself when speaking in
front of groups of people and was concerned with her ability to speak to a classroom full
of students. She spoke of these feelings in the following journal and interview excerpts:
"the biggest challenge was my timidness and trepidation about dealing with people
instead of petri dishes." (Journal entry 3/13/00)

...it's the deal with the people that is the biggest area [borders], I guess I
was more suited in my psyche to deal with, um, to be a researcher, in a
research area, to work with test tubes and I had to push myself and I had
to be pushed by my cooperating teacher to get in there with kids, and once
I did I loved it and the more involved I got with them... and work with the
family and the more I pushed myself to do that the better off it was.

(Interview 6/12/00)

Another psychological factor emerged from discussions with Daffodil and Dave. Both Daffodil and Dave came to the world of school science with a firm educational foundation and a rich array of career experiences in the world of science. They were, therefore, well grounded and confident in their knowledge of science and perhaps less than open to other teachers' ideas of the nature and philosophy of science. The process of accepting the science backgrounds and ideas of colleagues in the science classroom presented a psychological border for both Daffodil and Dave. Daffodil wrote of this border in terms of the conflict she perceived between her personal beliefs concerning the nature and philosophy of science and science as it is presented by the school curriculum. In a journal response she characterized the tension in this way:

*Probably the biggest challenge I face in my career change is dealing with the lack of understanding of what science is, how it connects to other disciplines, and what it can (and cannot) do for us. We seem to view science as cold, remote, even harsh, and completely objective, with only a single "correct" interpretation of "the facts". It's impossibly difficult for the "average" person to understand, too. If the humanities are "Beauty" then science is "The Beast".* (Journal entry 17)

This perceived conflict in beliefs concerning the nature and philosophy of science remains a continuing tension for Daffodil in her science teaching career.

Dave, both in his educational career and job experiences, interacted with colleagues who were professional scientists with extensive training and detailed
knowledge of their field of study. Upon entering the world of school science, Dave's collegial group shifted in focus from one whose aim was principally scientific investigation to one whose principal aim involved science teaching and learning. This shift in focus presented a psychological border for Dave. He wrote of this border in terms of comparing his level of scientific knowledge with that of his colleagues:

*The biggest challenge for me as I crossed from science career to teaching was now being around people who couldn't comprehend simple scientific concepts that I had always assumed everyone knew, kids and other teachers.*

*I was all of a sudden an "expert" on things instead of just some shmoe – who worked in a lab some place.* (Journal entry 3/13/00)

**Theme 2: Paying the piper.** For Daffodil, the transition from the army to student to science teacher was not a major financial problem. She said:

...tuition wasn't that high...it wasn't like I was the sole support, um, for us it wasn't a problem; I know that for other students in my cohort, uh, there were some very significant financial adjustments that they needed to make; uh, but, approaching it from later life you kind of know what happens if there are financial difficulties; so I knew how to handle it better; I knew how to budget, myself and the time, and money...

(Interview 7/20/00)

For both Dave and Rosalind, financial issues presented more of a border to their transition to school science. Dave said:
...my grandmother actually gave me a loan...I had to travel to get certified. And instead of getting a part-time job and doing this and that while I was going to school, I borrowed a couple thousand dollars and had gas money, a little bit of food money, stuff like that. Another monetary consideration was I had just moved to the state so I had to pay for all my schooling and, this was a highly sought after area, certification, even so, because I wasn't a resident, I didn't get any help...When I finished and the paychecks started coming in, it was nice. (Interview 6/16/00)

Unlike Daffodil and Dave, Rosalind was single and supporting herself through her laboratory job. Career change made it necessary for her to resign from her position in the lab and enter school fulltime. She had some money saved in the bank; still, going to school put a drain on her reserves. She wrote of these financial issues in a journal response:

Career change was both exciting and frightening for me. As I said before, I was my sole means of support so I had to figure to the dollar what I would need to live on, (rent, food, etc.) and pay for classes at TCU. All of this assumed that I would be hired by Fort Worth Ind. School Dist. When I finished student teaching. Big chance on risk. I did make it OK but I didn't have much room to spare. I had no money left for rent when FWISD hired me in the middle of the year! (Journal entry 11/15/99)

Dave and Rosalind were both able to negotiate these financial issues and were able to fund their career change in various ways. However, the issue of supporting themselves and their family during the time away from a job that returning to school required
represented a significant border for both in their transition from scientist to the world of school science.

Theme 3: Why do I have to learn this? The educational process required to obtain science teaching certification represented a significant psychological border for both Dave and Daffodil. Both Daffodil and Dave had work experiences that involved informal instruction and both felt these experiences adequately prepared them to effectively teach science. Perhaps as a result of these beliefs, Daffodil and Dave were less open to new insights and strategies to be gained from educational methods courses; this may have limited the benefits each gained from their preservice coursework. Another frustration expressed in the data was the fact that neither Daffodil nor Dave was given what they perceived as adequate credit for the science courses they had already taken. Daffodil related, "…there was a reluctance on the part of the college to accept my background as sufficient" (Interview 7/20/00). Daffodil related one incident where she had to argue to obtain credit for a class:

I had to argue about a line to not use any of my graduate courses.

The last graduate level course I took was in 1991; it was a biochemical class...something about it was 1 year too old...I did petition and the department, the chair of the department refused the petition; recommended against the petition. So I took it to the Dean of the College and he granted it. (Interview 2/25/00)

Dave related a similar story when describing his certification process:

...the process for me to become certified in Georgia was not a pleasant one. I did that 11 years ago. And at that point certification for a
nonGeorgia resident with a nonGeorgia degree was very hard. Now it's a lot easier as I understand it. They sent me back to school and I took a year's worth of, basically, prerequisite courses to what I had. And I was not real pleased with that. I actually went through enormously complex science and math classes and they sent me back to prerequisite courses for what I'd had. (Interview 9/23/99)

He summarized his frustration with this comment:

If you have a high level degree, it's not necessary to go back and retake courses regardless of where you're from. I must have the background or otherwise I would not have graduated with a degree in forestry. If you have a biology background or a chemistry background you must have the content. (Interview 6/16/00)

In contrast to Daffodil and Dave, Rosalind did not share similar experiences in her certification process. She returned to school fulltime with the idea of obtaining double certification, English and Biology. Since she already had more hours in English, she was required to take more science hours. Rosalind did not further address the issue of taking more science courses.

A second issue discussed in relation to the certification process was the education courses required for certification. This issue represented a significant border for both Daffodil and Dave. In an interview, Daffodil said:

No, [I don’t think the education courses were worthwhile]. There was a lot of emphasis on what I consider touchy-feely garbage, um, multicultural perspectives in education. That seems to be the big thing.
And it really doesn't do you much good. I didn't get anything that helped me know my students any better....I can't say I'm unique because I think that none of us got any benefit from it; most of us were there because they wanted to teach high school and this was the only was to get certified.

Um, the most worthwhile course was teaching reading in the content area. And we only met for a couple, 6 times; I would have liked to have had more of that kind of class. Um, it was field specific; there was no field specific teaching instruction; no, nothing that said OK this is how you teach science at the high school level. (Interview 2/25/00)

Dave, in much the same way as Daffodil, came to the science classroom confident in his ability to teach and in his knowledge of science. These beliefs were fostered by his educational background and the informal teaching opportunities afforded him by his science career. Much like Daffodil, Dave also felt he received little benefit from his education classes. He said:

No. Nothing [the education classes] I took was beneficial. Not the education or the science. I'd had most of it. I'd had it and on beyond what I took. So was it beneficial to me? Not really. Just hoops to jump through...so that I could be certified. (Interview 9/23/99)

Perhaps the beliefs with regard to education courses held by Daffodil and Dave were shaped, in large part, by the perceived competence in their abilities to teach. Rosalind, on the other hand, did not perceive of herself as a competent teacher when she left her lab career and began the transition to a career in science education. This opposite perception perhaps explained her differing opinion of the education courses which she
took as a part of her certification process. In describing her teacher education courses, she related:

*They [the education courses] were wonderful! TCU had a terrific program, I guess almost thirty years ago and I think they were way ahead of the time! We were out in the classrooms observing, first off. And we had other courses like on media, which back then, we were running 16 mm cameras. (Laughs). So, those dinosaurs went by the way, but it gave me a good beginning. You know, I just thought it was a terrific program...I've never had useless education classes. I can always find something that's helpful....I'm sure it's because I'm sure there's something there for everyone and there's something that can be useful.* (Interview 9/28/99)

For Rosalind, the education courses met a perceived need. She had experience as a microbiologist, but realized that this did not prepare her for teaching children. Perhaps she obtained more benefit from education courses than the other participants because she perceived the need for preparation in the art of teaching. Rosalind described her experiences in this way:

*I'm goin' from a lab with test tubes and petri dishes into a classroom full of kids and I need everything. I need every class I ever had in education from Texas to here in Georgia and they all helped in some way...I've never understood that viewpoint [that education courses are worthless]; I hear more rags out of education courses and I didn't have a bad one...I can't afford to be bored so I find ways not to be and I find ways to get something out of something that's goin' to help me. Anybody*
can do that. I never found, um, except one course and maybe two I wanted a little deeper and that was education for the exceptional child required here in Georgia when I first came in, and I think she was just too superficial with it; I wanted more in depth, I couldn't see then the relevance; she didn't show it enough to me, I think; I wanted more. I got that in gifted. (Interview 6/12/00)

Summary and Preview

This chapter presented a discussion of themes present in the data that were common across the participants. In some instances a common theme was suggested by the data collected for all three participants and in some instances a theme emerged from the data of two participants; in these instances, contrasts in data were discussed. The goal of this chapter was to construct a group portrait of these three second career science teachers and to develop an understanding of the common, as well as contrasting, aspects of their life experiences, career paths, and beliefs with regard to science teaching and learning. In presenting this group portrait of three second career science teachers, it is hoped that understanding of their life stories, career paths, and teaching beliefs may serve as useful tools to educational professionals who are planning programs of study for other trained scientists desiring a career change to the world of school science. Certainly this sub-group of science teachers represent a diverse population but it is hoped that commonalities between these individuals may be uncovered that will shed light on the development of enhanced teacher preparation programs that better meet the needs of second career science teachers. The themes discussed in this chapter were organized
around the four research questions that guided this study. Specifically, the four research questions that informed this study were:

1) What are the life stories of second career science teachers?

2) Where is science in their life stories?

3) What beliefs do second career science teachers hold with regard to science teaching and learning?

4) What professional, cultural, and societal borders did these second career science teachers have to negotiate to successfully participate in the world of school science?

The common theme across the data of the three participants with regard to research question #1 was "Completing the portrait". All three participants related life stories that featured the twin loves of science and learning. Through various data sources each participant revealed a life long curiosity about nature and a love of science that began at an early age and has continued to the present. Each participant also revealed a life long love of learning that also began early in childhood and resulted in a consistent record of high academic achievement through school, college, and career. For these three participants, the move into the world of school science reflected a melding or merging of these two life long loves into a single career that served to unify the two great avocations that characterize their lives. With respect to research question #2, the theme "Sci-evangelists" emerged from the data of all the participants. For each of the three participants, science has been a life-long passion. This love began early in life and has remained a guiding force in their adult lives. Each retained and brought with them into the science classroom a passionate, almost child like, curiosity concerning the world and
enthusiasm for scientific explanations. In their teaching each participant sought to spark interest in science among their students in much the same way as a television evangelist seeks to win converts. Participant responses to research question # 3 revealed the themes: "Adding to the passion", "Finding my center", and "To know is to teach/content is king". Common in the data across all participants was a passionate interest in scientific knowledge and a somewhat simplistic and limited understanding of the nature and philosophy of science. The participants, as a group, revealed limited philosophical understanding of the discipline of science as a field of human intellectual endeavor. The data gathered under this theme suggested that, for these second career science teachers, sharpening their understanding of the process, goals, and aims of science would enhance their effectiveness as science educators. The second theme that emerged with reference to research question #3 was "Finding my center". The data suggested the presence of tension between the beliefs concerning science teaching and learning held by Daffodil and Dave and current research concerning student centered constructivist models of teaching and learning. Both Daffodil and Dave believed that they, as teachers, were the center for learning in their science classroom; the challenge faced by Daffodil and Dave is to reconcile these disparate beliefs and synthesize a personal belief system that is more in concert with current research in the field of science education. With reference to research question # 3, the third theme that emerged from the data was the theme "To know is to teach/content is king". The discussion of this theme centered on beliefs held by the participants with reference to content knowledge and its relationship to effective science teaching. While all three participants believed that content was important to effective science teaching and learning, Daffodil and Dave held the belief that they had
the ability to teach effectively because they were well grounded in content knowledge
and had taught informally in their prior science careers. These beliefs made them
somewhat reluctant to internalize information related to pedagogical knowledge and
limited the benefit they might have received from their education courses. Rosalind, on
the other hand, did not feel competent to enter the classroom and effectively teach
science; perhaps as a result of this belief, she was more open to ideas concerning
effective teaching and felt she received great benefit from her education courses.
Analysis of the data concerning research # 4 revealed three themes: "Misgivings on the
passage", "Paying the piper", and "Do I have to learn this?". "Misgivings on the
passage" related psychological issues that had a negative impact upon the participants as
they completed the journey into the world of school science. Daffodil had little to say
about her transition period concerning this issue. Dave spoke of the discomfort he felt
with his lowered professional status as he made the transition from career scientist to
student and from student to novice science teacher. Rosalind spoke of the apprehension
she felt concerning the ability to stand and speak in front of large groups of people.
"Paying the piper" addressed the financial issues that impacted the participants as they
pursued their career change. For Daffodil, financial concerns were not a significant issue
for her during this transition period. Dave and Rosalind both spoke of more significant
financial concerns due to the loss of their salaries as they returned to school to complete
their science teacher certification. "Do I have to learn this?" related the negative
experiences perceived by the participants as they completed their certification programs.
Daffodil and Dave expressed frustration with the reluctance of certification officials to
grant credit for science courses completed in the coursework required for their science
degrees. Rosalind did not experience the frustrations of Daffodil and Dave. She had to take additional science courses to obtain her science teacher certification; the additional coursework was, for Rosalind, a positive experience. A second tension related to the certification process involved the science education courses, particularly those related to pedagogy. Daffodil and Dave expressed disappointment in the perceived benefit they obtained from this coursework; as described earlier, their disappointment with the perceived benefit received from these courses may have been related to their belief that they already knew how to teach. Rosalind, on the other hand, expressed nothing but praise for the benefits she received from her education courses. The perceived benefits she received were perhaps related to her excitement about taking education courses – she expected to learn something that would help her become a more effective science teacher in each class she took.

The next chapter presents a discussion of the implications the portrait of this group of three second career science teachers holds for the teacher education and research communities. Analysis of themes that emerged from the participants' data, both individually and as a group, provide insight that impacts the field of science education in three ways; these implications involve: science students, school systems, and science teacher preparation programs.
CHAPTER 6
DISCUSSION AND IMPLICATIONS

Introduction

Examining the portraits of the three participants raised several issues relative to the certification process of second career science teachers. Chapter 6 presents a discussion of these issues as well as the implications of these issues for science teacher education programs designed to incorporate career scientists into the field of science education. The first issue concerned the challenges faced as the participants moved from a teacher scientist to a science teacher. This journey involved not only a change in professional life and career goals, but also a change in outlook on teaching as well as an awakening to the realities of school science in terms of student motivation and diverse learning styles. The second issue involved the challenges faced by the participants as they adapted, to varying degrees, their visions of science teaching to include a focus on students. Participants came to the world of school science with much enthusiasm and content knowledge, as well as the belief that students would respond as positively to science instruction as they did. It came as a shock to the participants that students often have difficulty internalizing the subject. A continuing challenge for the participants is to expand their vision of science teaching to include a firm focus on students and student learning. In other words, to focus not so much on bringing science explanations to the students as on leading students to science understanding. This change in focus requires a change in philosophical learning framework, from objectivist to constructivist. From the
constructivist framework of learning, students are active participants in constructing their own knowledge in ways that made sense for them. Therefore, the focus of learning shifts from the teacher to the student. (Coble & Koballa, 1996). These issues will be discussed later in terms of the implications they present for second career science teachers as well as teacher education programs designed to meet the needs of second career science teachers.

Chapter 6 will also present a proposed model for science teacher preparation programs designed to prepare career scientists for the world of school science. This model is empirically derived from what has been learned in this study, reflects a variation on the majority of current certification programs and addresses issues raised through this study.

From teacher scientist to a science teacher

The life stories of the three participants reflected a journey begun in childhood, driven by a love of science, as well as a love of learning, that has continued into adulthood. Levinson et al., (1978) in their studies of the life cycle theory, found that adults were more likely to make career moves in what they termed "periods of transition". The adult years are described by the life cycle theory as a period of change in which an adult addresses differing challenges by undergoing changes in perspective which might involve changes in career. These periods of adult growth and change are described as periods of development and transition and were discussed in Chapter 2.

The work of Kanchier & Unruh (1988) and Graham (1973) expanded the work of Levinson et al. (1978) and applied it to describe an individual's career path. In their work, they apply Levinson's et al., (1978) adult transition periods to the changes an
individual experiences in her/his career; further, they maintain a person's self identity is at least in part tied to the development of her/his career. Kanchier & Unruh described a person's career identity as developing through stages; these stages are an entry stage, a mastery level stage, and a stage of disengagement. The entry stage of a person's career is a time that the person develops those skills required for success at that job; the mastery stage is described as a period of work when one attains excellence and a sense of accomplishment through the completion of their job tasks. Following the entry and mastery periods is a period in which a worker may experience boredom and indifference to their job; Kanchier & Unruh referred to this time as a period of disengagement. They maintain that a disengagement period is an inevitable development in an individual's career path unless there is growth in one's job responsibilities or a shift to a new aspect of that job.

The participants of this study reflected and supported, through their data, certain aspects of the theories of Levinson et al. (1978), Kanchier & Unruh (1988), and Graham (1973). Their adult lives were marked by periods of change as they responded to the challenges presented by external changes and followed the leanings of their internal passions. While the participants experienced periods of transition, these periods were not consistent in terms of the ages Levinson et al. described and were not consistent in terms of the participants. The theory of Levinson et al. is progressive in nature, describing phases of adult life that consist of developmental periods followed by periods of change or transition. The focus of Levinson et al. is the internal cycle of emotional and psychological development with which individuals respond to factors encountered in adulthood. The participants in this study, while exhibiting change in their adult and
professional lives through changes in career focus, did not appear to be responding to internal, psychological cues. Rather, career change for these individuals was prompted more by external factors. Therefore, the career transition periods for the participants in this study were inconsistent with Levinson et al. because the transitions were prompted by a variety of external factors and not due to an internal psychological developmental clock. Daffodil entered the world of school science after completing a 20 year career as an Army Reservist. Her career move might have corresponded to Levinson's et al. midlife transition period, but rather than reflecting a period of critical career evaluation, Daffodil's move toward science teaching was prompted by retirement from the military. Dave left his career in forestry to pursue science teaching after a 10 year career as a forester; his career move most closely corresponded to the transition period correlated by Levinson et al. with the thirties. Dave's career move was prompted not only by an evaluation of career goals but also by the graduation of his wife and an out-of-state move. Rosalind left her microbiology career after seven years. Her career move, prompted both by dissatisfaction with her boss as well as a discovery of her ability and new love of working with young people, most closely correlated with the transition period associated with the thirties. The three participants, while exhibiting in their lives evidence of Levinson's et al. ideas concerning adult growth and development, did not fit the exact pattern consistent with life cycle theory. Levinson's et al. life cycle theory provides useful insights into psychological development during the adult period of life. The participants in this study changed careers more as a response to external factors such as job dissatisfaction, retirement, and family relocation than as a reaction to internal developmental cycles. The results of this study suggested that external factors exert a
significant influence upon career development in adults, complementing and, perhaps, 
superceding the influence of internal psychological development.

The career paths of the participants were also inconsistent in terms of Kanchier & 
Unruh's (1988) and Graham's (1973) descriptions of career growth and development 
patterns in adult workers. Daffodil's career move to science education came as a natural 
extension of her career as a chemist in the military. This career move, rather than 
reflecting dissatisfaction with her career in chemistry, occurred as a result of her 
retirement from the military; it was not a response to internal cues regarding job 
contentment and fulfillment, but rather a response to the need for employment after 
retirement. Dave's career change most closely reflected the model of career development 
proposed by Kanchier & Unruh and Graham in that he experienced dissatisfaction with 
his career in forestry due to the changing aspects of the job requirements of a professional 
forester. As the field of forestry underwent a process of change, professional foresters 
were expected to fill roles that were inconsistent with Dave's deeply held career hopes 
and goals. As Dave faced the realities of his career, he began to consider a change of 
career and came to believe that a career in science education reflected an effective 
method to pursue his love of forestry in a different venue. The career path of Rosalind 
was not similar to either Kanchier & Unruh's model or Graham's model; they spoke of the 
need for a person to expand or enhance their career situation to avoid a period of 
boredom or difference which leads to a desire for a career change. Rosalind never 
suggested she was bored with her job; instead she experienced a personality conflict with 
her boss that led her to consider the possibility of a career move. At this time, through 
her sorority work, Rosalind discovered her love of working with young people.
Rosalind's experience demonstrated the impact of factors other than job indifference or boredom upon career change.

Each of the participant's moves to the world of school science represented a journey that contained obstacles to be overcome; these challenges have been referred to as borders in this paper and have been discussed in earlier chapters. In terms of their effectiveness as science educators, perhaps the most significant border for these "scientists turned science teachers" was the challenge of teaching science to students who were less than excited about the subject. Science for the participants has been a life long love and avocation; the challenge of teaching students who care little for science continues to present a significant cultural border.

In their work on border crossings, Phelan, et al. (1998), Phelan et al. (1991), Costa (1993, 1995), Aikenhead & Jegede (1999), as well as numerous other researchers, focused on the challenges faced by students as they struggle to achieve in science, a subject that has, for them, little impact in their day to day life. For these students, science is held with little regard by their family and friends; thus, for them, the importance given science in the classroom creates a cultural dichotomy that presents a challenge to their learning. In this study, the borders faced by the participants are reversed. Throughout their lives the participants have held science in high regard and have viewed the world through the lens of science. This lifelong love of science led to a science related career and has now led the participants to the world of school science.

The challenge for the participants centered on how to present science and teach scientific concepts to students who cared little for the subject. Attitudes held by some students came as a shock and were hard to understand for these second career science
teachers. Student attitudes represented borders which had to be successfully negotiated before the participants could become effective science teachers. These borders, while different from those explored by the researchers stated above, were no less real for these second career science teachers. Daffodil discussed her frustration with student attitudes toward science and motivation for learning. These attitudes were inconsistent with Daffodil's own love for science as well as for learning and academic achievement. Understanding, empathizing and helping modify such student attitudes represent borders which Daffodil continues to negotiate.

Student apathy was also a frustration for Dave. In his data he expressed frustration over student apathy and lack of motivation on numerous occasions. He was unable to understand why students would not be interested in a subject which he loves and has loved all of his life. This lack of understanding presented difficulties in teaching these students; activities that Dave found fascinating, the students found boring. Finding effective means through which to teach science to students who do not love science as he does remains a significant border for Dave. Rosalind expressed less frustration with student apathy toward science. This may have been due, in part, to the type of student she had in her classes; she taught gifted biology and an upper level human anatomy class. Perhaps if she taught regular level classes as do Daffodil and Dave, Rosalind would also have experienced more frustration with student apathy.

Students must be able to tie new concepts with what they already know before new concepts will have meaning for them. Student apathy may well be tied to lack of meaning assigned to new concepts by students. One of the skills science teachers must acquire is the ability to present science concepts to students in ways that have meaning
Teacher preparation programs designed for second career science teachers should address the varying levels of student knowledge, motivation, and apathy these preservice science teachers will face in the classroom and to develop the knowledge and understanding needed to present science concepts in a manner that promotes learning for all students. These programs should be designed to help preservice teachers make the transition from "scientists who teach" to "science teachers". By the phrase "scientists who teach" I am referring to individuals with a large background of education and career experiences in science – a career scientist who now seeks to teach the subject in a science classroom. By the phrase "science teacher" I refer to individuals who have the ability to teach all students the science concepts they need for success in school and career.

A successful science teacher is an individual who understands not only their subject, but also their students and the cultural perspectives which they bring to the science classroom. Shulman as cited by Anderson & Mitchener (1994) described this combination of subject knowledge and student knowledge as pedagogical content knowledge. Pedagogical content knowledge is the ability to understand content in ways that allow the teacher to present new concepts to students in meaningful ways (Anderson & Mitchener). For these participants, science has been the lens through which they view the world around them. They understood their subject but they demonstrated a lack of understanding of their students; this led to frustration. Frustration arose when their students did not share their excitement about science and were unable or unwilling to develop their passion for science. This raises the issue of how much science do students need. Do all students require the same level of scientific understanding for success in life or do science educators need to understand what science the students need and provide
that science in a culturally meaningful way? While it is true that all students need to understand science concepts to pass end of course exams, it is unlikely that a successful life and career is contingent upon students becoming passionate scientists. Rather than develop a passion for science, the NSTA Standards (1996), recommend science literacy for all students; science literacy, as defined by the NSTA standards, is the knowledge and understanding of science required to make personal decisions, participate in civic affairs, and become economically productive.

Participants in this study need to grow past the idea that all students need the same science taught in the same way, and embrace a broader view of presenting science concepts in ways that are relevant to students. Perhaps the more salient issue for these participants is to negotiate the border between their personal passions for science and the life worlds of the students so that they can present science in ways that have meaning for their students. Such opportunities for growth should be a part of a preparation program for second career science teachers and is addressed in the model presented later in this chapter.

Science teachers are individuals who should possess the content knowledge and the pedagogical and student knowledge to adapt their teaching to address the varying needs of all levels of students. Yeany, as cited by Cobel & Koballa (1996), wrote that the total amount of knowledge a person needs to effectively teach science involves more than just knowledge of science content. A strong background in science is necessary but also necessary is the understanding of pedagogy, knowledge about students and student learning, and the ability to utilize curriculum materials (Yeany as cited by Cobel & Koballa). These three participants came to the field of science education with impressive
educational and career backgrounds in science and brought with them a large body of content knowledge. In the course of this study, all participants expressed their belief in the importance of teacher content knowledge to effective science teaching. Daffodil and Dave both expressed the opinion that deep content knowledge was all they needed to teach science; at the same time they both expressed frustration that students were not as excited about the subject or as motivated to learn science as they had been during their formal educational background. Rosalind, while expressing the belief that content knowledge was important, also believed that student involvement in learning was vital and should be the focus of learning activities. She believed that the best teaching was done in a laboratory setting, preferring that students learn at the microscopes rather than taking notes on the subject. Daffodil and Dave represent scientists who are teachers – they have ample content knowledge but could, perhaps, teach more effectively if they had a deeper understanding of the pedagogical concepts useful to teach all students. Rosalind demonstrated some progress in moving toward a student-focused approach to science teaching. A second, related, goal for preservice second career science teacher education programs should be to enhance instruction regarding teaching strategies and techniques useful for teaching all levels of science students.

**Expanding the vision**

The vision for science education shared by Daffodil and Dave focused on the subject – science. They were both content oriented and believed that students should be motivated to learn science when they came to the classroom. Students come to the classroom with varying backgrounds and Daffodil and Dave did not appear to fully appreciate the impact of students' worlds on their ability to learn science. They both
wanted deeply for their students to be successful. Daffodil and Dave linked success with a deep understanding of science and the lack of students' success in science resulted in frustration for Daffodil and Dave. On a very deep level they did not understand why students did not love the subject. This frustration limited the joy and the satisfaction they were able to realize from their science teaching careers. Rosalind, on the other hand, expressed less frustration than the others. Throughout this study, Rosalind, while excited about science, was quick to point out that she teaches students and that the students are the focus of her efforts. Rosalind has managed to expand her passion to include, not only scientific knowledge, but student learning. In fact, Rosalind placed student learning at the top of her prioritized list of passions. It seems probable that there is a linkage between Rosalind's passion for student learning and the decreased level of frustration over student motivation for science. It is interesting to note that Rosalind had the most experience among the participants; she had roughly three times as much science teaching experience as the others. Perhaps through the years of her experience, Rosalind naturally evolved to be more student focused through her experiences teaching science to young people as well as her participation in professional organizations. Another possible factor was the fact that Rosalind changed careers at an earlier age than Daffodil or Dave; perhaps, since she was younger, she was more receptive to varying ideas concerning science teaching and learning. The frustration expressed by Daffodil and Dave highlight a challenge that may exist for many second career science teachers as they make the move from scientist to science educator; i.e., disappointment and disillusionment over lack of students' motivation for science. This disenchantment could well force them to feel they must leave the field of science education before they have had the opportunity
to develop a more student-centered philosophy of science education. Another goal of science teacher preparation programs should be to help preservice second career science teachers grow beyond the levels of frustration expressed by Daffodil and Dave over lack of student motivation for science to a higher level of empathy for and acceptance of student abilities evident in the data collected for Rosalind. One way to facilitate this growth might be to help prospective second career science teachers expand the passion they feel for science to include a passion for students. The question then arises how to prepare science teachers to be more empathic and tolerant of student perspectives. This issue is addressed in the model presented later in this chapter.

A second way to expand the vision is to help second career science teachers more fully understand the nature of science. Science teachers need to understand science as a field of human intellectual endeavor. They need to understand that science knowledge is subject to change and that science is unable to answer all questions concerning human existence (Coble & Koballa, 1996). Science teachers need to understand science inquiry as a process of explanation and prediction. Science teachers also need to be acquainted with the history of science so that scientific discoveries can be presented within the context of the culture in which they were made (Coble & Koballa). The three participants in this study exhibited a somewhat simplistic view of the nature and philosophy of science. They were very excited about science and viewed the world through the lens of science – looking to science to explain the world around them. As has been discussed earlier, their interest in science approached the level of religious passion and they held scientific explanations of the natural world with zeal assigning these explanations the philosophical label of truth. Their college coursework focused on career
preparation, allowing each the opportunity to gain the knowledge and skills needed to be successful in their chosen career. What seemed to have been lacking in their college curricula were courses and experiences that focused more on the big picture of science, i.e., the nature and philosophy of the discipline. This could explain, in part, the simplistic views concerning science expressed by the three participants. Another explanation for this simplistic view of science might center on their childlike enthusiasm over the results of science, i.e., science concepts and explanations. This enthusiasm may have led to a view of science focused on concepts rather than on the intellectual process that represents the nature of science.

The science teaching effectiveness, with regard to student learning, of the participants might also be enhanced if their vision were expanded with regards to science teaching philosophies. Preservice second career science teachers need to be exposed to different science teaching philosophies and the diverse methods that might be represented by these philosophies. Daffodil, Dave, and to a lesser extent Rosalind, demonstrated the need for increased understanding of student centered, constructivist concepts concerning science teaching and learning. Current research in the field of science teaching and learning focuses on the student with regards to learning and maintains that learning occurs as students actively construct knowledge based on their own experiences (Coble & Koballa, 1996). In constructivism, emphasis is placed on the learner, rather than the teacher, as she/he investigates and assimilates new concepts into existing frames of understanding. In this study, Daffodil and Dave appeared to be more teacher centered. They seemed to regard themselves as the possessors and conveyors of science knowledge and viewed the students' role to be passive accumulators of the concepts they present.
**Demonstrating the need**

One of the challenges in facilitating teachers' professional growth is to overcome the resistance expressed by Daffodil and Dave for pedagogical training. In this study they both expressed the belief that they could teach science because they knew science. They both expressed confidence in their knowledge of science and felt that adequate content knowledge must translate into effective science teaching. This belief was perhaps understandable given their backgrounds discussed previously. Daffodil and Dave brought to the world of school science a life long love of science; their desire has been to acquire a deeper understanding of science concepts and they have approached both their formal education and their careers from this perspective. For them, effective learning was the result of deep content understanding on the part of their teachers; the deeper the understanding of the subject held by their teachers, the more knowledge Daffodil and Dave were able to acquire. Since Daffodil and Dave equated effective science teaching with deep content knowledge, they believed they already possessed the ability to teach science. A second factor was the type of teaching to which Daffodil and Dave were exposed. Throughout their schooling, teachers stood and lectured; laboratory activities served to reinforce and verify the information taught in class. One challenge for science teacher preparation programs designed for second career science teachers is to help individuals such as Daffodil and Dave recognize the need to develop the skills to present science to all students in ways that have meaning for their lives. Teachers, such as Daffodil and Dave, not only need to develop these skills but also an awareness of the need for these skills. This professional growth might be accomplished through analysis
of science teaching vignettes, case-based pedagogy, action research, and community service learning.

Rosalind's move to the world of school science followed a similar path. Rosalind, like Daffodil and Dave, also approached her science courses with fervor, soaking up science concepts like a sponge. In her coursework she also was taught primarily through lecture with laboratory experiences that were verifiable in nature and designed to emphasize the concepts taught in class. Her first career did not involve supervising and training workers to the same degree as the careers of Daffodil and Dave. There were times, however, when Rosalind was asked to train her co-workers in new techniques she had learned at conferences. Somewhere along her path to the world of school science, Rosalind's framework for science teaching and learning was expanded and enhanced to include a more student centered approach. As her career in science education has progressed through thirty years she has remained open to new ideas and alterations in her understanding of effective science teaching and learning; Rosalind's teaching, in contrast to Daffodil's and Dave's, included modern ideas concerning effective science teaching and learning such as the need to provide opportunities for student exploration and inquiry.

Teaching science is much more than just reciting facts and interesting stories. While this may be an important adjunct to effective science teaching in terms of stimulating student interest, researchers in science education recognize the need for students to approach science from the standpoint of active participation. Science needs to be a verb for students, i.e., the subject needs to be something they do, not something they hear. Students need to actively explore concepts in the process of creating personal
understanding (Coble & Koballa, 1996). Students also need to actively engage their minds in the intellectual processes of scientific inquiry; i.e., hypothesizing, predicting, problem-solving, decision making, critical thinking, and critical reflection (Coble & Koballa). They acquire those skills through practice. The NSTA Standards (1996) state that high school science students should design and conduct scientific investigations using technology and mathematics. Students should generate hypotheses and design appropriate experiments to test their hypotheses (NSTA Standards). A sometimes attenuating factor in the process of constructive school science is the need to prepare for state mandated assessments such as the end of course evaluations beginning in the state of Georgia. Evaluations such as these, while necessary to assess and demonstrate the level of student learning, require the teacher to guide and focus student explorations along the path of curriculum guidelines.

In addition to preparation for state evaluations, science curricula, such as the State of Georgia's Quality Core Curriculum (QCC), are beneficial in that they assure that all students receive an equal education. A tension expressed by both Daffodil and Dave related to the impact of the curriculum (for them, the QCC's) upon their teaching and the limitations they perceived to be placed upon their effectiveness by curricula. Second career science teacher preparation programs must help participants integrate successfully their excitement and knowledge of science into the structure placed on their teaching by curricular concerns. Research has shown that students in science classes that are guided by a science curriculum learn more and have a better attitude toward science (Coble & Koballa, 1996). Specifically, this might be addressed through guided exploration of
literature related to science curricula, analysis of cases, as well as opportunities for participants to create and enact curricula in their content areas.

While some students may be less highly motivated to learn science and in fact, may not need in-depth science knowledge to successfully contribute to society, all students must grasp certain basic science concepts to pass the exit exams or end of course tests required to graduate from high school. The excitement for science that each participant brought with them into the classroom must be cemented to a firm understanding of what students must know to pass these required tests.

Another factor that impacts effective science education is the varying ways in which students learn science. Researchers in science education recognize the need for different teaching approaches to address student motivation as well as different learning styles (Coble & Koballa, 1996). Based on the data collected in this study, participants had a somewhat limited understanding of varied teaching techniques, while at the same time they expressed their belief that a deep level of content knowledge was all that was needed to effectively teach science. A tension expressed repeatedly by Daffodil and Dave related to their students' varying levels of motivation for science learning.

The data from this study suggested several areas in which the participants would benefit from professional growth. The participants would benefit from an enhanced understanding of student backgrounds and ways of learning; this understanding would help them present science in ways that have meaning for their students. The participants in this study demonstrated a limited, somewhat simplistic, understanding of the nature of science. The participants, while very excited over science and very knowledgeable of their field of science, demonstrated limited pedagogical content understanding of the
subject. This limited knowledge of pedagogy inhibited their ability to present science to students of various backgrounds and abilities. The impact of limited pedagogical knowledge, limited understanding of students and how they learn, and the limited understanding of the nature of science upon teaching suggested by the data in this study was consistent with the work of other researchers in the field of science education.

**What science teachers need to know**

Various researchers have identified knowledge and understandings that science teachers need to possess to enable them to effectively teach science. Shulman, as cited by Darling-Hammond (1999), classified the different elements of teaching knowledge; these elements included: knowledge of content, pedagogy, curriculum, pedagogical content knowledge, knowledge of learners, knowledge of educational contexts, and knowledge of the purpose of education. Darling-Hammond (1999) described three broad areas of knowledge which teachers need to possess. These broad areas included: knowledge of students and learning, knowledge about curriculum and teaching, and knowledge about context and foundations of education. The National Science Education Standards (1996) included the following standards for science teacher professional development: 1) science teachers need to learn science content through inquiry, 2) science teachers must integrate their knowledge of learning pedagogy and students, 3) science teachers must develop life learning skills, 4) professional development programs for science teachers must be coherent and integrated with recognized standards for science education. In a 2000 policy statement, the American Association of Colleges of Teacher Education addressed the issue of limited pedagogical training for teachers. As discussed in Chapter 1, to meet the shortage of teachers, educational policy makers
turned to alternative certification programs to quickly fill classrooms; policy makers, in many cases, are "endorsing preparation programs and issuing emergency certificates or waiving licensure requirements entirely. These actions resulted in a large, but relatively ill-prepared teaching force…. Basic intelligence, communication skills, general education and knowledge of subject matter are necessary, but not sufficient qualities of effective teachers." (AACTE, 1999). These ideas were echoed by Linda Darling-Hammond in her summary of teachers entering the profession with less than full preparatory teacher education courses; she stated that "these recruits tend to be dissatisfied with their training; they have greater difficulties than fully prepared teachers in planning curriculum, teaching, managing the classroom, and diagnosing students' learning needs" (Darling-Hammond, 1997). In another analysis of research concerning student learning, Darling-Hammond (2000) found that knowledge of teaching and learning had a consistently positive influence on teacher effectiveness.

Darling-Hammond (1997) described the types of teaching and learning knowledge needed by teachers. This knowledge included an understanding of content in ways that allow a teacher to present concepts such that they are accessible for others and an understanding of students; Darling-Hammond (1997) referred to these understandings as pedagogical knowledge and learner knowledge. In addition, Darling-Hammond (1997) wrote that teachers need an understanding of student motivation for learning as well as an appreciation for different types of learning. Finally, she wrote that in order to use their knowledge effectively, teachers must have command of a wide variety of teaching strategies, have a knowledge of curriculum resources that extends beyond a student text book and have the ability to reflect, analyze, and improve the instruction they
offer students (Darling-Hammond, 1997). The ideas of Darling-Hammond outline some of the understandings that second career science teachers need to be successful. This knowledge includes: understanding of students and content that makes it possible to present content in relevant ways, understanding of student motivation and an appreciation for different learning styles, ability to use various teaching strategies, ability to use learning resources above and beyond student textbooks, and the ability to reflect and improve instruction. These abilities would provide a good basis for science teaching.

The National Science Teachers Association (NSTA, 2002) has developed a list of competencies for science education that serve to amplify and extend Darling-Hammond's work. Darling-Hammond (1997) suggested the need for understanding the content. In addition to understanding the content, science teachers also need to understand the historical and philosophic grounding of science in the inquiry process and must have the ability to lead students as they learn to ask questions, seek answers, and solve problems. Darling-Hammond (1997) wrote of the need for pedagogical and learner knowledge. In this regard, science teachers need to develop an understanding of their students' worlds and the perspective from which students view science as well as the science teaching strategies that make possible the integration of science into those worlds in ways that have meaning for all students. The mass of science information available today can be dizzying; science curricula should serve to focus and direct student learning in ways that allow them to develop personally meaningful science knowledge and successfully complete required evaluations.
Preparation for second career science teachers must, in some way, demonstrate to participants the need to develop the understandings outlined above. The presentation of courses in teaching methods must take into account the perceptions of the participants. In this study, two of the participants, Daffodil and Dave, firmly believed they could teach and saw no need for further course work in teaching methods. This presents a conundrum – prospective second career science teachers need to develop pedagogical knowledge while at the same time they may not perceive their need for the educational courses that will help them meet this need. Preparation programs must find a method to offer opportunities for development of pedagogical knowledge in a way that demonstrates the need for such courses; this could be done through classroom observations, case analyses, and action research components. Analysis of cases is one way to tie pedagogical learning to issues encountered in the classroom. In their discussion of the use of cases in preservice teachers, Laframboise & Griffith (1997) stated "Cases can be described as problem-centered stories of teaching practice that are used to examine and clarify the complexities and connections in teaching practice" (p. 370).

Research on career cycles described the first stage of an individual's career development as the entry stage during which skills necessary for success are acquired. Second career science teachers also must proceed through an entry phase during which the understandings needed for teaching are acquired, including pedagogical knowledge. For Daffodil and Dave, courses in pedagogy were not effective in this regard. While Rosalind wrote of the benefits she received from her courses in pedagogy, she
emphasized the benefits of her experiences as a young teacher working with more experienced science teachers. Based on these data, pedagogical knowledge might be best gained through immersion in practical teaching utilizing case analyses and classroom teaching experiences.

Participants need the opportunity to reflect on their teaching experiences and explore alternative strategies for addressing classroom issues (NSTA, 1996). This could be done through on-line journaling or chat rooms in which participants discuss issues encountered in the classroom. The participants in this study had difficulty recognizing their entry level status; this was due, at least in part, to their educational and career backgrounds. One challenge for teacher preparation programs is to convince professional scientists of their need to acquire the knowledge necessary to teach science to students in the context of a science classroom. Exposure is, I believe, the key. Prospective second career science teachers must be exposed, early in their program, to the rigors and realities of science teaching and learning. They must develop an understanding of the varying learning styles and motivation levels of their students and must develop an appreciation for tasks of teaching such as curriculum alignment, planning meaningful lessons, and laboratories, as well as such routine tasks as grading papers and duties. Most importantly, they must be exposed to the best research concerning curriculum and pedagogy. This exposure could be accomplished by guided exploration of literature and an action research component that provides an opportunity to incorporate strategies discussed in literature to address issues encountered in the classroom.

The process of gaining these understandings must begin with experiencing these issues and developing insight into how teachers meet all the demands placed upon them.
The program I envision will place prospective second career science teachers into the classroom from the outset of their program and maintain that contact throughout their preparation. Prospective science teachers could be assigned together in small groups in science classrooms; this would give them an opportunity, through journaling and other types of documents, to reflect on the actions in the classroom. In addition, these cadres of prospective science teachers could meet once a week to discuss and reflect upon observations and issues; these reflective sessions could perhaps be conducted as student-led on-line group discussions. This constant contact with the classroom will help illustrate and reinforce the concepts presented in their educational coursework.

The program I envision will be built on four pillars: practical teaching experiences, supporting educational coursework and reflective experiences, teacher research, and service learning tied to their science content area. Through classroom observations and a course in the nature of the learner, program participants will develop an enhanced understanding of: 1) student perspectives with regards to science, 2) student motivation for learning, and 3) methods for addressing student needs. This will be accomplished through classroom teaching experiences followed by guided reflection and discussion of the experiences as well as consideration of pertinent literature to effect positive growth in understanding of pedagogical principles and the ability to apply those principles to the classroom. The supporting coursework and field experiences will focus on the art of teaching science; i.e. the pedagogy and understanding of students necessary to help all students learn with success. Class assignments might include guided readings, case discussions, personal teaching metaphors, teaching journals, and portfolios. Based on data collected in this study, a content area that needs emphasis is the philosophy and
history of science as an intellectual enterprise. One method by which prospective
teachers in the program could enhance their understanding of the philosophy and nature
of science is through completion of a course in this topic. This course might include
assignments such as guided examination of literature, class discussions, and student
action research projects conducted as a part of pillars three and four of the program.
Based on data collected in this study, second career science teachers in this program need
to develop an appreciation for the importance of pedagogy and need to grow past the
belief that "deep content knowledge equates to effective teaching". In my proposed
program, classroom teaching experiences and reflective analysis of those experiences will
help the participants experience growth in this area. Through a combination of class
discussions, guided readings, observations, and practice lessons the participants will
develop methods to integrate curriculum and the ability to utilize varied teaching styles.

In addition to the above, a third pillar, collaborative action research, will comprise
a component of this program. Data from this study demonstrated the need for second
career science teachers to develop understanding and skills with which to more
effectively address issues encountered in the science classroom. At the same time data
also suggested that second career science teachers believe themselves to have the ability
to teach science without further preparation. An action component will create a cadre of
preservice science teachers and exemplary science teachers that will explore and develop
alternative strategies to address issues of concern encountered in the science classroom.
Burnaford (2001) presented several models through which teachers could conduct action
research; among these alternatives was the model in which preservice and inservice
teachers collaborated to conduct research into improved teaching methods. The action
The research component of the preparation program I propose is based on the work of Burnaford and provides the opportunity for second career science teachers to gain knowledge and understanding through personal and collaborative investigation. The cadres of prospective second career science teachers would have available for consultation as needed science education researchers to guide and direct the research of the cadre.

The fourth pillar of the program, service learning, involves community service tied to their content area. The cadre of preservice second career science teachers, under the direction of exemplary science classroom teachers, would form a community service learning team. Data from this study suggested that second career science teachers have limited understanding of their students and this negatively impacts their ability to present science in a meaningful way. The community service component is one way in which teachers could gain better understanding of the cultural and social backgrounds from which their students come to the science classroom. "Service learning fosters positive acquaintance between preservice teachers and people outside their immediate biographies and raises consciousness about issues of culture that may impact science teaching and learning" (Boyle-Baise, 2002, p. 15). It is a method by which prospective second career science teachers can gain, through learning experiences in the context of their students' worlds, understanding and empathy for student perspectives that will help them present science concepts in ways that have meaning for their students. "Service learning is a perspective and pedagogy that respects experiential learning as integral to academic study…it can help prospective teachers challenge their biases, wrestle with issues of poverty, situate children in their communities and adapt what they learn to academics"
(Boyle-Baise, 2000, p. 11). The team would identify and learn about community needs and plan service learning projects that focus on issues such as water quality, solid waste management, health care and maintenance, etc. Cadre members could potentially involve their students as well. This approach would help expand the understanding of perspective of second career science teachers with regard to students' worlds as well as bring the science classroom into those worlds in a meaningful way. The materials needed as well as the funding for supervisors could come from private sources, grants, or educational partnerships.

Model for the Residency in Science Education (RISE)

Overview

The residency in science education program is designed to meet both the needs of school systems and prospective second career science teachers. State school systems have developed alternative certification programs to meet the increasing need for certified science teachers; they are interested in placing individuals into the science classroom as quickly as possible. As has been discussed earlier, prospective second career science teachers need a firm underpinning in pedagogy. This plan will place science teachers into the classroom after one semester of observations and coursework. RISE program participants will complete a two year program of coursework/experience which proceeds hand-in-hand with their teaching.

To more effectively prepare second career science teachers for the classroom, education programs should take into account the following points; these points serve as the guiding principles for the residency program in science education. 1) The RISE program will focus primarily on pedagogical knowledge. Science teachers must
understand the subject they are teaching so that they can organize and present the material in ways that will be meaningful to the students. Darling-Hammond (1997) referred to this understanding of subject material as pedagogical content knowledge and suggested that this is one of the areas in which science teachers need to be proficient. A second, related area that Darling-Hammond (1997) described as important for effective teaching is pedagogical learner knowledge which she described as understanding "how students think and reason, how they learn best, and what motivates them" (p. 296). Data from this study suggested that prospective second career science teachers have a sufficient knowledge of content, what is needed is development of an understanding of students and student learning as well as the skills needed to present material in ways students find meaningful. What these prospective second career teachers need is the pedagogical content knowledge Darling-Hammond wrote of that is necessary to effectively teach science to students with a variety of cultural backgrounds and prior skills; therefore, the focus of the RISE program will be in this area. 2) The RISE program is designed to meet the needs of school systems as well as the needs of second career science teachers. Programs such as this one must consider the needs of school systems for science teachers to fill teaching slots and should place teachers into the classroom in a timely manner; however, second career science teachers must not be rushed through an "assembly line" process whose only goal is to put a teacher into a position and which may provide limited mentoring. The cadre of second career science teachers will be placed in the classrooms of science teachers who have proven to be exemplary science teachers based on student achievement, local awards, and statewide or national recognition. Early placement of the cadre of second career science teachers in a
series of science classrooms would allow for ongoing classroom science teaching observation and reflection to exist along side the coursework needed for provisional certification. After provisional certification, cadre participants would be eligible for employment. During the observation period, the teacher cadres would begin their collaborative action research investigations described earlier; this component of the program would continue after cadre members had secured employment. Also during the observation period, the service learning components of the RISE program would be initiated. 3) The RISE program will be practical and applied in focus. Traditional approaches to pedagogy featured classroom instruction followed by the application of principles learned through a teaching practicum and student teaching. The participants in this study resisted traditional educational coursework and one went so far as to describe these courses as "worthless". What is needed is an approach to pedagogical training that is more applied in nature and tied to the teaching experience. This program proposes to teach pedagogy through case discussions of issues encountered while program participants are actively engaged in the teaching process. Research has shown that cases can contribute significantly to the learning of teachers. In their synthesis of case-based research, Lundeberg, Levin, & Harrington (1999) suggested that cases enable prospective teachers to: a) apply theory in practical classroom situations, b) develop reasoning, including problem-posing and reflective thinking, c) develop self-knowledge or metacognition, and d) compare and evaluate their perspectives with those of others. Participants would be required to keep reflective journals which would be used for discussion during the once a week nightly meetings with cadre members. Participants will write, share, and discuss dilemma-based cases and will develop action plans and test
possible approaches and ideas for addressing case dilemmas. During these discussion meetings participants would consider dilemmas that have emerged, reflect upon their teaching actions, consider current research pertinent to the issues, consider possible solutions, and actions to address the dilemmas. 4) Like many adult education programs, the residency program will utilize evening classes as well as summer classes; these classes will kept to a minimum. Participants in this study wanted to enter the classroom and begin teaching as soon as they had made the decision to change careers. The majority felt that they knew how to teach and were resistant to learning through education courses. The RISE program proposes to address this reluctance to take education courses through an action research learning component. Action research is classroom-based, practitioner research into practical questions of teaching and learning through which teachers systematically evaluate their own practice, develop and incorporate strategies designed to address issues encountered in the classroom, and reflect upon the effectiveness of those strategies. Action research is a continuous process of inquiry that proceeds "by way of a spiraling, recursive series of at least these four steps: 1) plan, 2) act, 3) observe, and 4) reflect" (Kemmis & McTaggart, 1982, p.1). Through an action research learning component, RISE participants embark on a continuing journey of personal and professional growth through which they can gain knowledge of methods by which to more effectively present science concepts to their students. 5) Participants in this program begin their teaching career with the support of exemplary science teachers as indicated by student achievement, local awards, and state or national recognition. During this novice period, each program participant would have multiple levels of support consisting of members of their cadre, their mentoring teacher, and the mentoring
teachers of other members of the cadre. Participants will then have a collaborative support team to call upon when challenges arise. 6) The learning objectives that form the basis for this program are based the work of Darling-Hammond (1997), Darling-Hammond, Wise, & Klein (1999) and are drawn from the National Science Teacher's Association's (NSTA) standards for science teacher education. These standards were selected since they appear to be fundamentals in other states' foundation standards for science teachers. The NSTA standards are based on a wide array of research including the National Science Education Standards and the Benchmarks for Science Literacy as well as a variety of articles authored by well known researchers such as Atwater, Bybee, Darling-Hammond, Roth, Schon, Stake, Tobin, etc.

Table 9
RISE Program – Guiding Principles

| 1. Learning focus on pedagogical knowledge and student characteristics for learning |
| 2. Meets needs of school systems and prospective second career science teachers |
| 3. Program is practical and applied in format |
| 4. Classroom learning driven by case discussions |
| 5. Residents begin teaching experience from the first semester |
| 6. Residents attend classes in the evenings and in the summer |
| 7. Program has a research component |

The program is partially patterned after medical residency programs and after teacher internship programs such as the one proposed by the State of Minnesota and
described in Darling-Hammond et al. (1999). The Minnesota internship is a one year plan which provides "an opportunity for prospective teachers to acquire and demonstrate the knowledge, skills, dispositions, and ethical standards necessary for such practice" (Darling-Hammond et al., 1999, p.140). The residency in science education is similar in structure but is designed to more closely meet the needs of second career science teacher candidates as suggested by data from this study. The name of the program includes the term "residency" to emphasize the applied and practical focus of the program and to highlight the fact that program participants will not be simply "going back to school" but will be learning how to use their science knowledge in a new way. Heretofore, the science professionals represented in this study have used their science backgrounds to conduct research or to carry out a science related job. For example, with the Christmas tree farm, the goal was to use science to grow more trees profitably. As participants enter the world of school science the focus of their science knowledge is changed – now it is used to guide students to mastery of science concepts. Just as medical residents are training to gain the expertise necessary to use their medical knowledge in the treatment of a specific set of disease or injury conditions, participants in the residency program for science education are training to gain the expertise needed to teach science concepts to learners of varied backgrounds and abilities. It is hoped that such a focus will help overcome some of the "negative stigma" placed on education courses by participants in this study.

Learning and Performance Objectives

The instructional foci for the residency program are based on the NSTA Standards for Science Teacher Education and are modified to more closely meet the needs of
second career science teachers as indicated by the data collected in this study. The details of the learning and performance objectives are presented in a format based on and consistent with the NSTA standards.

NSTA Standard One applies to the level of content knowledge recommended for science educators. The NSTA Standards defined content as the "concepts and principles understood by science, that unify science domains, and the processes of investigation, including mathematical applications, used to develop knowledge in a given subject area" (NSTA Standard 1). The participants in this study demonstrated a deep level of content knowledge and, unless a specific need is demonstrated, the residency program will not concentrate on enhancements in content knowledge. While not a major focus area, there could be occasional seminars on cutting edge science research that would be required to ensure that their knowledge is up to date. Program participants will be assessed on their level of content knowledge based on observations of their guided teaching experiences.

NSTA Standard Two focuses on teacher knowledge of the nature of science. The NSTA Standards stated that science teachers should be prepared to "engage students in activities to define the values, beliefs, and assumptions inherent in the creation of scientific knowledge…, and contrast science to other ways of knowing" (NSTA Standard 2). The participants in this study demonstrated the need for more in depth understanding related to the nature of science. For the participants in this study, science seemed to be regarded as explanations of natural phenomena that were accepted with an almost child-like enthusiasm and faith. What appears to be needed is a greater appreciation of science as a pragmatic, intellectual enterprise that seeks to solve problems and answer questions as well as an understanding of the temporal nature of scientific explanations. The
The curriculum of the residency program will meet this need by including student understanding of the nature of science as a focus of action teacher research, seminars, and colloquia. Assessment of RISE participants for strand two will be based on the quality of student performance in the action research projects, as well as contributions made in seminars and colloquia.

NSTA Standard Three concerns teacher knowledge of inquiry in scientific investigations. According to the NSTA guidelines, inquiry includes the processes of asking questions and solving problems, constructing knowledge from data, collaboration while seeking solutions to problems, and developing concepts from experiences (NSTA Standard 3). The participants in this study were all involved in scientific investigations both in their formal education and career experiences. What the participants require is the ability to incorporate scientific inquiry into the learning opportunities offered students and to effectively engage students in active inquiry. Participants will be assessed on their ability to successfully incorporate scientific inquiry in the learning opportunities they provide for students.

NSTA Standard Four concerns preparation of science teachers so that they can "relate science to the daily lives and interests of students and to a larger framework of human endeavor" (NSTA Standard 4). Inherent in this standard is the ability to relate science concepts to the daily lives of students. The participants in this study, probably as a result of their education and career experiences, demonstrated the ability to highlight the practical applications of scientific concepts to daily life. What seemed to be a need among the participants is the ability to relate science to students in a meaningful way. A related need that emerged from this study is more cultural awareness by Daffodil and
Dave and a greater understanding of the lives of the students and the cultural and familial perspectives from which the students enter the science classroom. This need will be addressed through the community service learning component of the RISE program. This community service learning component will require that teachers become involved in the communities in which their students live. Their involvement might include community improvement projects related to their content area. Through such interactions prospective second career teachers would gain an understanding of the cultures of their students and ways to make the subject more meaningful for the students. Participants will be evaluated on this standard through their performance in this component of the program.

NSTA Standard Five concerns the practice of teaching and suggests that preservice science teachers be prepared to "create a community of diverse student learners who can construct meaning from science experiences and possess a disposition for further inquiry and learning" (NSTA Standard 5). Competencies with regard to this standard include the ability to utilize appropriate teaching strategies and methods, meaningful student interactions and use of student ideas and interests to promote learning, effective organization of classroom activities, effective use of technology to extend and enhance learning. In this area the participants in this study demonstrated a need for increased understanding of students, student learning, and the effective use of varied teaching strategies to promote student learning. As has been described earlier, in many instances the participants expressed frustration at the lack of student motivation for science and, at the same time, a dearth of strategies with which to effectively address this issue. To address this need the RISE program will include: 1) analysis of cases drawn
from literature that illustrate pertinent issues encountered in the classroom, 2) action research in which the cadre reflect on their teaching experiences and explore alternative strategies for addressing challenges encountered in the classroom, and 3) educational "rounds" in which problematic concerns related to student learning and science teaching pedagogy are discussed and current pertinent literature is brought to bear in the process of constructing alternative strategies with which to address the topics at hand. The idea of educational "rounds" is borrowed from the medical field and is analogous to hospital "rounds" in which interns and residents learn through doing and discussing problematic cases. The educational "rounds" would include case discussions of issues that, while not yet encountered, are likely present challenges for novice science teachers. The assessment of RISE participants in this area will be based on knowledge demonstrated in case discussions as well as knowledge applied in their guided teaching experiences.

NSTA Standard Six addresses curriculum and suggests that preservice science teachers be prepared to "develop and apply a coherent, focused science curriculum that is consistent with state and national standards for science education and appropriate for addressing the needs, abilities and interests of students" (NSTA Standard 6). The data collected in this study suggested that the participants have limited understanding of the role curriculum plays in effective science teaching and learning. One participant, Dave, across several data sources, referred to the curriculum (the QCC's) as "worthless". When reviewing participant responses, one is left with the impression that curriculum (the QCC's) was viewed as a hindrance and a burden that negatively impacted science teaching. Beliefs such as these give evidence to the fact that the participants in this study need to enhance their understanding in the area of science curriculum. Science curricula
serve as guides for what information and knowledge science students need to master.

With so much emphasis on learning assessment through end-of-course testing, it is critical that second career science teachers understand the impact and importance of a curriculum as a guiding influence upon science experiences in the classroom. The RISE program will address the demonstrated need in this area by: 1) the educational "rounds" sessions will include discussions of curriculum issues, 2) the community service learning component of the program which will help cadre members better understand how to present science to students in a meaningful manner. 3) The action research component will allow cadre members to evaluate their teaching in light of science curricula, bringing in current curriculum research to synthesize teaching strategies which more effectively merge the needs of the students with the requirements of state and local testing.

NSTA Standard Seven recognizes the social context in which science learning occurs and is "intended to facilitate inclusion of members of the immediate community and the family in the teaching of science" (NSTA Standard 7). The participants in this study understood the workplace context of science and the use of outside community resources in the teaching of science. The data collected in this study suggested the need for increased understanding of the students' social and familial environment and an enhanced appreciation and empathy for the effect of environment and cultural background on student learning. One participant, Daffodil, in several interviews expressed the belief that emphasis on multiculturalism is detrimental to students since all students have to learn the same material, be evaluated by the same testing, and must achieve success in the same work environment. Daffodil's statement suggested the need for preservice science teachers to have exposure in schools with different racial and
socioeconomic make-ups. Her statement also highlighted the need for the RISE program to provide learning opportunities, in the form of educational "rounds" as well as community service learning experiences that will help participants expand their understanding of and empathy for the impact of different cultural backgrounds on student learning. RISE participants will be assessed in this area based on performance and understanding demonstrated both in educational "rounds" and community service learning.

NSTA Standard Eight describes the importance of using a variety of assessment techniques that evaluate the "intellectual, social, and personal development of the learner in all aspects of science" (NSTA Standard 8). The process of assessment involves the aligning of instructional goals and procedures, evaluation of student learning in a variety of ways, and the use of assessment to reflect on instruction in progress. The participants in this study consistently expressed frustration with how poorly students scored on tests. Although the participants had some training on alternative methods of assessment, they did not seem to "buy into" the concept of multiple modes of assessment; this is due, perhaps, to their educational background. The RISE program addresses this need by providing additional opportunities for the participants to utilize a variety of assessment methods in their guided teaching experiences – a sort of a trial and error, let's see what works for me. The cadre would explore the issue of variety of assessments through discussions held as a part of educational "rounds" and through the action research component of their program.

NSTA Standard Nine involves the environment for learning and describes the necessity for science teacher education programs to prepare science teachers to "design
and manage safe and supportive learning environments reflecting high expectations for the success of all students" (NSTA Standard 9). NSTA described the learning environment as including the physical, psychological, and social environment in which science learning occurs as well as ethical use of living organisms and the promotion of safety in all areas of science instruction. Of all the participants in this study, only Daffodil spoke of the importance of laboratory safety. None of the study participants commented on the physical, psychological, or social environments for learning in their schools. Participants in the RISE program will gain understanding in the area of safety and ethical treatment of organisms through participation in workshops sponsored by science equipment vendors as well as through conventional courses. Through experience in science teaching as well as clinical discussions of those experiences, participants will gain the understanding necessary to manage a learning environment which safely meets the needs of all science learners. In addition, these issues will be addressed through the action research component of the RISE program.

NSTA Standard Ten describes the importance for preservice science teachers to participate in professional organizations such as the Georgia Science Teachers Association (GSTA) and NSTA and to improve their teaching practice through continuing education fueled by personal reflection of their teaching. Participants in this study exhibited a limited level of identification with professional science education organizations. Only one participant, Rosalind, was actively involved in professional science teaching organizations; the other two participants, Daffodil and Dave, had previously been involved in professional science organizations and still maintained close identification with those organizations. While in the residency program, participants will
be required to attend and actively participate in state, regional, and/or national science education conferences and enter into mentoring relationships with teachers holding leadership and service positions within these organizations. It is hoped that by emersion in the function of professional associations, lasting relationships with organizations such as these that seek to promote quality science teaching and learning will be established.

Table 10

RISE Program – Learning Foci

| 1. NSTA Standard 2 - The Nature of the Learner |
|---|---|
| 2. NSTA Standard 5 - Characteristics of the learner and methods of teaching science |
| 3. NSTA Standard 6 - Science curricula |
| 4. NSTA Standard 7 - The social context within which science learning occurs |
| 5. NSTA Standard 8 - Methods of assessment |
| 6. NSTA Standard 9 - Management of the learning environment |
| 7. NSTA Standard 10 - Professional association |

**Educational Program**

The RISE program can be characterized as a clinically based learning program. This term, borrowed from the medical education field, describes a curriculum in which learning is driven by discussion and close examination of clinical cases. Case discussions, some student generated and others drawn from published books or commercially produced videos, provide practical examples of concepts that students have
the opportunity to explore in depth. The RISE program adopts a similar approach to learning. The clinic becomes the classroom as participants discuss and analyze issues raised through teaching experiences in what are termed educational "rounds"; these discussions will serve as springboards from which to initiate deeper exploration of pertinent research in science teaching and learning.

Admission to this program must include criteria that will admit students with the greatest potential to successfully translate their existing science careers into long term effective and productive careers as science educators. In addition to adequate science educational and career backgrounds, data collected in this study provided some insight into personal characteristics that might prove helpful in selecting candidates. Of the three participants in this study, Rosalind stood out as one who has most successfully translated her previous science career into a career as a science educator. Rosalind's success seemed to be related to her attitude toward science teaching and her focus on student learning. Rosalind adopted a science teacher as learner metaphor in her approach to science teaching. In other words, Rosalind viewed science teaching as a continual process of gaining new knowledge and understandings which would allow her to better present science in ways that had meaning for her students. In contrast to Daffodil and Dave, who believed they already knew what they needed to teach science, Rosalind believed she needed to learn how to teach science. Rosalind, to the present day, continues to feel driven to improve and enhance her teaching techniques through continuing education. A second trait that stood out with Rosalind was her focus on students. In contrast to Daffodil and Dave, who believed that science content was the focus of teaching, Rosalind believed she taught students and that student learning, rather
science content, was the focus of her teaching. Rosalind's passion for science translated into passion for learning new ways to present science to students in meaningful ways. For Rosalind, the impact of her learner metaphor and her focus on students has guided her throughout her career and continues to breathe fresh life and vitality into her teaching. Selection criteria for participants in the program should assess applicants in ways that identify positive traits such as commitment to lifelong learning and the ability to empathize and focus on student achievement. Specific requirements for admission might include: at least a bachelor's degree in a science field, five years in a science-related career, assessment of aptitude for working with people, and assessment of philosophies concerning learning. Methods to assess candidates' aptitudes for working with people could include letters of recommendation or a video of each candidate working with a group of people. To assess the philosophy of the candidates, as a part of the application, candidates could write a philosophy statement concerning science learning and the role of the teacher.

The RISE program will feature teacher action research in which members of the cadre reflect upon their teaching experiences, and, in group discussions, consider pertinent research, and synthesize alternative strategies with which to address issues encountered in the classroom. Another feature of the RISE program is a community service learning component in which cadre members take part in community service projects which better acquaint them with the cultural backgrounds of their students. These community service projects would include opportunities for cadre members to reflect upon their experiences and connect them back to the content area in which they teach.
The RISE program will be designed to accommodate a small number of residents, perhaps 10 - 15 individuals per cadre, and will extend for seven semesters during which the residents will be actively engaged in science teaching while completing required learning experiences. Learning experiences will generally occur in the evenings and on weekends except during the summer semester and are designed to meet the educational needs detailed in the learning objectives for the program. For the duration of the residency, program participants will stay together as a cohesive unit. The program will utilize a team collaborative approach; the collaborative team will consist of residents, exemplary science teachers, professors of science education at the college level, as well a residency coordinator to oversee and direct the participants as they complete their residency.

The residency coordinator would serve a guiding function similar to that of major professor for graduate students. Program participants will begin practical teaching experiences as co-teachers and co-researchers from the first semester and the RISE curriculum will be organized so that course discussions and assignments support the teaching experiences; in other words, course discussions and assignments will address situations encountered during classroom experiences and serve as a point of departure for deeper examination of pertinent issues that have been brought to light by observations in the classroom. The educational "rounds" will serve as the vehicle by which cadre members learn to do action research on science teaching and learning. This approach will allow participants to address "real world" situations by synthesizing and applying current research in science education. An on-going evening class, meeting once a week and extending the entire length of the residency, will be utilized to carry out these case
discussions and explorations. In addition to the on-going case discussion classes, there will be a series of required experiences designed to meet the needs outlined in the previous section of this chapter.

Residents will begin their practical teaching exposure with a period of traditional observation and practice teaching experiences; they will be teamed up with science teachers with whom they will co-teach classes and accompany as they carry out duties and attend teacher meetings and parent conferences. The residents will assist in all phases of teaching, including planning and execution of lessons, management of student behavior in the classroom, communication concerning student progress, as well as all duties and meetings. In addition, the residents will maintain an interactive journal in which observations and issues are posted on-line weekly and are used to direct chat room discussions as the resident cadre, under the leadership of their resident coordinator, examines pertinent research and uses this research to create understanding of appropriate strategies with which to address the issues raised through observations. The teaching partnership will form the basis of an action research team as the residents and their teaching partners, along with the cadre, conduct research into issues related to science teaching practice. The mentor teachers are exemplary science teachers as evidenced by criteria listed previously and could be paid through a grant program. Under the guidance of the RISE coordinator, the mentor teachers could begin the process of becoming nationally board certified and thereby earning additional salary. Simultaneously, residents will begin their professional development through a variety of learning experiences; the curriculum will be designed to address the standards described earlier and would include any courses, such as the exceptional learner, that are required by the
individual states for teacher certification; these learning opportunities will be guided by
the faculty of departments of science education and will consist of appropriate
assignments.

Ideally, the residency will begin in the spring semester with the co-teaching phase
of classroom experience. Program participants, now with provisional teaching
certificates, could then be hired by school systems the next fall to fill science teaching
positions where they would teach a normal load of classes. During this period of the
program, residents will continually have the support of both an exemplary teacher in their
school system, selected through consultation with system science coordinators and GSTA
leadership, as well as their RISE coordinator, and will continue the learning experiences,
including educational "rounds", action research, and community learning service required
to complete the objectives of the residency program. These continuing experiences will
be directed by the RISE coordinator through weekly evening sessions.

The RISE program is designed to address several issues raised by the participants
in this study with regard to their certification programs. Daffodil and Dave expressed
marked frustration with the experience of "returning to school" and the "loss of
professional image" that their career transition necessitated. As Dave expressed in his
data:

...being very much a professional in one respect, in forestry, having

graduated from one of the top schools in the nation, and being told I'm not

qualified even when I've had this experience, being sent back to school for

several years for several prerequisite classes and most of this by people
that I was more qualified than and more intelligent than...(Interview 6/16/00)

Kanchier & Unruh (1988) and Graham (1973) in their work on career cycles, described changes in status that accompany any change in career and it is reasonable for any participant changing careers to expect a degree of novice status as they gain the knowledge and understandings needed for their new career. However, any reduction in this type of "negative stigma" associated with returning to school will serve to make a program more attractive to science professionals desiring a career move to the world of school science. A second issue related to science teacher certification relates to courses in teaching methods. Again, Daffodil and Dave expressed negative opinions concerning the benefit of the educational courses they completed as a part of their certification program. These individuals believed, possibly based on their college and career experiences, they could already teach science and it is probable that this belief helped limit their ability to create new knowledge from their class experiences. It is hoped that the collaborative co-research model used in the RISE program, as well as the clinical approach model for learning will effectively address feelings toward returning to school that might exert negative influences upon the participants' ability to assimilate new information and create new understandings. Further, it is hoped that the case approach to learning will emphasize the benefit of educational courses and thus enhance the residents' ability to gain and apply new knowledge to their new career.

In summary, the RISE Program is intended and constructed to meet the needs of science professionals who desire to enter the field of science education. It is designed as a clinically based program of learning with classroom activities and other learning
Table 11

Components of RISE Program

<table>
<thead>
<tr>
<th>1. Clinical based learning program design</th>
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<tbody>
<tr>
<td>2. Designed for 10 - 15 residents</td>
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<tr>
<td>3. Program extends for a period of 7 semesters</td>
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<tr>
<td>4. Residents begin teaching experiences from the first semester</td>
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<tr>
<td>5. Program utilizes a co-researcher / collaborative model</td>
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<tr>
<td>6. Program includes an action research component</td>
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<tr>
<td>7. Residents hired to fill science teaching positions in the third semester</td>
</tr>
<tr>
<td>8. Program includes a community service learning component</td>
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opportunities driven and fueled by field experiences. In this way, classroom learning is tied to issues encountered during teaching experiences; classroom experiences will demonstrate the need for new understandings and strategies which will enhance the creation and assimilation of new knowledge by RISE participants.

Summary

For the three participants in this study, the career move represents a continuing journey as they seek to grow in understanding and ability past the basic level of a scientist who is now in the classroom explaining a subject, to the deeper level of a science teacher who has the knowledge and understanding to present science to all students in ways that have meaning for them. This journey has not been without hurdles to overcome and there continue to be challenges for the participants in this study. Data
collected in this study were used to create a preservice teacher program that will help other scientists make the transition to the world of school science.

A continuing challenge evident in this group of second career science teachers is the need to expand the vision they have for science education. Daffodil and Dave are excited about science and want their students to share their passion; their vision of teaching focuses on students who are highly motivated to learn science. In a real sense, their vision of science education is centered on the subject and includes limited understanding of the students they instruct. Rosalind, on the other hand, has evolved over her teaching career a more student centered vision of science teaching and learning. She is still excited about her subject, but when asked about her teaching, Rosalind will quickly reply that she teaches students and that her students come first. In contrast to Daffodil and Dave, Rosalind, while retaining her love of science, has expanded her vision of science education to include the mantra "I'm teaching students not Petri dishes". She expresses more satisfaction with her teaching career than do either Daffodil or Dave; perhaps if Daffodil and Dave could expand their focus in the same way they would derive more rewards from their teaching experiences.

If Daffodil and Dave could be helped to develop a receptiveness for new teaching ideas, perhaps their level of satisfaction with their careers could be enhanced as they developed new understandings of their students and alternative teaching strategies that allowed them to present science in meaningful ways. It seems that Daffodil, Dave, and perhaps other second career teachers, need to have demonstrated to them the benefits they would realize from enhanced pedagogy; perhaps an effective way of accomplishing this is the practical, problem-solving, action research approach featured by the RISE program.
The RISE program is designed to meet the needs outlined earlier while helping prospective second career science teachers acquire the knowledge and understanding needed to make a successful transition to the world of science teaching and learning. The learning objectives for the program are based on the NSTA standards for science education programs that outline the knowledge and competencies science teachers need to possess in order to effectively facilitate science learning. One focus of the RISE program is to help residents gain the knowledge and pedagogical skills that will allow them to become, as defined earlier in this chapter, science teachers in the full sense of the word. A second area of focus for the RISE program is to help residents increase their knowledge and understanding of students, the varied ways learning occurs, and the impact of culture on student motivation and performance. In this way, hopefully, the program will help participants expand their vision to include a student-centered focus in their teaching. The RISE program also focuses on the practical application of knowledge in the classroom and on acquiring new knowledge as a means to address classroom challenges; in this way the need for teacher training can be demonstrated for all participants. Through its focus on NSTA standards, its clinical approach, and its teaching component, the RISE program provides prospective second career science teachers the opportunity to gain the knowledge and competencies they will need to make their career move into the world of school science.

Second career science teachers represent an important resource for education, especially in light of consistent shortages of teachers in the areas of math and science. The wealth of educational and career experiences they bring to the classroom make them a powerful force in the effort to present science in ways that help all students achieve
success. For second career science teachers to successfully help students construct science concepts, they must have the knowledge and ability to present science concepts in ways that all students find meaningful. One understanding that has grown from this study is that scientists who enter the classroom to teach may not possess the ability to lead their students to learn science. It is incumbent upon the science educators to help prospective second career science teachers gain those teaching abilities they need in ways that do not dampen their enthusiasm for the science teaching field. I hope that the knowledge constructed from this study will, in some small way, help in the important process of preparing scientists to enter the world of school science.

Personal Perspectives Influencing this Project

In Chapter 1 of this document I commented upon the importance of identifying any areas where personal preconceptions and life experiences might exert a negative influence upon the analysis of data collected in this study. Personal biases on the part of the researcher serve to cloud the knowledge that is created from the participants' data, thus muffling their voices and distorting the meaning that is constructed from their life experiences. While unable to purge completely the effects of personal experience upon data collection, it is imperative that the researcher seek to identify any areas of personal bias and keep these influences in the forefront of her/his consciousness so as to recognize the intrusion of preconceptions upon faithful analysis of the data contained. This I have endeavored to do.

As I began this study I identified three aspects of my personal and professional life experiences that might impart artificial color to the lens through which I analyzed the data. One set of personal biases grew from my experiences over the past 25 years as a
traditionally certified high school science teacher. The risk has been that my science teaching career might cause me to unconsciously judge data through the lens of my personal experiences, thus clouding any meaning gleaned from the participants’ individual experiences. Throughout this study I have consistently and consciously attempted to keep self out of the equation. The input of others, particularly my husband James and my major professor Deborah, has been a great benefit to me as I have sought for rigorous and impartial analysis.

A second set of personal biases stem from my undergraduate training as an entomologist. In my science training, research projects are begun with a definite question to be answered yes or no – a very closed ended type of process. The results of one experiment are used to plan further experimentation. This work represented a qualitative study of second career science teachers; therefore, the goal was to cast a wide net around the data so as to gather different meanings that might be present. The risk was that my analysis of the data would be too narrow and meaning might slip away undetected. The process of stepping back from the data and away from any first impressions as well as examining it from different perspectives continues to present a challenge for me; my efforts have been greatly aided by Deborah's input and advice.

A third set of personal biases stemmed from the fact that my husband was alternatively certified as a science teacher fourteen years ago. I have intimate experience with his career change journey and the risk has been that I would interject the experiences of his journey into the data obtained from the participants. The inclusion of beliefs and opinions generated from an outside source would certainly have contaminated the meanings that have been constructed from the lives and careers of the participants in this
study. I have made a conscious effort to "keep my distance" from the data throughout the study so as to minimize the impact of family experiences. It is my hope and belief that I have successfully minimized the impact of these, and any other, as yet unidentified, areas where self could have intruded itself into the stories of these participants. I can only certify that the effort was consistently made to analyze the data collected in this study in a fair and unbiased manner.

When reflecting upon the personal biases described above, I was made aware of a fourth bias, while not personal in nature, was present and may have exerted a significant upon the data collected. I refer to the inexorable bias of time. Throughout the data collection process of this study, participants were asked to recall and relate life experiences that occurred many years ago. Further, they were asked to describe personal reactions and feelings to these events. It is possible that the passage of time affected their ability to accurately recall the details of life events and colored their responses to these events. While the passage of time is an inevitable factor in data collection for a study involving life remembrances, it is important to at least recognize and acknowledge the impact it might have played in the responses of the participants.

Implications for Future Research

In reflecting on this research, its focus and its aims, several areas come to mind in which useful avenues of investigation were left unexplored. The research questions for this study focused on the life stories, career paths, and teaching beliefs of the participants. One area left unexplored was the teaching actions of the participants. In other words, how do the beliefs of second career science teachers translate into actions in the science classroom? While there have been studies that have shown links between teaching
beliefs and teaching actions, the extent to which the teaching beliefs of second career science teachers result in teaching strategies that are consistent with their beliefs is open to more study.

The research focus of this study did not delve in depth into the type of certification program each of the participants experienced. Limited data were collected on their certification process. A second follow-up project could be to more closely examine each of the certification programs with the goal of identifying any relationship between type of certification program and teaching beliefs and/or actions.

A third question left unanswered is why Rosalind was more satisfied with science teaching than Daffodil or Dave. Based on her data, Rosalind was happy in her career even when teaching low level students in intercity schools. In contrast to Rosalind, Daffodil and Dave expressed a higher level of frustration with "regular level" students; their frustration permeated their responses across the data sources. The question of why Rosalind was more satisfied with her career has not been definitively answered in this study. Follow-up studies to examine second career science teacher satisfaction could give useful information in terms of predicting longevity for these science teachers and helping to establish learning objectives for certification courses that would help promote science teacher retention.
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Autobiography Instructions

A type of document used to access information concerning a person’s life history is the autobiography. Whereas your historical timeline presents a chronological depiction of significant life events, the autobiography represents a non-linear and non-chronological account of the significant people and events that have shaped your life in terms of science teaching and learning. The focus should be the feelings, emotions, and beliefs that you attach to each event. I would like you to discuss any remembrances of yourself as a science learner in situations not associated with formal education. Be creative. In summary, the goal of this document is to elicit information concerning the significant people and events in your life that have shaped your personal beliefs concerning science teaching and learning.
APPENDIX B

INSTRUCTIONS FOR MAKING A HISTORICAL TIMELINE
Historical Timeline Guidelines

Construct a visual depiction of the significant events, memorable experiences, and memorable experiences specific to science teaching and/or learning that have occurred in your life. Focus on events in which science impacted your life in some way or experiences which led to a science teaching career. For each event depicted in the timeline, provide a short description (1 - 2 sentences) of the significance of that event.
APPENDIX C

QUESTIONS USED TO GUIDE INTERVIEWS
Background Interview

(Interview # 1)

1. What is your name? Where did you grow up? Would that area be described as rural, suburban, urban?

2. Tell me about your formal and informal educational background. Where does science have a significant place in your educational background? When did you get interested in science?

3. Describe your career prior to science teaching. How long did you work in that career? What were some likes and dislikes about that career?

4. Describe the factors/life events that led you to change careers. Why did you pick education as a second career and science teaching as a focus?
5. Describe your certification process. Describe your experiences and coursework associated with your certification program.

6. Describe your science teaching experience. How long have you taught? Subjects? Where?

7. Tell me about a typical school day. What happens in your class?

8. Describe the most important things that stand out in your mind that prepared you for science teaching.
Interview # 2

1. How would you define the phrase “a science legacy”?

2. How would you describe the science legacy in your family?

2a. Tell more of the ways your father’s science/teaching career influenced you. (Dave)

3. How is a science legacy built? How is it passed on?

4. Describe your science legacy.

5. Tell me more about the role of academic achievement in your family.

6. What have been the influences of gender on your academic and career paths?

7. What do you see as connections between your first career and science teaching?
8. Do you see yourself as a learner? How does this influence your science teaching?
Interview # 3

Protocol

1. Some science teachers are very careful to precisely follow standard curricula and established science teaching/learning practices; while other science teachers are more risk-takers in that they are inclined to try new and innovative science teaching/learning strategies. How do you perceive yourself as a risk-taker in the science classroom?

2. What differences do you see in risk-taking between science teachers who worked in a science career prior to teaching and those who graduated with a B.S. in science education and whose only career has been teaching?

3. Describe some examples where you have “stepped outside your comfort zone” in teaching science.

4. In what ways has your initial career influenced how you view the role of technology in science teaching? In what ways do you see technology changing the science legacy that you leave for your students/kids?
5. If you could put a banner on your door that would portray the science legacy you want to leave your students, what would that banner be?

6. Metaphor questions:

Metaphors cannot be treated as products, or stable representations of your belief. Rather, they might be considered as dynamic representations of struggles. Discuss the nature of the “struggles” embedded within your metaphor(s) and the positive or negative aspects of these “struggles”.

Rosalind

a) I enjoyed your metaphor of a band director/orchestra conductor. Could you describe some experiences in which you were functioning as a director/conductor?

b) I also loved your organic gardening metaphor. You mentioned the need for good soil amendments – teacher certification, strong foundation and love for subject matter, love for young people, and desire to make a difference in education. How would you rank these amendments in terms of their importance to science teaching/learning?

c) Could you describe some experiences in which you were “organic gardening” in the classroom?
d) Are there times when you would like to be a conductor or gardener but you must fulfill another role? If so, what would that role be?

Dave

a) I can really relate to your metaphor of policemen/baby-sitter. Could you describe some other experiences where you are serving as a policemen/baby-sitter?

b) Are there times when you don’t have to act as a policeman/baby-sitter? Describe some of those times.

c) Your ideal science teacher metaphor is a conductor of an orchestra. Can you describe some instances in which you could be the conductor in the science classroom?

d) What could be done to bring the ideal and real teaching experiences closer together?

Daffodil

a) Your metaphor of a leader of an expeditionary force was intriguing. Describe some ways in which you would like to lead your science classes in a voyage of discovery.
b) In reality, you mentioned that you have to be not only the leader, but the bus mechanic. Describe some ways in which you would like to lead but you must play bus mechanic first.

c) What could be done to bring the ideal and the real science teaching experiences closer together?

7. Can you describe another personal teaching metaphor? How would you describe, metaphorically, the science curriculum, QCC, or the National Standards?

8. Of the following, which is/are the most important traits of the science educator: passion for the subject, content knowledge, pedagogical knowledge, passion for student learning?

9. How do you view or value the emphasis on multicultural issues related to science teaching?
Interview #4

1. In reflecting upon your life experiences, what factors / events / experiences do you think led you to the world of school science?

2. Rosalind – When referring to your career change, I loved your statement that you came to believe that you needed to be working with “teens and not test tubes”. Why / how do you think you came to that belief?

   Dave – In a previous interview you spoke of how you came to believe that students and not trees were what you wanted to work with. What do you think were that factors / life experiences that led you to this decision?

   Daffodil – In a previous interview you spoke of how you took part time teaching jobs from time to time while you were still in the Army. What do you think were the factors / life experiences that led you to the classroom then and back to the classroom after your retirement from the Army?
3. The challenges faced when changing careers have been referred to as “borders to be crossed”. Could you speak to prospective second career science teachers concerning the borders you faced and the process of negotiating the borders in your career change?

   a. Were there financial borders?
   b. Were there family / societal borders?
   c. Were there professional borders?
   d. Were there borders related to preparation?

Are there borders you continue to negotiate? Why?

4. How could have your science teacher education program better prepared you for the classroom? How do you perceive that science teacher preparation for a second career person would be similar or different than the preparation of a traditional student?

5. What advice could you offer prospective second career science teachers?

6. How have your day to day experiences as a science educator compared to the expectations concerning teaching you held prior to your career change?
7. How can multicultural preparation as part of science teacher certification programs better address the challenges faced by science students today? How could other kinds of multicultural science teacher training better address the challenges faced by science students today?

8. Some second career teachers describe their move into the classroom as an experience that feels to them like “coming home”? How would you describe your feelings concerning the move into science teaching? Why do you think the experience feels like that?

9. What were some of the strengths and weaknesses of your teacher preparation program? What was the most memorable experience from their program in terms of influencing your teaching? (Be very specific – not field experiences or student teaching – give specific experiences.)
APPENDIX D

JOURNAL INSTRUCTIONS AND QUESTIONS
Journal Instructions and Journal Question # 1

I would like for you to keep a journal for approximately 18 weeks. I would like for you to record entries into your journal at least once a week. In the journal, I would like for you to reflect upon the week that has just ended and to comment on any issue related to Science Teaching / Learning. I will also give you a specific question each week on which to respond. The question for this week is the following: “Describe a Science Teaching/Learning experience in which you felt like you were really teaching”. It would be helpful if you dated each entry. Thank you so much for taking part in this research project.
Journal Question # 2

In your journal this week I would like you to reflect on the challenges you face as you teach science. Specifically, I would like you to reflect upon your prior career in science and respond to these questions: Are there ways your prior career helped prepare you for a career in science teaching and learning? Are there ways in which these work experiences help you handle the challenges science teachers face?

Journal Question # 3

In your journal this week I would like you to reflect on the convergence/divergence of your two careers. Specifically, I would like you to reflect upon your prior career in science and respond to this question: Describe any areas of convergence/divergence between your 1st career in science and your career in school science. As you reflect and ponder this question, I’d like you to write your definition of school science.

Journal Question # 4

For this week’s journal response, I hereby elect you “main person in charge”. In this role you can teach your students in any way you desire. You have no limitations of space / time, no administrative constraints, no QCC concerns, and no monetary restrictions. Given this completely hypothetical (sadly) situation I would like you to describe some of the ways in which you would teach your students.
Journal Question # 5

For this week’s journal response I would like you to consider science as a life influence. Specifically, I would like you to describe examples of the ways in which “science as a discipline” or “science as a way of life” has impacted your life story.

Journal Question # 6

For your journal question this week I would like you to respond to these two questions: Do you see yourself more as a “teacher of science” or more of a “scientist who teaches”? How does science differ from school science?

Journal Question # 7

For this week’s question, I’d like for you to think back to your previous career and describe the aspects of your first career in science in which you performed the duties of a “science teacher”.

Journal Question # 8

For this week’s question, I’d like for you to focus on the process of career change. Specifically, I would like you to reflect back on the significant events that occurred during the process of leaving one career and entering your school science career.

Journal Question # 9

For this week’s question, I would like you to reflect upon the ways science has impacted and enriched your life.
Journal Question # 10

The journal question I’d like you to consider for this week concerns a pattern I found in your data that I refer to as a science legacy. By science legacy I mean the people and events in your life that influenced you and fueled your interest in science. This week I would like you to reflect upon your remembrances of people, places, events, etc. that led to your interest in science.

Journal Question # 11

This week for your journal entry I would like to explore another pattern that is present in your data. This pattern concerns your experiences as a student and importance placed upon school achievement by members of your family. This pattern I refer to as your academic legacy. This week I would like you to reflect upon your experiences as a student, both in formal school settings and in informal learning opportunities, and any ways in which you were encouraged by family members or others in your school career.

Journal Question # 12

For this week’s question I’d like for you to reflect on different boundaries you had to cross to become a science educator. J. had to negotiate several “boundaries” as he made the switch from veterinary medicine to science education. For instance, when J. was practicing veterinary medicine, he always received a professional discount at the dentist. As soon as he began science teaching, the discount stopped. In the dentist’s mind, J. went from a “professional” to an “unprofessional”. J. was an experienced professional small animal clinician; when he began teaching he immediately became an inexperienced
“novice” teacher. Our family had to negotiate an economic border as J. changed careers.

What sorts of experiences did you have as you traveled from one career to another?

Journal Question # 13

In your journal entry this week, I’d like you to respond to the following question: How has being a science teacher (or, if you prefer, a teacher of science) enriched your life?

Journal Question # 14

This week’s question relates to your personal experiences with science teaching and learning.

Describe a meaningful science learning experience related to your student years.

Journal Question # 15

Describe a meaningful science teaching/learning experience related to your teaching.

Journal Question # 16

What do science do students need for the 21st century? Is this really science or is it technology? How do you differentiate between science and technology?

Journal Question # 17

This week’s question again relates science teaching and your prior career. Describe any specific examples of challenges you faced as you crossed the border from a science career to a science teaching career. As you made the transition from your science career
to a science teaching career, what knowledge, skills, and experiences (even strategies) did you bring that have been useful tools for teaching science?

Journal Question # 18

For this week’s journal question, I’d like you to reflect on your science teaching career. How have teaching beliefs regarding science teaching and learning evolved over your science teaching career? How do your science teaching experiences compare with your preservice expectations? What could your certification program have done differently to better prepare you for the realities of the classroom?
APPENDIX E

INSTRUCTIONS FOR CASE NARRATIVE STORIES
Instructions for Case Narrative Stories

For this datum source, I would like you to write about a dilemma or challenge you have encountered while teaching science. I would like you to write specifically about a dilemma related to science teaching/learning and not a discipline related dilemma. Your case narrative may be based on a dilemma that is resolved or unresolved (still ongoing). Include in your case narrative a clear description of: 1) the dilemma itself, and 2) how you resolved the dilemma (if applicable). Include some (or all) of the following components when writing your narrative: 1) description of the teacher, 2) description of the teacher’s background and experience, 3) description of the school and community in which the dilemma occurred, 4) description of students, 5) description of the teacher’s and student’s feelings and intentions, 6) descriptions of other relevant individuals important to your case, i.e., parents, administrators, peers, 7) formal/informal theories about science teaching/learning or human behavior, 8) meaningful personal experiences as a teacher/student/parent, 9) meaningful experiences shared by peers or friends, 10) real or imaginary dialogue between yourself and others, lessons to be derived from the case.

There is no “correct” way to write a case narrative story. You are welcome to look at the examples of case narrative stories I have.
APPENDIX F

INSTRUCTIONS FOR PHOTOESSAYS
Photoessay Instructions

This source of data is a relatively new source of information for researchers. Photoessay is considered a non-literary form of narrative in which participants’ stories are captured in ways other than written or spoken words. You will select the objects in the photos yourself; this will provide a rich source of data relevant to your personal life experiences. I would like for you to take photographs that: 1) illustrate the intersections of your previous career with yourself as a science teacher, 2) reflect some of your beliefs about science teaching or science learning, or 3) a combination of items 1 and 2.

Once you have taken your photographs, return the film to me so I can have it developed. Once the film has been developed, I will return the photos to you in order for you to organize your photoessay in a way that makes sense to you. Include in your photoessay short paragraphs that explain the significance of each photograph.
APPENDIX G

INSTRUCTIONS FOR WRITING TEACHING METAPHORS
Metaphor Instructions

For this datum source, I would like for you to write three metaphors. In one metaphor, I’d like you to describe yourself as a science teacher. In another metaphor, I’d like you to describe your image of the ideal science teacher; in other words, how would you like to teach science? In the third, I’d like you to write a metaphor for a science curriculum. As you write your metaphors, you may find that more than one metaphor describes you or what you do. That is OK; but, if you choose to write about more than one, please write about each in depth. I have several metaphors that reflect what I do as a science teacher. As you write, focus on feelings, emotions, and beliefs. Each metaphor should be at least one page in length.

Teaching metaphors generally focus on a person’s feelings, emotions, and beliefs concerning their beliefs as an educator. Metaphors are one tool used by researchers to uncover and illumine deeply, and sometimes subconsciously, held personal beliefs concerning teaching, learning, and the role of the teacher in the process. The goal of such self examination is to help the educator better understand their beliefs for the purpose of reinforcing positive beliefs and recrafting negative belief patterns. I have several examples of metaphors written by preservice teachers for you to look at if you wish.
APPENDIX H

INSTRUCTIONS FOR COMPLETING LIFE LEARNING MAPS
Life Learning Map Instructions

A life learning map is similar to an autobiography; but, is in a graphic form similar to a concept map or web. The life learning map allows a teacher to reflect upon social and cultural experiences which have occurred during their life history. Many people have found it helpful to base their life learning map on a metaphor. The metaphor serves as a framework upon which to organize one’s life experiences into a coherent story.

To construct your life learning map:

1) Begin by selecting a meaningful metaphor of your life experiences as a learner.

2) Based on your metaphor, draw a map of your overall life learning experiences. Be creative!!

3) In your journal, write a short description of what you have draw and why.

4) Reflect upon your map. Can you identify people, experiences, places, or materials that have helped you or hindered you in your learning? Make a list of these in your journal.
5) On your map of general learning experiences, highlight or add, experiences related to science learning.

6) In your journal, write a short description of what additions or changes you have drawn and why.

7) Reflect upon your map. Can you identify people, experiences, places, or materials that have helped you or hindered you in your science learning? Make a list of these in your journal.
APPENDIX J

LIFE LEARNING MAPS OF THE PARTICIPANTS
Dave's life learning map

Birth: Cincinnati, OH
(12/17/55)

Roots of tree - close to nature
Trunk of tree:
Family
Dad an engineer
Married
Children
Teaching
Teaching at church

Branches:
Value of learning
Wanted to learn
Great books, East Coast
travels
A type of work
Forestry in industry
Teaching
Teaching

Grew up in Family
California, Washington, Pennsylvania
Wisconsin, Back to N.Y.

Always grew close to nature.

Cincinnati, OH

High School
Married
1959

Marriage
1961

Wife
1968

U.K., Kids 1971

Wife
Back to Bed

Industry: Most
Field work
Respect

1981 - Good of society, smart people

Pine tree
Tree growing upward toward sun
Sun = tomorrow

Celebration
Most enjoyable. Best thing experience of my life

1984
APPENDIX K

AN EXCERPT FROM DAVE'S PHOTOESSAY
The Greenhouse:

I thought this would be great. We could grow things and set up experiments. One thing I forgot was - I teach Chemistry and Physics as well.

I have no one to take care of the greenhouse. Anything that needs doing I must do with no outside help. This would be okay but ⅔ of the kids will pay attention or participate and the other ⅓ screw around, get in trouble or pay no attention at all.
Garden plots - another good thing gone bad. We have a garden plot available but the kids won’t work in it — even under threat. They might get dirt on their shoes or hands. This gets frustrating. So many chances to excel & I keep getting shot out of the saddle. But I continue to try with the hope that I’ll eventually get that class that clicks.
This is the edge of a small piece of woods, right next to our school.

It provides an excellent shade habitat for our classes during the spring semester.

We come here on insect and plant I.D. trips.

I'm returned to the forest.
These are just an example of what's really important in a school system. Acres of playing New track, new tennis courts, a baseball complex, several soccer fields, and several football fields.

But this is also my return to my days of running on our campus (mine as a student).