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Attitudes toward science and science teaching as reflected in the science autobiographies of preservice elementary teachers

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ATTITUDES TOWARD SCIENCE AND SCIENCE TEACHING AS REFLECTED IN THE SCIENCE AUTOBIOGRAPHIES OF PRESERVICE ELEMENTARY TEACHERS

by

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ABSTRACT

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Stacey A. Gauthier
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As part of a study of the preservice science education of elementary school teachers, data were collected from 80 prospective elementary teachers relative to their prior experiences with science both in and out of the formal setting of school. These data were obtained largely through the preservice teachers' science autobiographies as well as through informal interviews and correspondence secured throughout the course of the study.

The study explores the relationship between preservice elementary teachers' prior experiences with science and their expressed attitudes toward science and science teaching as they begin the formal study of elementary science pedagogy. The analysis represents an effort to identify the contextual variables within the science experiences that the preservice elementary teachers shared in their science autobiographies and to determine the influence these contextual variables have had on their expressed attitudes toward science, science teaching, and their sense of efficacy in teaching science to elementary school children.

Major results reveal that students perceive their science experiences in-school as different from and more influential to negative attitudes toward science than science experiences outside of school. Students reported two kinds of science; school science and 'real' science. Combinations of teacher and curriculum variables influencing positive attitudes had students interested in the subject, putting forth great effort, and being interested in further study. Combinations of teacher and curriculum variables influencing negative attitudes had students bored, disinterested, and avoiding future science courses. No pattern was shown that as students progress through school their attitudes become more negative toward science.

Science experiences outside-of-school started early and student curiosity was nurtured in a variety of contexts. The influence of significant other variables was important to attitude formation. While the nature of the outside of school experiences varied greatly, they overwhelmingly influenced attitudes toward science in positive ways.

Students identified that their future science teaching would be modeled after their best science teachers and hope to avoid the kinds of teaching behaviors and environments that influenced them in negative ways. Many variables they hope to include in their science teaching were variables present in their outside of school science experiences.

CHAPTER ONE

Introduction

The Purpose of the Study

"Science is a special kind of story-making with no right or wrong answers, just better and better stories. You live with the best story you have at the moment."

Mary Budd Rowe
Professor of Education
Stanford University

In this study I describe and interpret the science experiences that eighty preservice elementary teachers have shared with me through writing their science autobiographies. The following questions serve as guidelines for my study:

1. What are the science experiences that preservice elementary teachers have had in school and outside of school?
2. What are the contextual variables within the science experiences and do patterns exist within and across autobiographical texts?
3. How do the contextual variables within the science experiences influence their attitudes toward science, science teaching, and their perceived ability to teach science to elementary school children?

My study attempts to identify the contextual variables of their experiences with science and to examine how these variables may influence their efforts to understand the content of science and the processes of scientific inquiry, and their attitudes about science and the teaching of science in the context of elementary school classrooms. To accomplish the aims of this study, I focus on the science experiences both in the formal context of schooling (K-16) and in their lives beyond the walls of the school. Attention is directed to the students' interactions with science as both a body of knowledge and as a way of looking at the world; how these interactions may have been influenced by significant experiences, by teachers, peers, parents or significant others; and how these interactions might relate to the preservice elementary teachers' attitudes about science, science teaching, as well as their sense of efficacy in teaching science. The usefulness of the autobiography rests on the premise that current and future attitudes and behavior are rooted in prior experience.

My choice to focus on attitudes toward science and science teaching rests on the fact that a major goal of science teacher education is the development of positive attitudes toward science and science teaching among preservice elementary teachers (Caprie, 1973; Carin & Sund, 1989). The rationale for this emphasis is based on the assumption that teachers who possess positive attitudes about science and science teaching not only promote science in their classrooms but also cultivate similar positive attitudes in their students. Evidence is clear that elementary teachers continue to express negative attitudes toward science and the teaching of science, a condition that science educators consider to be a deterrent to the effective teaching of science (AAAS, 1987; Buzrow, 1973; Cox & Carpenter, 1989; Jenkins, 1971; Westerback, 1982).

One of the major educational curriculum reform efforts currently underway is attempting to address the questionable quality and limited quantity of science being taught in our nation's elementary schools. The American Association for the Advancement of Science (1987) identifies the teaching of science in the elementary schools to be of critical importance to the future scientific and technical literacy of this country.

The status of science education and the scientific illiteracy of U.S. citizens have been widely documented (Hornbeck, 1988; Penick & Yager, 1986; Recer, 1988). According to Edwords (1986), most people do not understand scientific methods or the way science works, and they rarely have even a conversational knowledge of some of the most significant scientific discoveries or major theories of the twentieth century. According to Miller (cited in Fleury & Bentley, 1991)), studying the knowledge of adults in the United States reveals that only five percent know enough to be considered scientifically literate.

Yager (1989) argues that teachers, among all of the elements involved in a school's science program, are the most crucial component for student success in learning science. Yet, as Fluery and Bentley (1991) note, many science teacher educators realize that in terms of scientific literacy, prospective teachers of elementary science are not much different from the general adult population. Few elementary teachers have strong academic backgrounds in science and, as a result, lack fundemental scientific knowledge related to the content of elementary school science curricula (Stake & Easley, 1978).

Research indicates that science experiences at the elementary level form lasting impressions on students (Vannen, 1971). Westerback (1982) further noted that the preservice elementary teachers he studied cited a former science teacher as the most important single influence on their attitudes toward science, and one-fourth (1/4) of those 'influential' teachers taught elementary grades.

The limited quantity of science teaching in the elementary classroom is not new. Based on results from a study of New York teachers conducted over two decades ago, Washton (1971) concluded that the 100 educators he studied felt that their own teachers dislike of science was contagious. As a result, they were afraid to teach science to their own students and avoided teaching science whenever possible.

It is this concern that science be taught in the elementary schools by teachers who possess positive attitudes toward science and science teaching that fostered many studies between 1966 and 1989 on how to effect a change in the attitudes toward science and science teaching of students in elementary teacher education programs. It appears that these studies assumed that achieving a positive attitude toward science was a logical first step toward ensuring that the students are open to acquiring a positive attitude toward teaching science.

The studies I have reviewed met with limited success in finding factors which effectively bring about positive attitudes for both preservice elementary teachers and experienced elementary teachers. A majority of these studies involved varying the approach by which elementary methods courses were taught. Many of the studies involved the administration of an attitude scale prior to and after taking a science methods course.

In search for factors influencing positive attitudes toward science teaching, investigators have examined many variables related to teacher preparation. Included within these are the contributions of early field experiences among student teachers (Weaver, Hounshell, & Coble, 1982), demonstrated science knowledge (Shrigley, 1974), and proficiency in what are now called the process skills of inquiry (Kennedy, 1973). Following a review of such studies, Morrisey (1981) suggested that insufficient attention has been given to dimensions of personality and teacher background variables that may influence expressed attitudes. Attitudes are surely influenced by a complex milieu of interests, beliefs, understandings, life experiences, and perceived abilities. Little has been done to investigate the direct or indirect effects on attitude toward science and science teaching that these variables have.

The influence of significant others on the formation of beliefs, attitudes, and subsequent behavior has been overlooked by most researchers involved in the study of attitudes toward science and science teaching. For the most part these researchers have focused on the attitude object (i.e., science) without regard for other influences known to mediate change. Several social psychologists have suggested that social arrangements, situations in which people subconsciously, intuitively, or deliberately perform for others, should be considered as determinants of attitude formation and change (Ajzen & Fishbein, 1980).

My research focuses on the relationships between life experiences with science and preservice elementary teachers' expressions of attitudes. While there has been considerable attitude research in science education, much of it has been criticized by science educators. Haladyna and Shaughnessy (1982), in an effort to quantitatively summarize the results of 49 studies, confirmed earlier reviews showing such research to be somewhat disorganized and chaotic (Peterson & Carlson, 1979), concluding that "research on attitudes is diffuse in focus as well as emphasis" (p. 557).

Two areas that have made attitude research in science education problematic go hand in hand. First, there are problems in defining "attitude toward science" which leads to a lack of conceptual clarity (Gardner, 1975; Germann, 1988; Munby, 1983; Schibeci, 1983) and second, there is concern over the psychometric quality of the instruments used (Gardner, 1975; Germann, 1988; Krynowski, 1988; Munby, 1983; Schibeci, 1983). Some researchers are studying scientific attitudes, whereas others are investigating attitudes toward science (Munby, 1983). According to the distinction made by Gardner (1975), "scientific attitudes" are predominently cognitive in origin, whereas "attitudes toward science" are predominently affective. Germann (1988) has stressed the need for making clear which of the two aspects of attitude is being studied, a distinction I will make clearer later. Munby (1983), in a review of attitude instruments found that not only were the reliability and validity of many instruments not verified, but on several instruments, scientific attitude items are mixed with attitude toward science items. This underscores the conceptual problems in the construction of attitude instruments.

Evolution of the Method

The choice to use the science autobiographies of preservice elementary teachers in order to investigate the contextual variables of their science experiences and their attitudes toward science and science teaching, is a deviation from traditional methodology in science education research. I have selected this approach for a number of reasons. As indicated earlier, the attitude assessment instruments typically used have had problems of validity and reliability, as well as mixing attitude toward science items with scientific attitude items. In addition, because experimental strategies have limited ability to detect variable interactions (Cronbach, 1975) some methodologists who originally used quantitative approaches to research problems have found a context-embedded qualitative inquiry more useful (Miles & Huberman, 1984; Yager; 1982). The rationale for efforts in such an approach was stated by Paul DeHart Hurd when he said (Yager, 1980):

> Researchers in science education need a more flexible, holistic methodology that allows them to describe the interaction of various configurations of goals, agents, resources, practices and events through which knowledge is acquired and utilized. The methodology should allow the researcher to perceive systematic relationships without forcing them in an overly simplistic fashion.

In selecting an appropriate method for this study, both the questionable quality of the instruments used in previous research to examine attitudes and the move within the science education research community toward recognizing the utility of qualitative methods were considerations. These came, however, only after deciding the research itself was worthwhile. As Hurd reminds us,

> Whatever the method utilized, it will be ineffective and meaningless without a normative rationale about science teaching to provide a basis on which to make inferences.... The justification of a research effort ought to rest as much on the worthiness of the problems as on the elegance of the technique.

The significance of the problem of the poor attitudes of many elementary teachers toward science and science teaching seems clear. But, where might these attitudes have originated? What happened in their past experiences with science that has a significant number of practicing and prospective elementary teachers saying things like, "I don't like science and I'm not going to teach it if I can avoid doing so. "? What happened that has very few of them expressing positive attitudes such as, "I love science and it will receive equal attention in my class."? Answering the question of what happened in their past experiences seems prerequisite to designing strategies to improve the negative attitudes expressed by too many prospective elementary teachers of science. This question seems best answered through the stories these future teachers themselves tell.

Norma's Story

My first experience with having preservice elementary teachers share their science histories with me through the use of autobiography came in the summer of 1991. I was teaching a section of the required science methods course for prospective elementary teachers and two classes had already been completed when Norma asked if she could enroll. I was a bit concerned that she had missed too much and besides, there were already 27 students in the class. I knew I wasn't going to be pursuaded easily.

I spent a few minutes outlining the strengths of waiting until the fall to take the course. Norma didn't buy into any of these. She said she really needed to take the course *now* and would do *anything* to get caught up. I remember thinking to myself, why does it have to be now and what would I have her do to make-up for the writing assignment the other students were to hand in for the next class. My answer to the second question came after I boldly asked her the first.

Norma responded, "Look, I've been dreading this science course and for some reason today is the day I have enough courage to try." I jokingly said, "So you've heard we dissect people in here," to both relieve the tension and to see if the course had a bad reputation. Grimmacing, she remarked, "I just don't feel good about science. I guess I shouldn't tell *you* that but, that's the way it is."

While signing her registration form I explained that the other students were writing a reflection paper on an activity we had completed in class that day. I asked her to consider writing a reflection paper on her experiences with science. I called it a science autobiography.

Norma discounted the possibility almost immediately. She did not perceive herself as possessing such a thing. "A science autobiography implies a tale to tell; a story to recount; a personal experience worth writing down." After thinking about the idea for what seemed like an eternity, she nodded, indicating that she could prepare the science autobiography and followed with

"Sure, afterall the absence of a story worth recounting is, in itself, a tale to be told."

That is not to say Norma could recall *no* memorable science experiences in school. She could. But as she put it, "no continuity of experience exists which links these classroom experiences together, like the beads in a necklace, to span the 12 years I spent in compulsory education." She asked for a few more days to rehearse her story before writing.

To prepare, she talked to several women her age about their recollections of science experiences in school. She realized her memory lapse was not unique. Norma's friends each had a few vivid recollections (good and bad) of teachers and science projects. Most of the adjectives used to describe the memories were "serious" "important" "separate" and "messy/mushy". Norma thought the woman who remembered science as being mushy was at an advantage. Her ability to describe science experiences in tactile terms meant that she had probably interacted with some materials along the way. From her description that it was messy, Norma inferred that the teacher may have allowed a certain degree of freedom for individual exploration. The terms "separate" and "serious" were by far the most common adjectives used within her group of interviews. Norma felt these were comfortable words for her story.

Norma began her science autobiography with a story of her seventh grade Introductory Physical Science (IPS) class, a junior high level course in which "science was a distinctly separate part of the curriculum." She recalls her initiation into science as having an air of solemnity, sensing the instructor's caution every step of the way to " ask good questions" so that the class would eventually obtain "good results".

Mr. Wilson, described as well-dressed and very business-like, seemed more interested in maintaining control than in stimulating interest. The class included a series of experiments and observations carefully prepared by him. Throughout the course of the work in the large, well-equipped lab, students were repeatedly told to keep the place in good condition, clean and orderly at all times. Of equal importance to the general labkeeping, close attention was given to the scientific method. "Follow it perfectly at all times", rings clearly in her mind's ear.

What excited Norma about the class initially was the opportunity to write in her lab journal; those card-board covered books filled with sheets of 1/4" graph paper inside, and black and white marbled covers outside. "I loved to write, I loved to observe what happened around me and record my own impressions. I was *thrilled* ." But this thrill was quickly squashed by what Norma called "a fear of stating a hypothesis" and Mr. Wilson's reaction to her journal. Her account of what these experiences meant to her follows:

When it came to the scientific method and asking a question that would lead to the development of a worthy hypothesis, Mr Wilson warned us again and again, "Think of a *serious* question. Make your hypothesis an important one. Once you've chosen it, stick with it. And whatever you do, *don't* change your mind in the middle of your experiment." And so, the "H" word came to be linked in my mind as an insurmountable obstacle. I could picture myself peering up at the incredibly high side of an enormous letter

"H". Could I come up with a serious enough question which would enable me to scale its height and reach the top? Probably not. I (and I suspect many of my friends) ended up (figuratively) dangling by one arm from the crossbar in the middle of the "H", my carefully worded question slowly slipping from my hands after Mr. Wilson had deemed it "too obvious" or "not worth investigating". (page 4)

Norma concluded that she and her classmates would then go on to simply accept Mr. Wilson's improved version of what the hypothesis could have (should have?) been. "We did not own our discoveries, we borrowed them. The discoveries, afterall, were based on *his* questions, *his* interests, not *our's*. While the experience (of this class) turned out to be challenging and interesting some of the time, it did not feel authentic to me." (page 4)

With regard to the lab journal, Norma included as much information in her lab book as possible. She recorded initial observations, drew diagrams of changes, reported final results, and stated conclusions. She taped samples of litmus papers from an experiment and drew tiny pictures to illustrate the way the experiment looked. "This was the part of the class I really enjoyed and I was convinced I would do well when Mr. Wilson collected them for grading. I remember the first time they came back in the room in one big stack and I could see mine on top. He got the class to quiet down, held my book up in the air, and said something about wanting to show us an example of superior work. My heart was pounding in my throat. I felt proud and affirmed for my efforts. He proceeded, "*This* one is easy to read. There are no spills on the pages. It even has some cute little pictures in it. But most importantly, its *neat.*"

That was it. Passed back like a trophy, but a trophy of what? No mention of the content of my work, my observations, the questions I asked, the answers I had found during the discovery process. How was I doing? With all the emphasis on *serious questions* and *good results*, I wanted to know if I was on the right track." While she recalls she got an A in that class, "for performance, like you give a secretary praise for typing a letter with standard margins and no white-out covering up the typos" she felt cheated. And it turned out, so did some of her friends. They had gotten similar responses. At least she wasn't alone, she said. " I guess at age 12 we didn't have the sense or the experience to ask Mr. Wilson to evaluate our work, not our 'neatness factor'!" (page 5)

Norma continued her story for another five pages, highlighting two high school courses, biology with Mr. Davis and anatomy and physiology with Mr. Crouch. "I loved these classes. These two teachers really valued student questions and observations. They challenged me to look beyond what I read and accepted in the textbook. I began to make connections between the academic study of science and the immediate experience in many areas of my own life." (page 7)

Norma described the teaching styles of these two teachers as "fairly traditional by today's standards. There were many worksheets and vocabulary lists. We examined models and visual aids but in a passive manner. We stayed at our desks as the teachers manipulated the models and described their various functions and their relationship to the material we were learning. I recall these experiences positively however, because these two science teachers got me to think about what I was learning *and* conveyed a real interest in listening to my ideas. Despite the influences of these two teachers, I still didn't feel I could actually ask a 'good question' or produce 'interesting results'. Mr. Wilson's words never left me." (page 8)

Norma shares much about these three experiences with science and the meaning she has made from them. She could not recall any science at all in her elementary years, although claims to remember vivid experiences in all other curriculum areas. Her introduction to science left, as she put it, a lasting impression on her. She finished her autobiography by stating how important the initial experiences with science are and the crucial role teachers play in those experiences. "As I look back, I think a 'good question' was one that was asked at the cognitive level of the teacher not the child. I believe less emphasis should be placed on coming up with the one 'right answer' and more on getting students to take a surprising or unexpected result and use it as the starting point for a new avenue of exploration." (page 10)

The aim of this study is to reveal what preservice elementary teachers, like Norma, have experienced in their past encounters with science and how these experiences might influence their attitudes toward science and science teaching. Norma's story does not present a complete record of all the science experiences she has had. I never asked her, as I did the other study participants, to consider her outside of school science experiences. Nor does Norma's story address many of the issues surrounding science, science learning, science teaching, and attitude formation and change. Her story, however, had me explore my own views on such issues.

Conceptual Framework

Every researcher brings preconceptions and interpretations to the problem being studied (Denzin, 1989) and it is recommended that the researcher makes clear to the reader what these preconceptions and prior interpretations of the phenomenon being investigated are. Unless they are clarified, their effects on subsequent interpretations remain clouded and often misunderstood.

My interpretations of the individuals' experiences with and attitudes toward science and science teaching, as reflected in their autobiographies, are interpretations that are inevitably framed by the ways I view the nature of science, science learning, science teaching, and my conception of attitude. While my conception of attitude (to be discussed in the next section) had a strong influence on what I selected as relevant data and how I interpreted the data, my own conception of science was not so obviously and indirectly influential in this study. Because I chose to accept the students' own sense of what counted as a science experience and their responses to what others presented to them as science, the influence of my conception of science was minimal. However, since what was presented to the students in this study as "science" and "science experiences" were undoubtedly influenced by alternative conceptions of science influencing science education in the last four decades, I offer a brief review of the debates concerning alternative conceptions of science at play in the culture during this time period.

The Nature of Science

A conception of the nature of science is seen as a foundational and important part of the knowledge base for teaching science (Fluery & Bentley, 1991). It deserves particular attention in science education as one's concept of the nature of science is a conception that frames one's scientific knowledge and influences how one teaches science. It is similar to what Bohm and Peat (1987) call the infrastructure of scientific knowledge - tacit beliefs and skills which allow one to understand and build scientific knowledge. If one's infrastructure contains misconceptions and contradictions, the subsequent knowledge and concepts built upon these faulty ideas will be fragmented and fallacious. Research has shown that many elementary teachers hold on to outdated and even erroneous conceptions of the nature of science which they communicate to their students (Zeitler, 1984). A concerted effort to better understand the nature of science and its relationship to the teaching of science is currently underway (AAAS, 1993) and is seen as urgent in light of the contemporary changes in our understanding of the cognitive and philosophical underpinnings of science.

In general, philosophers of science undertake to account for and explain the processes associated with scientific inquiry, which in turn, help shape and determine science as a form of knowledge. They focus on issues related to the meaning, justification and epistemological status of scientific claims. One important matter philosophy of science attends to is an analysis of the relationship between evidence and explanations. Another activity of philosophers of science is the investigation of the rationality and truth status of scientific claims.

It is beyond the scope of this paper to provide a complete history of the philosophy of science or even to review all of the developments in philosophy of science during the twentieth century. However, for the purposes of this research effort, it is, as I have mentioned, important to provide at least a sketch of the major developments of philosophy of science between 1950 and 1990 and their relevance to science education. One necessarily needs to begin by mentioning the beginnings of an extremely influential conception of science, logical positivism, which began at the start of the twentieth century.

Logical positivism is characterized by arguments for the objectivity of scientific observation and the truth of scientific knowledge and the basic assumption that natural laws can be inferred from experience. The central doctrine associated with logical positivism is what is called the verification theory of meaning, which states that a proposition is meaningful if and only if there is an empirical method for deciding its truth or falsity. Logical positivism has its roots in positivistic thinking - the philosophical position that scientific knowledge is objective, certain, and a mirror of reality. Positivism assumes that the knower and the known are clearly separated, an assumption reflected in the belief that theories are sharply distinct from facts and values. More importantly, positivism holds that subjectivity plays no role in the gathering of objective knowledge.

One important element in logical positivism then, is the separation of observations from theories with the appeal for a neutral observational language known as the observational-theoretical distinction. The influence of this view of the nature of science is seen in science programs that emphasize that students observe or "discover" science concepts without any consideration for or understanding of the background knowledge involved in, or even necessary for seeing or discovering. Another important element of logical positivism is the role of logic. Logical positivism holds that a strong theory is considered strong if and only if its theoretical statements can be logically justified by observational statements.

During the first half of the twentieth century, reconsideration of the role of observation and theory in science resulted in many brands of empiricist philosophy and in chronological order they were positivism, logical positivism, and hypothetico-deductivism (Losee, 1980). Hypothetico-deductivism is the method of justifying scientific knowledge claims that most science teachers would recognize as the standard scientific method. It is the method for testing hypotheses and holds that observations are considered to be independent of but confirming of theories. The hypothetico-deductivism approach also claims that although logic can be applied to *test* theories it can not be used to *discover* theories or other types of knowledge.

Logical positivism and the hypothetico-deductive method were met with resistance, some of which came from members of the scientific community who claimed that theoretical speculation was indeed dictating observation. Classic examples from various areas of science which were offered in support of this claim include Einstein's theory of relativity and the collective theories of quantum mechanics, Wegener's theory of continental drift, and the synthesis of Mendel's genetics with Darwin's natural selection theory. The relations between observation and theory and between the testing and discovery of scientific knowledge claims became two of the most important issues in philosophy of science in the 1960's. At the same time, the question of the rationality of science emerged as a serious issue with Kuhn's (1962) *The Structures of Scientific Revolutions.*

The positivistic assumptions about the nature of science have been challenged by what Abimbola (1983) called the "new" philosophy of science. This more contemporary "post-positivist" view questions the objectivity of observation. It also offers a means to address the tentativeness of the "truth" of scientific "knowledge" and the role of values in the production of scientific "knowledge". Two academic disciplines that emerged around the time of Kuhn's *Structures* that have had a significant impact on this new philosophy of science are the sociology of science and the history of science. Developments in cognitive science have also recently been influential in philosophy of science. The influences from history and sociology of science studies as well as from cognitive science have given rise to a number of different conceptions of science. Thus, the term "post-positivism" needs to be viewed as an umbrella term for a number of different conceptions of science.

George Sarton is given credit for establishing a style for doing history of science studies. The guidelines Sarton developed sought to characterize and understand the choices scientists make in the pursuit of explanations, and the conditions, socio-political or otherwise, under which the choices were made (Thackray, 1985). A close scrutiny of the history of science seems to indicate that science is better characterized as a discipline in which dynamic change and alteration is the rule and not the exception. Further, the view of science as an inductively logical process - a process moving from empirical fact to the development of scientific theory - has not been supported by studies in the history of science.

The new methods of writing history of science and the new findings in history of science studies reveal that the rigid form of science advocated by logical positivism did not match actual existing practices of science. Instead, for some, history of science reveals that all aspects of science (ie., standards, meanings of terms, application of methods, and theoretical forms) progress through stages of development (Thackray, 1984). Based on the new history and sociology studies, some philosophers of science claim to have discovered three things about the nature of science;

1. the standards used to assess the adequacy of scientific theories and explanations change from generation to generation;
2. the standard used to judge theories at one time are not necessarily better than the standard used at another time;

3. the standard used to assess scientific explanations are closely linked to the then-current beliefs of the scientific community.

(Duschl, 1994)

It became clear through some history of science studies that what was observed, measured, evaluated, or hypothesized in science was done with strong theoretical commitments. In other words, it was argued that a strong observational-theoretical distinction did not hold and that theory determines observation. Norwood Hanson (1958) puts it this way, "What we see is determined by what we know." This idea about the impact of prior knowledge on what is learned carries over to our contemporary view of how people learn science and partially explains the interest researchers have in studying student misconceptions in science.

The studies in history and sociology of science, it is claimed, also reveal that the hypothetico-deductive method is not an accurate picture of how scientists conduct their work, but is more often an artificial story of the personal history of scientific inquiry that has been constructed (Dorling, 1973; Nickles, 1987). In such a constructed story the individual scientist pieces together the line of argument after the conclusion is in sight. The emphasis on the actual practice of scientists and the quest to preserve and understand the rationality of science has led to the emergence of many alternative epistemologies.

While Thomas Kuhn's role is considered critical to the shift away from logical positivism, his voice has been but one among many that assert very different opinions concerning the growth of scientific knowledge. During the 1970's a number of efforts to articulate the dynamics of the growth of knowledge were put forth. Prominent among them are Lakatos' (1970) idea of the role of research programs and Laudan's (1977) research traditions and the role of rationality in science. Briefly stated, Laudan extended the work of Lakatos, who extended the ideas of Kuhn. Each tried to articulate in detail a context of discovery for scientific knowledge, with scientific knowledge identified primarily as theories and explanations. In Lakatos' theory, competition in science is between or among research programs and a revolution in science is merely a case of a better program superceding an older one. For Kuhn on the other hand, there is no independent question of whether the change constitutes progress. For Kuhn, there is nothing more to progress than gaining the allegience of the majority of scientists in the field. Lakatos called this "irrationalism." In contrast, he claims that his is a theory of "rational progress" (1970, page 93). Rational progress in science for Lakatos occurs only if the successful "research programme" is in fact more progressive than previous ones by the standards of his methodology. Lakatos' standards are viewed by some (Suppe, 1989) as targeting an important aspect of theoretical development and the roles of experimentation and testing therein. This important aspect is that when one is developing a theory, one uses experimentation not to refute or confirm a hypothesis, but rather as a crucial ingredient in further defining a crude approximation of what is believed to be a promising theory into what will be an ever-increasingly close approximation to an ultimately adequate theory.

Lakatos further seeks to make the distinction between the logic of science and the psychology or sociology of science. He makes the distinction coextensive with that between "interal" and "external" history. Like Lakatos, Laudan also in his theory of scientific rationality demarcates external from internal history. Basically they argue that inquiry into the social or psychological facts of an episode in the history of science is superfluous, only the internal history of the episode, told in the terms of the program in which it ocurred, is required. The terms of the program formed, for Lakatos and Laudan, a systematic rational method for human knowledge and inquiry.

Among those supporting a careful analysis of history of science is Paul Feyerabend (1978), but his views were quite different from those of Lakatos and Laudan. He rejects the notion of scientific progress altogether and insists that no fixed method or theory of rationality exists. His use of the history of science leads him to conclude that if there is a principle of rationality that can be defended under all circumstances and in all stages of development it would be the principle: *anything goes.* His views are characterized as an anarchistic attack against the views of Lakatos and Laudan; his stance is often referred to as a form of radical relativism.

The sociology of science got its greatest support at the University of Edinburgh in the late 1960's under the direction of David Edge, a scientist turned sociologist of science. An assembly of historians and sociologists including Barry Barnes, David Bloor, and Steven Shapin seek to relate strands from the general sociology of knowledge literature with that from philosophy, anthropology, and ethnomethodology. David Bloor (1976) calls these related strands "the strong programme for the sociology of scientific knowledge." Four tenets emerged and the major general features of the Edinburgh-school's theory of science follow:

First, it is not concerned merely with the content of science but with the social structure in which science operates or the conditions that foster or inhibit science, and with "the conditions which bring about beliefs or states of knowledge."

Second, it is naturalistic. "The sociologist," wrote Bloor (1976, page 4), "is concerned with knowledge, including scientific knowledge, purely as a natural phenomenon." The strong programme explicitly denies any fundemental distinction between "reasons" and "causes". It is never sufficient, according to the strong programme, to explain a scientific belief by saying that it is true, or that it follows logically from the evidence, or that it is rational. A sociological explanation of scientific belief can, in principle then, be as complete as any explanation in any other science.

Third, the naturalism of the strong programme extends to the sociology of science itself. The sociology of science is a science like any other and is thus part of its own subject matter. Merton long ago noted the relexivity of the sociology of science but the strong programme extended reflexivity to include the "beliefs" or theories of the sociology of science and not just its social structure. Thus, the Edinburgh-style cognitive sociology of science is in direct conflict with philosophical theories that seek to distinquish logic or rationality from psychology or sociology.

The influence of the sociology of science can be seen in current reform efforts in science education, one of which is the Science/Technology/Society project. Basic to STS efforts is the production of an informed citizenry capable of making crucial decisions about current societal problems and issues and taking personal action (Yager, 1991) and prepared to make informed choices in the societal and political arenas. In short, the STS program emphasizes responsible decision-making in the real world where science and technology are components. The kinds of questions proposed in the STS program include "How did this become a problem?" and "What are the potential individual and societal effects of applying various solutions"?

A wholly different debate in philosophy of science concerning the ontological nature of the "products" of science (theories, principles, laws, etc.) may have little consequence for science education. Some (Van Fraassen,

1980) argue that the products of science are merely the instruments or tools for producing accurate observational predictions (instrumentalist view), while others (Giere, 1988; Suppe, 1989) view them as being independent of our knowledge of them (realist view). Yet, others (Nagel, 1961) argue that the realist-instrumentalist distinction is basically a semantic one. What the realist-instrumentalist controversy concerns itself with is the nature of the truth of scientific knowledge claims. Are scientific theories approximations of what truly exists in the world? Are revisions of models, theories, and explanations progressive in the sense that they are better approximations of the actual structure of nature? Or are scientific theories instruments or inventions that are used by scientists and discarded when they no longer provide an adequate account of nature? Whatever view one takes, it is clear that the activity of science is best conceived as one in which replacement, substitution, and even outright abandonment of "knowledge" claims, in light of new evidence, is an accurate description of the growth of scientific knowledge (Duschl, 1994). It is difficult to see just how the resolution of this debate should significantly influence science education.

As stated earlier, some post-positive views of the nature of science have been influenced by cognitive science. Ronald Giere (1988), a leading proponent of the significance of cognitive science to philosophy of science debates, argues that history of science only provides us with descriptions of how science has been pursued. He asserts that from descriptions we can not derive substantive norms prescribing how science *should* be pursued. For him, "...history in this framework, can at best provide illustrations of science having been pursued as some proposed norms would prescribe." (page 18) He believes that one can only achieve rough generalizations regarding scientific practice or development because historians do not specify the sampling method by which the instances for detailed historical reconstruction are selected. Further, he questions whether the natural unit of study for the history of science ought to be the traditional "scientific biography".

Giere and others have argued that there is a structure that can be applied to scientific discovery (Giere, 1988; Thagard, 1988). They find it fruitful to join philosophical concepts addressing theory development with psychological concepts focusing on schema theory (Carey, 1985; Giere, 1992). It has been argued that the process of theory development by scientists can be usefully compared to the development and acquisition of an individuals' knowledge of the world (Kitchener, 1986, 1987, 1992; Piaget, 1967). Within science education this comparison of theory development with an individuals' growth of knowledge has led to increased attention paid to exactly how conceptual change occurs in students' thinking.

In science education, the interplay of cognitive science with philosophy of science has been interpreted in the following way. Knowledge is seen as a mental representation of the natural world. It is acknowledged that the mental representation constructed by an individual is influenced by prior experiences, understandings, language, and culture. From this perspective, a scientific theory is not "proved" true; rather, the fit between theory and the existing knowledge base, as well as the goals of the individual or of the intellectual or social community, are examined. What follows from this perspective is that theories and values can not be entirely separated from facts; an element of subjectivity remains in all objective statements. What one sees or experiences is couched in terms of previous observations and experiences. This view holds that all new observations and experiences are theory and value-laden. Our perceptions of experiences, our observations, are dependent on the structure of the theories that we hold. From here, we can say that one's perceptions become meaningful only through theory - the illusion of objective experiences and hard facts dissolves. In other words, theories have an interpretive and an explanatory role. Advocates of this position argue that scientific observations are not totally objective because the observations to be made, the topics to be investigated, and the hypotheses to be tested are affected by the values, experiences, language, and culture in which scientists operate (Fleury & Bentley, 1991). It is not wholly clear, however, that the strong distinction between descriptive and prescriptive views of science is maintained or acknowledged.

There are two other interesting developments that fall under the umbrella of post-positive views of science. One is feminist critiques of science and philosophy of science; the other is a "post-modernist" view that deconstructs the unity of science thesis.

Feminist critiques of science have developed over the last decade or more and focus on the ideologies, politics, epistemologies, and economics of science. Through the feminist critiques, new views about the politics and practice of science have been proposed. Basically, these critiques have uncovered the complex interconnection of sexist, racist, and classist biases grounding theories of human nature and the ways in which such biases permeate the entire structure of science.

Difficult questions have risen in response to the feminist critiques. "Is sexist science bad science?' "What kind(s) of science is (are) consistent with feminist critiques?" "Is there a feminist method?" "Do women do science differently from men?" There appear to be two classifications into which the feminist critiques of science can be organized: (1) critiques of the practice of science and (2) critiques of theories of science. Within these two classifications there are a variety of perspectives.

What is common among the feminist critiques, however, is that with a greater understanding of the depth of the impact of the gender system in science, has come the realization that surface inequities are often grounded by less visible gender biases in the methods and metaphysics of science. This has led to questioning the model of science in which science, done properly, is viewed as the epitome of objectivity. Feminists, in the company of other theorists, have rejected this image of science. Science is seen as a cultural institution and as such is structured by the political, social, and economic values of the culture within which it is practiced. Although feminists were not the first to reject the traditional image of science, feminists were the first to explore the myriad ways in which sexist biases affected the nature and practice of science.

Harding (1989), Keller (1989), and Longino (1989) all respond to the question, "Are we looking for a feminist science?" with a definite, "No!" Harding argues against the idea of a distinctive feminist method of research, noting that the important component of many feminist critiques is the rejection of the "methodolatry" of assuming that any method can encompass the varieites of possibile types of knowledge and experience. Harding offers not a quest for a feminist method but for an examination of the characteristics that account for the power of contemporary feminist research.

Keller (1989) and Longino (1989) emphasize the social construction of the category of "feminine" as well as that of "science". Keller notes the parallels between the relation of sex and gender, and the relation of nature and science. She employs this parallel to illustrate the political construction of our notions of difference, and calls for an alternative understanding that would make viable a notion of *difference* in science rather than a *different* science. Longino's work clearly articulates the feminist recognition of the ways in which values inform the theory and practice of science. But she cautions against uncritically embracing the notion of a science that values the feminine, reminding us of the multiplicity of women's experiences, as well as the social construction of our conception of the feminine. Longino suggests a shift from research programs that are an expression of woman's nature to programs that are consistent with the values and commitments expressed in feminists' lives. In other words, she recommends that we shift our attention from the task of constructing a feminist science to the process of doing science as a feminist (Tuana, 1989).

Hubbard's (1989) reflections upon the nature of science show a desire for a science in which people take responsibility for the facts that are generated. Hubbard considers a science *for* the people and a science *by* the people. To emphasize the need for such an alternative, she illustrates the variety of ways in which people get excluded from science. In the social structure of the laboratory, in the ideologies of woman's nature, and in the gender bias of the language of science, Hubbard points out the political content of contemporary science. Agreeing with Harding and Longino that politics is an inherent part of any science, Hubbard calls for a science to which more people have access and for a process of validation that is more open to public scrutiny. One major influence of the feminist critiques of science has been focusing the attention of research in science education on the causes of gender inequities in science through the examination of educational variables.

The other development in the philosophy of science I mentioned concerns different responses to the 'unity of science' question. The notion of a unity of science is considered by some (Oppenheim & Putnam, 1991) to involve three theses. These will be mentioned in order of increasing strength. The first is the "unity of language" thesis which usually (but need not) means a common reduction for the definitions of the terms used in all branches of science. Second, the stronger thesis of a unity of science claims a unity of laws and asserts that the laws of science can be reduced to the laws of some one discipline. Third, the strongest unity of science thesis is that the laws of science can not only be reduced to the laws of some one discipline, but also the laws of that discipline are in some sense unified or connected.

Oppenheim and Putnam (1991) use the phrase 'unity of science' in two ways, to refer to an ideal state of science and to a pervasive trend within science toward that ideal. In the first sense, 'unity of science' involves unity of language and unity of laws. That unity of science in this sense, can be realized, constitutes an overarching metascientific hypothesis which enables one to see a unity in scientific activities that might otherwise appear disconnected or unrelated, and which encourages the construction of a unified body of knowledge. In the second sense, unity of science exists as a trend within scientific inquiry, whether or not scientific unity is ever attained.

The expression 'unity of science' is employed in various other senses as well, two of which I will identify. First there is a unity of method in science which is represented by the thesis that all empirical sciences employ the same standards of explanation, of significance, of evidence, etc. The second is a radical reductionist thesis of a logical kind, not an empirical kind.

The unity of science thesis is considered to be positivistic in many regards and has been attacked by those who would advocate instead, a disunity of science (Kitcher, 1991). Sometimes called a post-modern conception of science, this approach takes as the unit of analysis the methodologies and practices found inside individual or 'local' subdisciplines, not the alleged unity of methodologies and practices across disciplines.

Instead of seeking 'global' or dependent language, laws and knowledge claims, the disunity of science approach advocates the independence of disciplines. The trend in science education today appears to support a unity of science approach and not a post-modern, disunity approach.

The debates that have been presented here have, to varying degrees, influenced the development of national standards for science education in grades K - 12 which are expected to be completed and published by the fall of 1994. As I understand them, these National Science Education Standards will be narrative descriptions of what all students should be able to do to engage and understand the natural world and will address science curriculum, teaching, and assessment issues. It is claimed (NSC, 1992) that these standards represent a consensus of teachers and other science educators, scientists, and the general public as to what constitutes science as a form of knowledge. That consensus has been reached, given the alternative conceptions of the nature of science debates that have been presented here, is hard to imagine. However, these debates in philosophy of science and their potential influence on science education, while important and interesting, are not the focus of study of this dissertation. The focus of the dissertation is on the attitudes of preservice elementary teachers toward science or more exactly, what has been presented to them as science.

Attitude

A clear definition of what is meant by an attitude as it relates to science and science teaching has been hard to find in the research literature. Without such clarity however, the task of assessing attitudes and the effects of any attitude change approach would be hard to document, much less explain. The definition or concept I will use is derived from research efforts to generate conceptually sound approaches to research design and attitude assessment in science education by Koballa and Crawley (1985), Koballa (1988), Shrigley (1983), and Shrigley, Koballa, and Simpson (1988).

The term 'attitude toward science' refers to a general and enduring positive or negative feeling about science (Koballa & Crawley, 1985). As stated earlier, it should not be confused with scientific attitudes (ie., suspended judgment , open-mindedness and critical thinking) which are meant to characterize the thinking processes of scientists. "I like science," "I hate science," and "Science is awful!" are considered to be expressions of attitudes toward science because they denote a general positive or negative feeling toward science. The favorable or unfavorable feelings a person has toward objects, persons, groups, or other identifiable aspects of our environment are considered the most important quality of the attitude concept (Koballa, 1988).

There are some experts in the field of attitude research who feel that other attributes of the attitude concept might be set aside, making the evaluative quality the only element of the definition (Fishbein & Ajzen, 1975; Mueller, 1986). While the evaluative quality is seen as central to the attitude concept, Koballa (1988) sought to make clear other components within the most agreed upon general definition of attitude to date, that of " *a learned predisposition to respond in a consistently* favorable or unfavorable *manner toward an attitude object"*.

Attitudes are learned. People are not born with attitudes toward pollution, seventh grade life science or nuclear weapons; these attitudes are learned from experience, either vicariously or directly. On this matter of nature versus nurture, Shrigley, Koballa and Simpson (1988) quote Byron et al. (1977, p. 105) who wrote persuasively on the role of learning in attitude:

> Heroes may be born, but bigots are clearly made. No one would seriously suggest...that children spring from the womb with all the complex attitudes they will later show as adults firmly in place. Rather, there is virtually universal agreement that they acquire these reactions in precisely the same manner that they acquire other forms of behavior - largely through a prolonged period of learning.

Attitudes are learned from experience and because they are learned, they are susceptible to change. According to Miller and Coleman (1981), attitudes have temporal stability; they are enduring enough to be stable yet transient enough to be changed. According to Wrightsman (1977), the transient nature of attitudes depends on their specificity. For example, a chemistry teacher's attitude toward science is relatively enduring, while her attitude toward microlabs, a new textbook, or cooperative learning are more specific, more transient, and more easily changed than the broader object.

Attitudes are learned in many ways and the social influence of others is integral to this process. Allport (1954, p. 5) has written that we " ...are influenced by the actual, imagined, or implied presence of other human beings." Social interactions are known to influence student attitudes (Zimbardo, Ebbesen, & Maslach, 1977).

Attitudes are viewed by many as predispositions; inside the mind and unobservable. Allport's (1968) initial characterization of an attitude as "a state of readiness for mental and physical activity" (p. 60) has been somewhat refined. Seen as a mental posture to respond to varied situations (Fishbein & Ajzen, 1975), attitudes accompany us as a readiness to interpret experience.

Consistency is seen as the key component of this posture (Koballa, 1988) enabling us to interpret experiences based on expectations and react to new and varied circumstances.

Consistency as related to the concept of attitude refers to the relationship between attitude and human behavior. Kiesler and his colleagues (1969) describe attitude-behavior consistency as "... the tendency of different individuals to behave differently in the same situation and the same individual to behave similarly in different situations" (p. 8). A contemporary example used by Koballa illustrates both sections of Kiesler's definition. To the first, pro-choice and pro-life marchers will carry different placards at the same public rally, with little intermingling between the two groups. The groups behave consistently to the same situation - a rally where abortion is the common focus. To the second, a pro-lifer may not only march, but she may write pro-life letters to newspaper editors. Or the same person may contribute money toward the upkeep of an adoption agency that offers alternatives to abortion. This individual responds consistently to different situations related to the attitude object.

The consistency between attitude and subsequent behavior has proven to be somewhat troublesome. In 1969, Wicker found low levels of correlation between attitude (attitude scores) and related behavior after reviewing 32 studies. A review by Schuman and Johnson (1976) however, suggested that the correlational consistency between attitude and behavior is high enough to indicate that causal forces exist between attitude and behavior. Through advancements in attitude assessment and attention to the situations in which behavior is observed, views of attitude-behavior consistency are at a point where most experts agree that attitude and behavior are related in a probabalistic, not deterministic, manner (Ajzen & Fishbein, 1980). But, we should also note that when attitudes are defined as a learned predisposition to respond and are then operationalized in terms of behavior, we can also say it is a conceptual link that exists between attitude and behavior.

Turning to the last component of the definition, "... *toward an attitude object*," attitudes always have a referent. We can say that some referents generate more emotional intensity than others. For example, abortion and evolution would most likely generate more emotion than chain letters and trash recycling. Further, the attitude object can be something as general as a person, group, policy, issue, or abstract idea or can be more specific, such as a person's eating habits, the radical members of a conservative group, smoking areas in family-style restaurants, discrimination in medical care for AIDS patients, or truth in the advertising of a particular diet product. The fact that the attitude object can be quite specific makes the attitude concept of interest and importance to science educators. For example, a negative attitude toward science, which is quite general, could in fact be a negative attitude toward a certain area of science, such as Biology, or a certain topic within the area of specialty, such as, experimental research with animals, or even a particular instructional method employed by the teacher, such as, dissecting fetal pigs.

In summary, attitudes have an evaluative quality. This evaluative quality is agreed by most to be the heartbeat of attitude. Second, attitudes are learned, not inherited. We are not born liking or disliking science, we learn to like it or dislike it. The influence of others is integral to this process. Third, attitudes are a predisposition to respond. Fourth, the relationship between attitude and behavior is both conceptual and probabalistic rather than deterministic. Lastly, attitudes have a referent and some referents generate more emotion than others.

Earlier in this discussion, the distinction was made between attitudes toward science and scientific attitudes. Unfortunately, the distinction among attitudes, beliefs, and behaviors has been unclear in some of the research literature related to attitudes toward science, thus engendering some additional confusion. An attempt will be made to lessen this confusion.

Attitudes and Beliefs

The distinction between attitude and belief is made by Fishbein and Ajzen (1975) in the following way: "Whereas attitude refers to a person's favorable or unfavorable evaluation of the object, beliefs represent the information a person has about the object. Specifically, a belief links an object to some attribute" (p. 12). "Science is too mathematical," and "Science is messy," are examples of beliefs a person might have about science as the object with the attributes being "mathematical" and "messy" in these examples.

Like attitudes, a person can have beliefs about most anything (i.e., people, groups, policies, issues) and the attributes associated with the object are limitless (i.e., traits, qualities, other objects). However, unlike attitudes, beliefs need not have an evaluative component and can range from descriptive to evaluative (Oskamp, 1977). Attitudes, on the other hand, have evaluation as the central component. The belief that "Iron is hard" might be considered factual. In comparison, the belief " the discovery of gravity is the most important scientific breakthrough of all time" is highly evaluative.

Beliefs can be held by people at varying degrees of strength (Koballa, 1988). I may believe that the depletion of the ozone layer is a possible environmental problem, whereas you may be absolutely certain that ozone layer depletion is an environmental problem. This point reveals another aspect of beliefs; beliefs often link objects with attributes at some level of probability between 0 and 100 percent (Shrigley, Koballa, & Simpson, 1988). An elementary teacher, for example might believe science is messy and attribute "messy" to the object "science", but recognize that science need not be messy. This teacher may, as a result, have the belief that "science is messy 80 percent of the time."

Fishbein and Ajzen (1975) claim that a set of beliefs forms the basis of one's attitudes. Whether a person has a positive or negative attitude toward something depends on whether the object about which one has relevant beliefs is evaluated positively or negatively and the strength with which the beliefs are held. It seems to make sense to propose that our attitudes are dependent upon our beliefs. Koballa (1988) gives an effective example of how this dependency operates:

> Suppose that you have a relatively large number of related beliefs about acid rain, three of which are that acid rain disrupts the life cycles of plants and animals, effects humans indirectly by contaminating the food we eat and water we drink, and has strained political relations between the United States and Canada. Suppose further, that you are confident that acid rain disrupts the life cycles of plants and animals (belief strength =

> 90%), quite sure that acid rain contaminates human food and water (belief strength = 70%), and confident that acid rain has strained relations between the United States and Canada (belief strength = 90%). Finally, imagine that you value environmental quality and good health, and are sensitive to the welfare of our northern neighbors. In this instance, your attitude toward acid rain is going to be strong and very negative.

This example illustrates that attitudes are organized around beliefs; beliefs are their cognitive backdrop.

Attitude has been characterized as a learned predisposition to respond in a consistently favorable or unfavorable manner towards an attitude object. This predisposition to respond is claimed to be actualized in behavioral terms either through behavioral intentions or actual behaviors. Because I regard the behavioral response aspect of attitude as critical to the current study, a further distinction needs to be drawn between behavioral intentions and behavior.

Behavioral Intention

Some researchers have defined behavioral intentions as people's personal estimate of how likely it is that they will perform certain actions (Fishbein & Ajzen, 1975). This assumes that when we intend to behave in a certain way we are likely to do so and we probably could give an estimate of how likely it is that we will carry out our intentions. This may be an unduly narrow view of behavioral intentions as I understand them.

What I have in mind when I speak of behavioral intentions is more akin to someone expressing a desire or wish to behave in a certain way. This does not necessarily entail that an individual estimate how likely it is that he or she will behave that way. For example, if we ascribe to someone the attitude of curiosity it is understood to mean that the person will be predisposed to want to investigate the particular object of his or her interest. To my mind, it does not mean that the person is likely to estimate that she will investigate her object of interest 50% or even 75% of the time. While the person may want to investigate (ie., has the behavioral intention to do so) and might publicly express her desire to investigate (ie., state the behavioral intention), it seems odd to expect, at the same time, that she will be estimating the probability that she will investigate her object of interest.

Behavior

Whereas attitudes, beliefs, and behavioral intentions are internal, not observable, and most are inferred from verbal or written statements, behavior can be observed directly. The relationship between attitude and behavior has been described earlier as being probabalistic rather than deterministic, resulting from interactions of situational variables and the influence of others. This context dependent aspect of the attitude-behavior link means it may be easier for students holding a positive attitude toward science to behave accordingly in one classroom, but not in another. Teachers, facilities, and peers determine the context and therefore the consistency between attitude and behavior. The science-related behaviors of students and teachers have been the ultimate interest and concern of science educators/researchers. Because of the interrelationship between attitude and behavior, any discussion about improving science teaching (quality of behavior) and increasing the amount of science taught (quantity of behavior) must deal with attitude and context (Shrigley, Koballa, & Simpson, 1988) .

CHAPTER TWO

Review of Previous Research

Teacher education programs have been portrayed negatively in recent educational reform reports and have been especially criticized about the manner in which elementary teachers are prepared to teach science. Often cited are a general lack of content training and failure to develop an effective repertoire of teaching skills (Carnegie Task Force, 1986; Holmes Group, 1986; National Science Board Commission, 1983; Weiss, 1978, 1987). Frequently reported is elementary teachers' avoidance of teaching science; for example, time for school science is among the least allocated in the elementary school curriculum (Cawelti & Adkisson, 1985; Goodlad, 1984; Harms & Yager, 1981; Mechling & Oliver, 1983). Furthermore, self-reports by elementary teachers indicate they prefer to teach other subjects over science (Czerniak & Chiarelott, 1985). In addition to the poor preparation of elementary teachers to teach science, other reasons given for problems in elementary science education include teachers' lack of content knowledge, high levels of anxiety about teaching science, and negative attitudes toward science (Harms & Yager, 1981; Mechling, 1984; Weiss, 1978, 1987).

Current demands in the fields of science and technology are such that science teaching should stimulate and sustain student interests from the time children begin schooling. Many studies show that young primary students are interested in and enjoy their science lessons, but science interest fades during the primary and secondary years (Walberg & Ahlgren, 1973; Shymansky & Kyle, 1988). Negative attitudes of students toward science have also been shown to increase by grade level (Yager & Yager, 1985). Lack of interest in teaching science and negative attitudes toward science by teachers can not stimulate interest to learn or positive attitudes toward science for students.

Research has shown that positive attitudes by elementary school teachers toward science and science teaching increases their commitment to and intensity of science teaching. The research by Earl and Winkeljohn (1977) and Shrigley (1974) indicates a greater intensity of science teaching in classrooms where teachers have a positive attitude toward science teaching. This intensity is reflected in more time spent teaching science, greater teacher concern toward including science as an essential basic subject in the elementary curriculum and greater utilization of hands-on materials. It seems logical to assume that poor attitudes on the part of teachers does not produce these desirable outcomes.

The lack of familiarity with science as process and inquiry, and the lack of familiarity of appropriate science teaching strategies manifests itself not only in the quantity of science instruction, but also in how teachers approach teaching science, i.e., the quality of instruction. In the mid-1970's, approximately 30% to 40% of elementary teachers taught science largely as a reading/lecture course (Helgeson, Blosser, & Howe, 1977); this in spite of the fact that excellent, "hands-on" investigative materials had been developed through a large number of federally funded elementary school curricula projects (e.g., ESS, SAPA, and SCIS). In 1976-1977 fewer than 35% of the U.S. school districts used the federally funded science curricula programs and fewer than 30% used them prior to 1976-1977 (Weiss, 1978). In 1977, 65% of K-3 classes and 54% of 4-6 classes used a hands-on activity of some type in their most recent lesson, but by 1985-1986 these percentages had dropped to 57% for K-3 classes and 45% for 4-6 classes (Weiss, 1987).

Currently, 38% of elementary science classes are taught in rooms with no science facilities or materials (Weiss, 1987) even though research has shown that investigative, inquiry-oriented, and/or process approach science activities can actually help improve children's performance in and attitudes toward science (Shymansky, Kyle, & Alport, 1982, Bredderman, 1983) and elementary teachers' attitudes toward science and science teaching (Kyle, Bonstetter, & Gadsden, 1986). Other researchers concur that most elementary teachers are not using a laboratory-oriented approach to science education. In fact, lecturing dominates elementary science teaching (Goodlad, 1984; Mullis & Jenkins, 1988). Reasons suggested for the lack of teachers using the federally funded programs and/or other inquiry-oriented science activities in elementary science classrooms include lack of assistance and training in how to use them effectively, how to integrate them into new curricula formats, and how to develop their own activities that provide an inquiry approach (Bredderman, 1983).

Textbooks, by far, still constitute the chief source of the curriculum in most schools (Weiss, 1987). Within the first chapter or two, which describes the nature of science, a positivistic nature of science is presented. Textbook authors often present the scientific method as a series of logical steps, beginning with observations or questions, proceeding to the formation of hypotheses and tests, and ending with conclusions (Moyer & Bishop, 1986). The research of scientists is also presented in this logical form even though the work itself probably proceeded along innumerable paths. Pointing out the confusion between the logic of doing science with the logic of reporting science, Abraham Kaplan (1964) in The Conduct of Inquiry labels the former as "logic-in-use" and the latter as "reconstituted logic" (p. 3). This view of science as reconstituted logic denies the tentative nature of scientific work and portrays science as a technical, mechanical process to both students and teachers and contributes to their growing alienation from it. Even teachers who possess positive attitudes toward science and science teaching may be misrepresenting the nature of science and scientific inquiry and thus, not provide the environment conducive to appropriate science learning.

Morrisey (1981) recommended that more attention needs to be given to dimensions of personality and teacher-background variables that may influence expressed attitudes in the related science education research. Reviews of studies focusing on personality and teaching (Balzer, Evans, & Blosser, 1973; Brophy & Good, 1986; Simpson, 1978) reveal the dominant theme of such research to be the effects of student and teacher characteristics on student performance and achievement. Seldom considered are the intervening relationships, particularly between life experiences and teacher behaviors or expressions of attitudes.

The remainder of the review of literature relevant to the present study will be divided into two parts; that of research efforts to identify the influence of specific variables on changing the attitudes toward science and science teaching of preservice and experienced elementary teachers and that of investigations into students' perceptions of their experiences with science and science teaching throughout their schooling. For the purposes of this dissertation, the importance of the first body of research is to reinforce the fact that preservice and experienced elementary teachers have negative attitudes toward science that need to be improved and to reveal that science teacher educators/researchers have taken seriously their efforts to improve these negative attitudes. The second body of research is provided to shed some light on the development of attitudes toward science during certain points and within certain contexts of a student's schooling. As will be seen, neither body of research is sufficiently informative with respect to the identification of and possible interrelationships of specific contextual variables within life-long experiences with science that influence the attitudes and behavioral intentions of prospective elementary science teachers. I begin with studies that highlight current teaching practices at the elementary level and propose reasons for the abundance of negative attitudes toward science of elementary teachers.

Teachers' Attitudes Reflected in Their Teaching

A teacher's attitude toward science is reflected both in the manner in which it is taught and in the amount of time the teacher spends teaching science. Given the immediate concern that educators have regarding the lack of science taught in our nation's schools, it is striking to note how little time elementary teachers in self-contained classes reported devoting to science compared to the amount of time spent teaching other subjects (National Center for Education Statistics, 1993).

Amount of time devoted to teaching science. Results show that teachers who teach at the kindergarten through fourth grade levels report spending about 30 minutes per day teaching science and about the same time teaching social studies (33 minutes). In contrast, about 5 times as much time was spent teaching language arts (128 minutes) and 58 minutes a day spent teaching mathematics (NCES, 1993). At the fifth and sixth grade levels, the amount of time spent on science increases by about 10 minutes per day, increases for social studies by 15 minutes, stays relatively the same for mathematics and drops about 25 minutes for language arts teaching time (NCES, 1993).

These recent results reveal a modest increase in amount of time afforded science in the last decade. Rowe (1980) found in grades K-3, an average of only 17 minutes per day is spent on science instruction and in grades 4-6, the time has increased to only 28 minutes per day. Results from a study of New Hampshire elementary schools by Andrew (1980) reported a similar range as did results of a study of the Little Rock schools by Glasgow (1983). This latter study indicated as little as 0-6 minutes of physical science instruction per day is provided in grades K-6. Additional data at the elementary level indicate that the amount of time teachers spend teaching science varies considerably (Purkey & Smith, 1983). Student assignments become critical, especially when one teacher may spend twice as much time teaching science as another teacher in the same school at the same grade level.

Time spent teaching science may be related to confidence. The relatively small amount of time teachers reported spending on science may reflect elementary school teacher's lack of confidence in their ability to teach science. Elementary school teachers surveyed in the 1985-86 National Survey of Science and Mathematics Education (Weiss, 1987) indicated that they were much more confident in their ability to teach reading than in their ability to teach science. The overwhelming majority (86%) of elementary teachers in this survey indicated they felt very well qualified to teach reading.

By way of comparison, only 27% of elementary teachers felt "very well qualified" to teach life science, 15% felt "very well qualified" to teach physical science, and 15% felt "very well qualified" to teach the earth/space sciences (Weiss, 1987). In contrast, 11% felt "not well qualified" to teach life science, 23% felt "not well qualified" to teach physical science, and 22% felt "not well qualified" to teach the earth/space sciences (Weiss, 1987). A negative self-perception of a teacher's own ability to teach science is believed to be a component of negative attitudes held towards teaching science among elementary school teachers and leads to a high degree of science anxiety, described as apprehension, concern, or uneasiness (Cox & Carpenter, 1989). Additionally, it is believed that some individuals may be deficient in their preparedness to teach science because of their developed anxiety/attitude which may interfere with their current ability to learn science (Greenburg & Mallow, 1982).

Preparation in science content. It is the case that most elementary school teachers are female (Weiss, 1978, 1987), and females traditionally enroll in more life science courses than earth or physical science courses (Jones & Wheatley, 1988). Specifically, 85% of elementary school science teachers have had one college biology course, only one in three have had a college chemistry course, and one in five a college physics course (Weiss, 1987). This situation could reflect why teachers responding to a Personal Abilities in Science Teaching instrument (Cox & Carpenter, 1989) indicated that they not only felt their preparation to teach anything but life science was poor, they had a negative attitude toward teaching science in general, did not enjoy teaching it, and provided few science experiences for their students.

Several research reports support the view that teachers with a stronger science content background tend to exhibit the attitudes and behaviors associated with effective science teaching. For example, a National Science Foundation report (Bonnstetter, Penick, & Yager, 1983) found that exemplary science teachers in the Search for Excellence in Science Education (SESE) study were older, more experienced, and had better subject-matter knowledge than a national sample of teachers. Exemplary teachers were also more professionally involved, had taken more coursework recently, and were involved in inservice programs regularly. Amount of training in science has also been found to be associated with science anxiety. Westerback and Primavera (1987) concluded that teachers' lack of content knowledge and experience with science teaching strategies increases their science teaching anxiety.

An earlier study by Shrigley (1974) was designed to explore the variables in the preparation of elementary teachers that might have some bearing on their attitude toward science. The major purpose of this study was to assess the correlation of two variables, science attitude and science knowledge of third year preservice elementary teachers. Attitude was defined as the feelings of preservice teachers toward science and the teaching of science. Science knowledge was defined as the understanding preservice teachers had of science concepts taught in the elementary school, inclusive of comprehension and application of science concepts. Results showed that there was no correlation between these variables for the 92 participants each of whom had previously completed four content science courses. The study implies that enrolling preservice elementary teachers in more college science courses will not necessarily result in positive attitudes toward science. However, this may say more about the specific nature of college content science courses than the authors had considered.

University science courses organize their discipline around a set of facts and principles. They do not address the kinds of questions that Anderson and Smith (1987) note teachers need to have answered: What is special about scientific knowledge? What aspects of scientific thinking is like common sense thinking? What are different? What are the basic conceptualizations upon which knowledge in a scientific discipline are built? As Arons (1983) points out:

> To develop a genuine understanding of concepts and theories, the college student, no less than the elementary school child, must engage in intense deductive and inductive mental activity coupled with

> interpretation of personal observation and experiences. Unfortunately, such activity takes place in only a handful of passive listeners, but it can be enhanced, nurtured, and developed in the majority, provided it is experientially rooted and not too fast paced (p. 94).

Relative to the lack of correlation between science attitude and science knowledge, ethnographic research methodologies have been employed in examining the training of elementary education majors in science in an attempt to gain insight into whether or not their training in science contributes to the apprehension elementary teachers have toward science (Duschl, 1983). This 14 week field study included weekly observations in the elementary education majors' science methods class and science content class, interviews with students and instructors, and survey instruments to assess the students' preparation in science. Two different approaches to the study of science were documented, one content and one process. It was suggested that the difference in the two approaches may contribute to the students' confusion, insecurity, and avoidance of science. The students' perception that science is learning content (facts), an objective of introductory level science courses, and the science methods class's objectives of teaching science as a process, sets up an "antagonistic dilemma" between the two. Due to this antagonistic dilemma or contradiction, students become confused about what is necessary to teach and/or learn science. This confusion could be revealed later in the lack of instructional time accorded to science by these future elementary educators and help explain some current conditions.

The science experiences individuals encounter influence their perceptions. To offset student perceptions developed in science courses that stress principally content, the students need science experiences that truly represent science as inquiry as was the suggestion of the above cited study's researcher. Lucas and Dooley (1982) also investigated science content and science methods courses. They found that only the methods course affected the student teachers' attitudes toward science teaching but that neither content nor methods courses significantly changed attitudes toward science. Specific activities and individual variables within the activities that may have influenced or caused a change in attitude were not studied.

Preparation in science pedagogy. The evidence that teaching effectiveness is enhanced, science teaching anxiety reduced, and attitude toward science improved with an increase in teacher preparation in science content is inconclusive. However, some research results indicate that a teacher's development in the process skills involved in scientific inquiry may be more important to attitude changes and instructional improvement than the amount of content training. For example, Goldsmith (1986) found that preservice teachers' levels of anxiety about teaching science could be significantly reduced with a process-skill orientation in science methods classes. Consequently, process skill training may be important for lowering anxiety toward science teaching, improving attitudes toward science, and influencing the effectiveness of science instruction.

Yager, Hidayat, and Penick (1988) concluded that although a strong science content background was necessary, it alone was insufficient for effective science teaching. A summary of National Science Foundation (NSF) literature reviews in science education published by ERIC (Blosser, 1979) and a meta-analysis by Sweitzer and Anderson (1983) indicate that inquiry-oriented in-service training such as those provided by NSF institutes have lasting effects on teachers' attitudes toward teaching science and teachers' utilization of teaching skills and strategies. The NSF review also indicated that knowledge of science content was unrelated to the development of process skills.

Both science content preparation and methodological preparation were found to be necessary to reduce science teaching anxiety and increase science teaching efficacy (perceived ability to teach science) by Czerniak (1989). Teachers who had taken more science content courses in college and who had experienced success with science content courses had lower levels of anxiety and greater science teaching efficacy. These teachers were also more likely to use innovative, inquiry-based science instructional methods in their science classes. Stefanich and Kelsey (1989) found that coursework in science which is specifically designed to give preservice elementary teachers background in science content through small classes with frequent utilization of hands-on investigation has a significant effect on attitudes toward science and science teaching. The results of the study appear to indicate that the influence on attitudes of prospective elementary school teachers of 'pragmatic success-oriented' courses in science as prerequisites for entry into science methods courses generates an improved attitude toward science content, and science teaching.

The suggestion that science needs to be presented as inquiry is the recommendation of researchers Kyle, Bonnstetter and Gadsden (1986). From results indicating slight increase in the science attitude for teachers and a significant increase in the attitude for students using an inquiry approach, the suggestions made by these researchers included the need for prospective teachers to experience more science as inquiry in their preparation and less didactic, passive lectures followed by confirmatory labs. Teachers need to experience science themselves and see it in action and instructors in preservice science teacher preparation programs need to model the same behaviors they expect their students to demonstrate in the classroom so that they are familiar with them in theory and practice.

One study which provides insight into a model for changing science attitudes of preservice elementary science teachers uses the credibility principle (Martin, 1985). Supportive of earlier results (Shrigley, 1976), the credible instructor of an elementary science methods course refers to someone who uses practical teaching activities in class, has taught science to children, assumes responsibility for teaching content, models teaching modes similar to those proposed for children, and counsels student teachers. Both studies provided support in general that the credibility principle is indeed important to attitude change. However, no causal link could be determined. The influence of other variables within the methods course (ie., the field-based activity of teaching a science lesson to a group of elementary students and its success or failure) were not identified or controlled. Both studies did suggest that for attitude changes to persist over time, specific training in pedagogical skills must be provided and reinforced on a consistent basis.

Investigators have examined many variables related to teacher preparation in the search for factors influencing attitudes toward science teaching. Included in this body of research are the contributions of early field experiences among student teachers in studies conducted by DeBruin (1977), Piper and Moore (1977), Piper (1977), and Weaver, Hounshell, and Coble (1979). All of these studies dealt with studying the effect of field-based experiences in science methods courses on the attitudes toward science of pre-service elementary teachers and involved the student teachers in actual situations that require them to teach science. Results of these investigations proved conflicting.

The study by DeBruin (1977) was concerned with providing early field-based experiences and studying their effect on elementary student teachers' attitudes toward science and science teaching. The results of this year-long study indicated a slight (not significant) positive increase in student attitude toward science and science teaching. This study made an attempt to identify the field-based factors and isolate them from factors pertaining to campus experience.

Piper and Moore (1977) investigated the attitudes toward science of student teachers who had taken a competency-based, field-oriented methods course. Also, attitudes of student teachers who had taken Physics for the Elementary Teacher were compared with those who had not taken this course. The results seem to support the conclusion that a competency-based, field-oriented science methods course will result in a favorable attitude of student teachers toward activity-based, hands-on science teaching. A major implication of this study is that science methods courses should include the use of hands-on science materials in field experiences. The physics group had the more favorable attitude (not a significant difference) toward the activity-based, hands-on science teaching. This finding implies that pre-service elementary teachers' attitudes toward science can be improved by taking science courses specifically designed for them.

Piper (1977) conducted a follow-up study to determine attitude changes of elementary pre-service teachers about science teaching as they progressed through a competency-based, field-oriented science methods course, and to determine attitude changes toward teaching science of these students as classroom teachers one year later. The author concluded that participation in the specially designed course changed pre-service elementary teachers' attitudes toward teaching science. It was also found that this change in attitudes remained constant over a year's time. The author recommended research be conducted to determine more characteristics and combinations of characteristics that help change attitudes toward teaching science.

The Weaver, Hounshell, and Coble study (1979) involved 80 East Carolina University students enrolled in "Teaching Science in the Elementary School" for the winter quarter 1976-77. Forty elementary education majors enrolled in student teaching during the same quarter were used as a comparison group, the purpose of which was to compare the attitudes of methods students engaging in early field experiences with the attitudes of student teachers not having participated in early field experiences. The conclusions of this study indicate that students enrolled in a science methods course with or without early field experience will exhibit similar attitudes toward science and science teaching. Field experiences did not enhance the students' attitudes toward science nor did it appear to be detrimental to their attitude toward science and science teaching. Of importance, however, was the expressed attitudes of confidence about potential performance in student teaching practice in the area of science by those students participating in the field experience. No follow up data were obtained.

A more recent study investigating attitude change of preservice teachers participating in methods course activities involving some field experience was conducted by Pedersen and McCurdy (1992). The semester-long integrated science-math methods course met 3 hours a day 3 times a week and included student participation in a number of actual science teaching activities (ie. , in-class individual and team teaching experiences; a 3-week practicum in a local elementary school). The questions investigated in this study were: (1) Were the attitudes toward teaching science changed in a positive direction, and (2) Was the change in attitude consistent for high achievers and low achievers?

One unique feature of this study was its use of a revised version of the Science Attitude Scale (1974), a revision provided by Thompson and Shrigley (1986) that attends to the major criticisms of attitude surveys in general. According to Thompson and Shrigley (1986), "The Revised Science Attitude Scale is a reasonably valid and reliable scale ready for use in comparing treatment effects of groups of preservice teachers toward the attitude object of teaching science" (p. 342). The instrument was administered to a total of 145 preservice elementary teachers participating over a four semester time frame.

The results for the first question under investigation indicate that "the experiences that the preservice elementary teachers had in the methods course affected the attitudes in a positive manner" (p. 145). The pretest/posttest difference was significant. No causation can be stated however, due to the number of variables involved and the neglect to examine any one variable. It may, in part, support previous research that indicates that teachers' attitudes can be improved by taking courses that specifically include hands-on inquiry oriented and field-based activities.

The results for the second question showed low and high achievers (based on final grade) both benefited from participation in the methods class. Both pretest and posttest results showed no significant difference between the attitudes of the low and high achievers. Due to unclear criteria regarding the final grade, the authors' suggestion that this result supports the contention that science knowledge and attitudes toward teaching science are not necessarily related must be questioned.

In summary, research has consistently found elementary teachers and preservice elementary teachers to have negative attitudes toward science. These veteran and prospective elementary teachers continue to exhibit what can be termed "science phobia". Negative attitudes toward science and science teaching are reflected in the amount of classroom time devoted to science and the quality of the instruction. Claims of insufficient content knowledge and inexperience with inquiry or process approaches to teaching science have been documented as reasons these teachers give for their apprehension to teach science or to teach science in ways that are considered meaningful by science educators. Differences between science content courses and science pedagogy courses have been suggested as possible reasons for their attitudes. Studies conducted to address these varied concerns have had varying success rates on improving the attitudes of these teachers. In some cases, results seem conflicting at best. Much of the research involved using questionable attitude scales and survey instruments to test various approaches to presenting science content and pedagogy at the preservice teaching level. None of the studies investigated the relationship between life-long experiences with science and the attitudes held by preservice teachers about science and science teaching.

Student Interest In and Attitude Toward Science and Science Teaching

Relationships between important environmental influences and attitude formation of school aged children has received recent attention in science education. One model for research about educational environments, which was developed by Keeves (1975), identified three educational environments that interact to influence achievement in and attitude toward schooling in general. These environments are identified as the home, the school, and peer group. Kremer and Walberg (1981) reviewed studies on three constructs, as well: home environment, school environment, and motivation. It was their conclusion that all three constructs are important correlates in science learning.

Haladyna, Olsen, and Shaughnessy (1982) suggest there is "powerful evidence" that student attitude toward science is linked to a perception of self and the ability to learn. It appears that students with a strong positive regard for their own abilities to learn have a more positive attitude toward science. Positive relationships between student self-perception and cognitive and noncognitive learning outcomes have been reported by several other investigators, as well (Bloom, 1976; Kremer & Walberg, 1981; Simpson & Troost, 1982; and Urgulou & Walberg, 1979).

The family has also been shown to be a strong influence on the adolescent student. Kremer and Walberg (1981) examined thirteen studies in which home variables were related to student learning outcomes. The results of these studies indicated that high parental involvement in the child's overall learning in school was related to positive science attitudes and high interest among adolescents. Schibeci and Riley (1986) found that home environment and parent education exerted a strong influence within a causal chain linking instruction with attitude and achievement.

Classroom environment has been shown to be an important determinant of attitudes toward science. Several authors have examined the relationship between the classroom environment and cognitive and affective outcomes (Keeves, 1975; Haladyna et al., 1982, 1983; and Walberg, 1968, 1969). In general it is reported in these studies that characteristics of teachers, peers, curriculum, and classroom climate are strongly related to attitudes toward science.

A study by Napier and Riley (1985) involved data collected in the 1976-77 NAEP survey of seventeen year olds to analyze the hypothesis that there are affective determinants of science achievement. The affective scales of motivation, anxiety, student choice and teacher support were found to account for the majority of the correlation between affective determinants and achievement. It was concluded from the results that the type of class which fosters achievement can be described. However, the comments on science pedagogy should be limited to correlation studies (ie., no causal link can be stated between the affective determinants and achievement). Nonetheless, the five characteristics include (p. 381):

1. the teacher encourages students to do extracurricular work such as reading science articles and books, watching science shows, attending science lectures, doing science projects, having science hobbies and discussing science topics with others;

2. the teacher establishes a classroom where the coursework isn't too difficult, students feel comfortable and happy, and students are not made to feel stupid;

3. the teacher avoids allowing students too much latitude in choosing their topics or projects for class, the way the topics are sequenced, the mode of learning and the rate of work, as well as when to take a test;

4. the teacher allows students to state opinions, encourages students to think for themselves, and helps students to be creative;

5. the teacher admits he/she does not know everything and takes a personal interest in students.

This description of the type of class that fosters achievement is similar to what science educators have advocated except for the lack of student choice (AAAS, 1987; 1993).

Self, home and school were found to play important roles in shaping student attitude toward science, as the above cited studies suggest. The purpose of a study by Talton & Simpson (1986) was to examine the relationships of three categories of variables; self, family, and classroom environment with student attitude towa: d science. Two research questions were developed.

1. What is the contribution of each category of variables; self, family, and classroom to attitude toward science?
2. Of the entire set of variables, which show the strongest relationship with attitude toward science?

Students in grades 6-10 were administered several subscales of an instrument developed by Simpson & Troost (1982) to assess student attitude toward self, family, classroom environment, and science. A description of the subscales used in this study and their reliability and validity statistics are offered in order to temper the authors' conclusions. Student perceptions of self were measured using four subscales: Achievement Motivation (4 items), Anxiety (4 items), Science Self-Concept (2 items), and Self-Concept (2 items). The reliability estimates of the subscales are .90, .52, .53, and .50 respectively. Student attitudes about the family were measured by two subscales: Family Science (5 items) and Family General (3 items). The reliability estimates for these subscales are .65 and .33. A measurement of student attitudes toward classroom and school environment was obtained from seven subscales: Climate (3 items), Curriculum (4 items), Physical Environment (2 items), Teacher (5 items), Other Students (3 items), Friends (4 items), and School (6 items). Reliability estimates for these subscales range from .32 for Other Students to .73 for Science Curriculum. Student attitude toward science was measured using a seven item subscale with a .90 reliabilty estimate. While the attitude subscale has a high reliability estimate, the reliabilty of the instrument as a whole is highly questionnable. The validity of the instrument is unstated by the authors and an item analysis of the subscales shows a very narrow conception of variables (ie., physical environment is confined to: 1) the science classroom is attractive, and 2) the classroom contains a lot of interesting equipment).

Major findings of this study showed the three categories of variables to be significant predictors of attitude at a .05 level of probability. Examining each category separately, classroom environment possessed the strongest relationship with attitude toward science. Climate, curriculum and friends were the strongest classroom environment variables.

Talton and Simpson (1987) conducted an additional study in which they concluded that, although the classroom environment contributed to achievement in science, the relationship was not as strong as the relationship between classroom environment and attitudes toward science. This study, which included 1560 tenth grade biology students from 70 biology classes in four schools, suggests that student feelings about the emotional climate and physical environment of the classroom, activities within the science classroom, the science teacher, and student interactions with their classmates are all important factors that should be considered when examining how individuals feel about science. The authors used the same instrument as in their 1986 study.

The influences of attitude toward science, achievement motivation, and science self-concept on achievement in science were investigated by Oliver and Simpson (1988). Their study also revealed that affective behaviors in the science classroom were strongly related to achievement. A study by Schibeci (1989) on the influences of home, school, and peer groups on student attitudes and achievement in science revealed a strong interrelationship among the affective and cognitive variables.

A study by Schibeci and Riley (1986) involving a total of 673 individual 17 year olds, extended previous research by highlighting the causal inference that perceptions of instruction influence student attitudes and that these attitudes in turn influence achievement. This study used causal modeling procedures to analyze nonexperimental data to test causal inferences about hypothesized relationships among student background, perceptions, attitudes, and achievement. The research hypothesis tested was that student background variables influence student perceptions of science instruction; these in turn influence attitude which, in turn, influences achievement. The study had two concerns: first, the identification of variables which influence student outcomes in science (attitudes and achievement); second, to test a model in which attitudes influence achievement (and the converse model in which achievement influences attitudes).

The influence of five background variables (gender, race, home environment, amount of homework, and parents' education) on three dependent variables (student perception of science instruction, student attitudes, and student achievement) was examined to determine the influence of background and perceptions on science attitudes and achievement. The results showed that gender was found to be an influence on attitudes and achievement, with females scoring lower in attitude and lower in achievement. Racial background was found to be an influence on achievement but not on attitude. Home environment, homework, and parent's educational background were the variables found to have substantial influence on attitudes and achievement. Evidence was indicated of a substantial causal link from attitude toward achievement with student perceptions of instruction influencing these attitudes. If one assumes that student perceptions of their instruction are valid indicators of teaching behavior, the results of this study support the view that what science teachers do in the classroom does make a difference.

The authors' claims that both gender and race influence attitude and achievement should have been followed up with some cautionary words. As stated, one could interpret that females and members of minority groups are somehow genetically inferior. While there is a large body of research on the subject of girls in schools that presents compelling evidence that girls are not receiving the same quality, or even quantity, of (science and math) education as boys (American Association of University Women, 1992), the authors omit any reference to this. The same is true for members of minority groups. Furthermore, the results should not be generalized to age groups other than 17 year olds.

The results of a meta-analysis on the relationship of student characteristics and student performance in science conducted by Fleming and Malone (1983) reveal that one's general ability, language ability, and mathematical ability have the strongest positive relationship to performance on cognitive, science achievement, and science attitude measures. These results are less than surprising and hold up across grade levels and subject areas. Generally speaking, however, science attitudes show a much smaller relationship with all the variables considered, general ability, language ability, mathematical ability, as well as socioeconomic status (SES), gender and race. An interesting interaction of SES with measures of science achievement and science attitude takes place from elementary school to high school. While the relationship of SES to science achievement becomes stronger, the relationship of SES to science attitudes weakens over the same period of time.

Gender appears to have the weakest relationship to the three performance measures for all variables considered, with males generally scoring slightly higher than females. This relationship is not consistent across grade levels. In fact,

> There appears to be an inverse relationship of science attitudes with cognitive measures and achievement over time. This is most evident at the middle school level where males' performance on cognitive and science achievement measures exceeds female performance, while females attitudes toward science are more positive than male attitudes (p. 493).

As in the earlier studv by Schibeci and Riley (1986), a discussion as to the crucial role that schools play in reinforcing or challenging gender-role expectations that undermine the self-confidence and achievement of girls should have been offered.

Many studies show that young primary students are interested in and enjoy science in school, yet that interest fades as they progress through grade levels (Walberg & Ahlgren, 1973; Shymansky & Kyle, 1988). Yager and Penick (1986), for example, found that 90% of elementary school children believed that science would be of value to them in the future, but this drops to

75% for seventh graders and further yet, to 20% for young adults. Many studies have shown girls become less interested in science and achieve less than boys, however, there is evidence (Shymansky & Kyle, 1988) that girls in single-sex schools do better in science than those in mixed schools.

Yager and Yager (1985), in their classic synthesis report of four studies, investigated the changes in perceptions of third, seventh, and eleventh grade students of science teachers, science classes, usefulness of science study, and what it is like to be a scientist. They concluded that " there is little evidence that school science affects student attitude ... in any positive ways" (p. 356). In fact, their analysis revealed the primary problem areas to be (p. 347) that:

1. science is less fun and exciting the longer students stay in school;
2. teachers are viewed as providers of information; the more preparation a teacher has and the more advanced the class, the less likely is a teacher ever to admit not knowing;
3. students do not feel more successful and/or more curious as they progress through a science program;
4. the school program does not provide increasingly accurate information and/or encouragement for science career choices.

In a study to determine dimensions of high school science anxiety, Wynstra and Cummings (1993) reported that 750 students identified six major categories that made them anxious. The categories cited were: 1) Danger Anxiety (referring to using poisonous or flammable chemicals, lighting a bunsen burner, or watching a demonstration that explodes and makes loud noises; 2) Test Anxiety (referring to taking tests, final exams, lab tests, and answering different kinds of questions); 3) Math and Problem Solving Anxiety (including reading formulas, working out story problems, and interpreting graphs and data tables); 4) Squeamish Anxiety (such as dissecting a frog, looking at a preserved specimen in a jar, or pricking one's finger to do blood typing); 5) Performance Anxiety (referring to doing activities such as science projects and explaining the results to the class, being asked a question, or having the teacher watch your lab procedure); and 6) Classroom Anxiety (including taking notes, listening to a lecture, and answering questions for a homework assignment).

Because science anxiety was found to be multi-dimensional, students could be high in all categories or only in some. Comparing overall average scores, freshman and sophomores had higher anxieties than juniors and seniors, and female students had higher science anxieties than male students. Students who had higher-than-average anxiety scores were less interested in science, had less positive attitudes about science, spent less time reading science books and magazines, spent less time watching science-related television programs, and were less likely to major in science or choose a science-related career.

As part of a study to compare the attitudes toward science of college students who were non-science majors with college students who were science majors, Gogolin and Swartz (1992) used qualitative research methods. The interview questionaire data results indicated that the non-science majors interviewed shared common traits and experiences. Although there were social distinctions, the majority of the students came from backgrounds of low science interest. Their family environments may have affected the students' perceptions of science and limited the opportunities they had for science growth as children. When reflecting on their science experiences, most could clearly remember experiences in the classroom, but few students could remember anything even remotely related at home. This suggests that early science interest could promote positive attitudes and that the home commitment to science is important.

The interview data also suggest that peer groups had an influence on their exposure to science, supporting earlier studies of Shibeci (1989) and Talton and Simpson (1985). The peers spent their leisure time together, joined the same clubs and teams, and took the same classes. When science was of little personal interest and this was reinforced by other members of the peer group, interest in science failed to develop. As Ajzen and Fishbein (1980) contend, social influence is one of the two major determinents of behavior, the other being personal attitude.

Most of the students reported having a respect for science teachers and an understanding of the importance of science. However, many of their experiences in the classroom did not foster an interest in science. Similar to the findings of the NAEP reports (Yager & Penick, 1986), they appeared to have an interest in and enjoyment for science in the elementary school that waned as they proceeded through grade levels. Several students related their science experiences to feelings of tedium stemming from what they considered meaningless memorizations. Few had been exposed to regular "hands-on" opportunities in the classroom. Some students had negative experiences with teachers which contributed to feelings of anxiety and confusion, and affected their ability to understand science. For these students, there was an uneasiness and lack of understanding about the nature of science.

This study was limited to 25 randomly selected nonscience majors. No data were provided as to the areas in which the students were majoring. Of the 25 students, 13 were male and 12 were female. There were no identified differences with respect to gender. The interview questionaire focused on four areas previously cited as being important to attitudes: home environment, school environment, peer relationships, and self-concept. Questions were a combination of closed- and open-ended questions; there was a total of 45 items. One potential strength in this study was the researchers' claim that students were encouraged to elaborate and present reasons for their views. The examples provided in the research report however, seem to reveal one-line reaction statements as opposed to elaboration of the particular event identified. While possibly better than correlation studies in identifying specific variables within science experiences that individuals themselves found influential to their attitudes toward science, the interview questionaire focused on variables predetermined by the researcher to be influential.

In summary, many studies have been conducted in order to determine the influence of home, school, peer group, and self-concept factors on achievement in and attitude toward science. Most of these studies were concerned with identifying those constructs which exert the greatest influence on achievement and attitude outcomes. While all constructs appear to have an influence on attitude toward science, there is strong support that the classroom environment is the most important. The instruments used in these studies identified influential classroom environment variables (ie., the teacher and the curriculum) but failed to offer specific characteristics about the teacher, the curriculum, or other variables that are influential.

Studies have shown that girls become less interested in science and achieve less in it than boys. There is evidence that the gender gap in science is not decreasing and may, in fact, be increasing (AAUW, 1992). There is strong evidence that interest in science for all students wanes the longer students are in school. Survey, questionnaire and interview data reveal students feel less successful in doing science the longer they are in school, have increased anxiety about science and are reluctant to pursue science related careers.

As stated earlier, current demands in the fields of science and technology are such that science teaching needs to stimulate and sustain student interest from the time children begin schooling. From the results cited, these demands are not usually met. The study of attitudes toward science and science teaching has become an increasingly important focus of science educators. It is influenced by research in social psychology that suggests that attitudes influence future behaviors. For science educators, such behaviors as career choices and abilities to deal with technological changes can be associated with attitudes toward science. For elementary teachers of science, attitudes toward science and science teaching can mean the choice to teach or not to teach science to students in their classrooms.

Much of the research presented here on preservice elementary teachers' attitudes toward science and science teaching and on student interest in and attitude toward science and science teaching sought answers to questions that necessarily demanded quantitative research methods. In their search for correlations and causal links researchers chose large sample sizes for reliable and valid results. These quantitative researchers relied heavily on statistical results that are represented by numbers and are context insensitive. For example, results showing a strong correlation between number of hours watching science programs on television with attitude toward science of 10 year-olds offers little in terms of the nature of the programs watched by individual children, whether the child watched the program alone or with other family members, the quality and quantity of dialogue among television viewers, what the child learned and was able to apply in his or her life, or other information the child might offer about the experiences with science television viewing. Similarly, identifying that a relationship exists between the quantity of school science experiences a preservice elementary teacher has had and her attitude toward science, yields nothing about the quality of those experiences.

Qualitative research methods are more appropriate in aiding this more holistic interpretation of a phenomenon or situation. Research investigating preservice elementary science teachers' attitudes toward science, science teaching, and their sense of efficacy to teach science through the use of their own reflective accounts depicting how they came to have those attitudes is wanting. Autobiographical texts have the potential to reveal a full range of conceptions that prospective elementary teachers have about science and science teaching and provide insight into how they were formed and should reveal less about the *a priori* assumptions of the researcher. An analysis of the life-long experiences with science shared in the autobiographical texts should also reveal some potentially powerful information about how these future teachers perceived their experiences with science outside of school from a very early age as being influential on their attitudes.

Retrospective narratives, such as the science autobiographies used in the present study, hold greater promise in identifying personally meaningful variables within experiences with science. Chapter 3 describes the methodology employed in the conduct of my study, an effort that focuses on the perceptions of 80 preservice elementary teachers of their past science experiences, the contextual variables within those experiences, and how those experiences influence the attitudes they have about science, science teaching, and their perceived ability to teach science to elementary school children.

CHAPTER THREE

Methodology

> "I would ask you to remember only this one thing," said Badger. "The stories people tell have a way of taking care of them. If stories come to you, care for them. And learn to give them away where they are needed. Sometimes a person needs a story more than food to stay alive. That is why we put these stories in each other's memory. This is how people care for themselves..."
>
> from *Crow and Weasel* by Barry Lopez

In this chapter I will describe how the research was conducted in order to provide an understanding of the findings in context. The points covered in this section fall under six major headings and follow Taylor and Bogdan's (1984) outline of the basic points they believe should be covered in presenting both the methodology and findings of a qualitative research report. First, I will state the general methodology and specific data collection procedures used in the study. Next, I will define the time and length of the study. Third, I will describe the nature and number of study participants and the setting in which the study was conducted. Fourth, I will discuss how and to what extent I established rapport or trust with the participants and the procedures used to gain informed consent. Following this, I will identify my original purpose in this study and how it changed over time - basically, stating my rationale for the change in research design outlined in my research proposal. Concluding this chapter will be a review of the procedures followed in the analysis of the data.

General Methodology

Two basic types of qualitative data collection constitute the bulk of the research effort, the solicited retrospective narrative and the interview. Each of these techniques is unlike the widely used structured research tools such as attitude surveys, opinion polls, and questionnaires which are typically administered to large groups of respondents or subjects who are asked to rate their feelings along a scale, select the most appropriate answer from a preselected set of options, or even to respond to open-ended questions in their own words. These structured approaches all adopt a standardized format: the researcher has predetermined the questions and the research subject answers only these questions. In contrast, the solicited retrospective narrative and interview are less directive, less structured, nonstandardized, and more open-ended.

The solicited retrospective narrative technique in this study has been modified from how it is often described in qualitative methods texts (see Taylor & Bogden, 1984 p. 90). The first modification in the approach has the participants focusing soley on their experiences with science in the course of their lives and those people's definitions of those experiences. As such, these solicited retrospective narratives are more like the abbreviated or focused autobiographies Fetterman (1989) speaks of as being sufficient in certain research projects, especially when used in combination with interviews and/or participant observation.

The term 'science autobiography' found throughout this report is used to represent the specific focus of a person's perceptions of experiences with science as expressed in their own words. These records capture each participant's perception of his or her past experiences with science, providing a window through which to view what kinds of experiences each participant has had and his or her interpretations of them and to see if patterns emerge within and between autobiographies.

I understand that self-report data, such as that provided in both the science autobiographies and the interviews, have limitations. As Borg (1987) warns:

> "A serious potential weakness of self-report measures is that the subject may tell you only what he wants you to know. Thus, such evidence may be distorted or subject to omissions. Even if the subject wants to give accurate information, he may lack the insight to do so ... (or) if the study is in any way threatening to the subject, if he feels that honest answers can harm him ...you can assume that many subjects will lie or give inaccurate answers (p. 157).

The science autobiographies were not verifiable by the researcher and may not be factually accurate, however , as will be evident in subsequent chapters that detail the results, all participants reported using a variety of personal documents to 'jar' their memories or provide specific examples within their narratives.

Personal documents as used here refer to such items as school grade reports, science projects and reports, homework or classwork papers, notebooks, photo albums, lab books or journals. No participant reported using a diary, private letters or other narratives, either solicited or unsolicited. Most students reported asking family members, (ie., parents, grandparents and siblings) to help them recall their experiences and several asked friends with whom they went to school for help. A few asked their former teachers. Microscopes, rock and shell collections, chemistry sets, space shuttle models and posters, and pressed flower books are all examples of artifacts that participants reported to have saved and to which they referred in writing their autobiographies.

While I asked each of the 87 students who were enrolled in one of three sections of the elementary science methods course I teach to prepare a science autobiography, 80 students consented to my use of their autobiographies for this research. A description of the participants, the course and the consent process will be described later. For the purpose at hand, the participants were asked to prepare the following:

> Each of us has a history with this thing called science. I encourage you to reflect in a critical way on the experiences you have had in your science history. For this assignment, write an autobiographical essay which highlights your experiences with science both in and out of the classroom. Include as much as you can and feel free to get memory jogs from home. Tell me about the experiences you have had with your teachers of science, and any other person with whom you have shared your science history. Please tell me how you see yourself relating science to elementary age students at this point in your teacher preparation. Please have this ready at the beginning of our third class meeting.

After reading and returning the autobiographies of all 87 students, each of which had questions of clarification in parts of the text which were deemed unclear in some respect, students were invited to participate in the study. The participation involved adding the information for which I asked clarification. Two means of providing this information were offered, participating in interviews and the subsequent rewriting of the autobiography or simply the rewriting of the autobiography based on the written comments I provided. This constitutes the second modification of the traditional retrospective narrative technique. It is usually the researcher who develops the final piece and then checks with the participant to see if its accurate.

Of the 80 who accepted the invitation, 20 participated in the interviews and rewrote their autobiographies incorporating the interview data into the piece. The remaining 60 simply rewrote the autobiographies and submitted them the following week. For the most part, I got significally more information than I had asked for due to students remembering more experiences and in a number of cases parents sending them documents in the mail. Several of the 20 who were interviewed brought these items to share which made for an easy beginning for the interview sessions.

Interviews were normally scheduled on the day the participant would be having class with me. The sessions were held either before or after class and lasted between one to one and one-half hours. This schedule worked best for the students and myself due to some students not being on campus except for this day and my heavy field responsibilities keeping me off campus, also. All of the interviews were conducted in my semi-private office and it must be stated that my open-door policy caused some interruptions - even a note on the door indicating an interview was in process was ignored at times. Interviewees, however, seemed much less distracted than I and continued or immediately commenced talking as though nothing had happened.

In determining an overall strategy for the interviews I decided to follow Fetterman's (1989) advice, "the most effective strategy is, paradoxically, no strategy." Relating to the interviewee on a personal level was made easy through having the autobiography and any other personally important documents visibly present - communicating a genuine interest from both parties.

The overarching guide in the interviews was a respect for each person. I did not use these occasions to interrogate them or to criticize science practices. The objective was to learn from the interviewee, not impress him or her with how much I already knew about science. More time was spent listening to them talk.

The interviews contained a combination of open-ended and closed-ended questions - mostly closed due to my specific focus on the points of clarification within the autobiographies. Open-ended questions came mostly in the form of " Tell me about this stuff you've brought to share with me," or "Tell me about what you enjoy(ed) doing with your parents". Closed-ended questions fell under two categories; attribute questions (ie., What made these experiences alike or different ?; What's different between 'discovery' and 'lab work' as you've used them?; What was it in this experience that had you say, "I loved this class!"?; Can you remember how you felt when that happened?) and structural questions (ie., What kind of facilities or materials were involved?; How often did you have science?; What time of day was your class?; Who was your lab partner?; How did your grandfather organize these adventures?). I kept notes during the interview which I then gave to the participant in order for him or her to prepare the final autobiography used in the research. I received these within one week of the interview.

Time and Length of the Study

I became interested in using science autobiographies during the summer of 1991 after having the previously described experience with Norma. This coincided with the start of my second year of full-time doctoral course work and influenced my choice of courses which might facilitate my research interest. I chose two qualitative research methods courses, one in research in reading and writing and the other specializing in ethnography. Both of these courses took a phenomenological perspective. A phenomenologist is committed to understanding social phenomena from the actor's own perspective. He or she examines how the world is experienced. The important reality is what people perceive it to be (Taylor & Bogdan, 1984). I also elected a course in statistics and probability, both because I felt perfectly at home with quantitative data and because I wanted a balance in research perspectives.

Two results came from the experiences in these courses. One, I realized that I did not want to conduct a study of culture nor did I want to do a correlational study. Neither approach (in the purist sense) seemed to fit the study I wanted to do. Second, I recognized the importance of 'opportunity' in securing data from a target population. As it turned out, I would be teaching one section of an elementary science methods course during each of the next three semesters so I wanted/needed to start collecting data right away. I also wanted to be consistent in each of the three course sections. The course sections were held during the Spring, Summer, and Fall of 1992.

Data were collected during the first four sessions of each course (first autobiographies, interviews and final autobiographies) and although the data was read over from time to time, no serious analysis was begun until well after all three sections of the course were completed which was in January of 1993.

Nature and Numbers of Participants and Settings

The 80 participants in this study are students who enrolled in one of three sections of the elementary science methods course offered during the Spring, Summer and Fall semesters of 1992 at the University of New Hampshire. This course is designed to meet specific objectives as one of a series of required methodology courses in the integrated undergraduate/graduate department of education program at UNH. All students self-selected their enrollment and groups were not formed through random selection or random assignment. This researcher was the sole instructor of all three sections.

Of the eighty-seven total students enrolled, eighty students participated, 28 in the Spring session, 30 in the Summer session, and 22 in the Fall session. Of the seven who did not participate, two were enrolled in the Spring session, one in the Summer session and four in the Fall session; six of the seven were female and one was male. None was asked to explain his or her decision.

The number of participants in this study who are female is 72 (90%) and who are male is 8 (10%). Data collected over the three year period from 1988-1991 show this 9:1 ratio to be somewhat typical of the elementary education population in the teacher education program at UNH. The age range of participants is 20 to 47 years, with a mean of 26.3 years. Further breakdown shows 81.25% are 20-29 years old and 18.75% are 30 years of age or older.

Due to the nature of the teacher education program at the University of New Hampshire, students enter the methods course at various stages of professional preparation. The only course that all students have had to successfully complete prior to any other course in the program is an introduction to teaching course they took as undergraduates, usually as a sophomore or junior. Of the eighty participants in this study, 12 were seniors. Eight of these students had been informed that they were accepted into the teacher education program and are referred to as 'early admits' and the other four were awaiting acceptance. Of the remaining 68 participants, 32 were first year graduate students who were taking courses, but not experiencing their full-year teaching internship; 16 were second year graduate students who had already completed some course work and their full-year teaching internship; 12 were either first or second year graduate students who were concurrently completing their full-year teaching internship and this course. The remaining four were experienced classroom teachers seeking either recertification credit or changing areas of specialty (ie., special education to elementary education).

My Relationship with Participants

There are various arguments as to why the establishment of trust with participants is important in the conduct of research. Among the concerns is that participants may not be truthful because they have things to hide, vested interests to protect, fears of public exposure, uncertainties regarding public disclosure, and so on. John M. Johnson (1975) identified four major theories relating to the phenomena of establishing trust, one of which I found particularly germaine to my needs. All of the theories address (1) how the participants define the researcher as a person, and (2) how the researcher's role is defined by the participants.

The theory I followed is termed the *psychological-need theory.* Obtaining valid and reliable data according to this frame does not involve such phenomena as being well-liked or being accepted. In fact, sociologist Chris Argyris (cited in Johnson, 1975) suggests a research project may be hindered by such emotional ties between the researcher and the participants. He argues that the data will be valid only if the participants define the research project itself as fulfilling their psychological needs:

> I doubt if the personal impact of the researcher can be a valid motivator for subjects. If the researcher could somehow be "all-loving" and well-liked, the resultant emotional tie between himself and his subjects could easily bias their reports. If one has emotional ties with the researcher, one might tell him that which one feels is pleasing to him.
>
> The researcher is, therefore, left with the subject's perception of his research as the primary motivating factor in inducing them to report valid information. Thus the research itself must somehow be perceived as need-fulfilling. The subjects must perceive the research as helping them to gain something which they desire; to explore problems hitherto not understood and unresolved. They must feel that they are contributing to something whose completion will be satisfying to them (p. 89).

I wanted to minimize the influence that I might have on the content of the students' autobiographies so I thought it best that they write their retrospectives within the first two weeks of the course. I generally feel a close relationship with my students by the time a course ends, but such is not the case within just a couple of weeks.

I was concerned, also, with any anxiety that they might experience due to being graded on the content or style of their writing. I assured them that credit would be given to every student writing an autobiography regardless of content, length, or style. I discussed the possible benefits of writing such a piece. These included the opportunity to explore the kinds of science experiences they did and did not enjoy in and out of school and what those experiences in retrospect, tell them about how they learned science and intend to teach science. Another benefit I suggested was that it could provide them a springboard from which to develop their own goals for the science methods course based on their perceived needs. I made every effort to avoid explicitly stating that the benefit of writing the autobiography was so that they could see a connection between science and themselves, although I'm sure it was implied. I also avoided making statements about intersecting knowledge and autobiography, enhancing intellectual humility, or the likelihood that they'll like and learn more science.

It was only after the students had written and been given credit for their science autobiographies that I introduced my research agenda. Informed consent was obtained prior to the conduct of any interviews and/or the revisions of the autobiographies. Each student electing participation in the study knew that he or she could withdraw at anytime, although no one took advantage of this. I assured them that their names and the names of any teachers, parents, siblings, friends, or others identified in their stories would be changed. The official request for review of this research by the Institutional Review Board (IRB), the Informed Consent Form used, and the letter of approval for the research by the IRB are found in Appendix A.

A Change in Focus

I originally designed this study to have two sets of data: the eighty autobiographies secured within the first few weeks of the course and an additional autobiography written at the conclusion of the methods course. One reason for having the students prepare the second autobiography was to consider the influence of the methods course on their expressions of attitude toward science, science teaching, and their sense of efficacy in teaching science to elementary age students. A second purpose was to compare how their original perceptions of their past experiences might have been elaborated or altered, and to see if additional past experiences were triggered into memory due to activities encountered during the course (ie., observing in an elementary classroom, interviewing an elementary teacher, teaching a science lesson to a group of elementary students, reading science teaching material).

The request for a second autobiography was made on the twelfth class meeting of each course section. Of the 80 participants, only 16 wrote a second autobiography. All 16 students were in the Spring, 1992 section. I have elected to hold onto these data for an additional study to be completed at a future date, one that follows several of these students through their internships and first years of teaching.

Analysis of the Data

The 80 Autobiographies. A careful scrutiny of the students' science autobiographies showed that their retrospectives could be discussed under three main headings that serve as an organizing device to discuss the themes found in the data. The three headings are recorded science experiences, identified variables within science experiences that are related to expressed attitudes, and stated goals for the teaching of science at the elementary level. These three main headings were determined after reading the autobiographies several times, listing the most apparent patterns found in them, and then developing thematic categories for the patterns. As I read through the data again, I coded the data according to the categories and included all new, more subtle patterns and categories that emerged. I then selected both positive and negative descriptive accounts that related to the categories from among the autobiographies in order to place the themes within the context of the students' experiences with science.

The first heading frames the patterns that are related to the experiences with science that students reported to have had (and not had) both in and out of school. These patterns will be presented in the order in which they appeared in the autobiographies - in chronological sequence from elementary, junior high, high school, and college. The themes related to out-of-school experiences will be presented last in the sequence.

The second heading frames the themes related to the contextual variables within the experiences and their influence on the attitudes expressed by the students. These themes are separated into two categories. The first category groups themes related to contextual variables that appear to influence positive attitudes toward science and the learning of science. Illustrative examples provided in this category report the students' positive feelings or satisfaction about themselves, others (ie., teachers, parents, peers), and/or the activities in which they were involved. The second category groups themes of contextual variables that appear to influence negative attitudes toward science and the learning of science. Illustrative examples in this category report negative feelings, dissatisfaction or complaints about themselves, others, and/or the activities.

The third heading frames the themes that emerged relative to how the preservice elementary teachers intend, at this point in their teacher education program, to teach science in an elementary school setting. Illustrative quotations and descriptions for these themes reveal the goals the preservice elementary teachers have set for themselves and their behavioral intentions about the kinds of experiences they will provide for their future elementary school students, how they will provide them, and why they've chosen them.

Case Studies of Students. I can not preserve and present the contextual elements of all 80 of the students' science autobiographies in this study. I can however organize the data and provide helpful interpretation without extinquishing the sparks of life from the study by presenting representational science autobiographies. As Kathleen Moore (1993) suggests,

> "In any presentation of data, there is the danger that the life of the data will be strangled out of it by the rope of the researcher's analysis being pulled tighter and tighter. By then, the data can no longer intrude, be

> untidy, contradict itself, pose unanswereable questions, or stir the reader to ask challenging questions." (pg. 65)

I have decided to conclude the report of my data with four case studies. Each case study will include all of the autobiographical information provided by the four students as well as introductory and interpretive remarks.

Choosing the 4 autobiographies as being representational of the group of 80 was a chore. I settled on the following criteria to guide my choices:

1. At least one student from each of the three course sections needs to be included;
2. At least one student from each of the four subgroups taking the course needs to be included (ie., undergraduate student, first year graduate student not participating in his or her internship, first or second year graduate student participating in his or her internship, student already having completed his or her internship);
3. At least one male student needs to be included;
4. At least one student who is in the 30 years of age and older group needs to be included.

I was able to adhere to all but one of the criteria. No student who was taking the course at the same time he or she was interning is included in the case study data. I am comfortable with this because, with the exception of the male subgroup, this particular subgroup of students (n = 12) has the fewest members.

Melissa, is a 20 year old undergraduate student representing the Fall section of the course. She has not been accepted into the teacher education program at the time she is taking the course.

Melanie is a 22 year old first year graduate student. She is not completing her internship while taking the Fall section of the course.

Robert is a 28 year old student who has recently completed his internship. He is taking the Summer section of the course.

Evelyn is a 33 year old undergraduate enrolled in the Spring section of the course. She has recently been accepted into the graduate program.

The introductory comments for each of the case studies provide both biographical data on the students and my initial perceptions of the students. The interpretive comments that follow each of the case studies relate the data found in an individual autobiography to the most prominent themes represented in the 80 autobiographies.

CHAPTER FOUR

The Data and Analysis of the Data

> If I were to produce a video highlighting my experiences in science in elementary school, the video would be rated 'M' for minimal. Mr. Patriaca was the "science teacher" at my elementary school, as well as being the shop teacher, a sports coach and one of the nicest teachers I've ever met. I can honestly say that I remember many things about elementary school, but only two of them relate to science.
>
> (Alfred, February, 1992)

I start this chapter with some general comments about the 80 autobiographies. These general comments concern the length, organizational structure, breadth and depth of the retrospective narratives. The second section of this chapter presents the data found in the 80 science autobiographies under the three main headings of recorded science experiences, identified variables within science experiences that are related to expressed attitudes, and stated goals for the teaching of science at the elementary level. I conclude with four case studies in order to preserve both the individuality of the students who participated in this study and the contextual elements of their science stories.

General Comments

I remember being amused when students in each of the three course sections posed the question, " How long should the autobiographies be? ". Although tempted to answer, "Well, it depends on how old you are; the older you are the longer it will be," experience reminded me that students are fairly anxious about the acceptable length of papers. I chose not to treat their concern with levity and instead offered the more serious and prepared response, "The story you choose to share with me is about *your* experiences with science. Tell your story the way you remember it to be. I am not going to set a limit on the number of pages it will take you to write your science story."

The average length of the final drafts was 7 - 8 double-spaced pages; varying greatly from a minimum of 2 pages (n = 4) to a maximum of 10 pages (n= 10). I found no relationship between the length of an autobiography and the autobiographer's age, gender, or undergraduate or graduate level status.

I did find that over half of the students (n = 42) started their autobiographies with what I consider to be warm-up sentences or paragraphs. Some of these students appeared to be apologizing for the length of their stories with statements like Jennifer's (September, 1992), "... my history with science is not going to be very long. The first time I remember doing science in school was when I entered junior high, so I'll have to begin there." Some needed to explain further that they had thoroughly searched their memories for experiences, but came up as empty as Neil (June, 1992) who reports, " I found it difficult to remember anything significant about my elementary science experiences before fifth grade even though I knew from looking at old report cards listing the grades I received for science, that I had science classes in grades one through four. " Still others began their stories with comments about the autobiography assignment itself. Marie (June, 1992) offered , " I believe this is the most difficult paper I have ever had to write. Most of what I have to say about science is far from pleasurable and I find it difficult to write about unpleasant things," whereas, Suzi (February, 1992) begins with, " Write about science? My favorite subject? A piece of cake... here goes."

Chronological sequence was the structure of choice by 78 of the autobiographers. This aided the coding and reporting of experiences by grade level and by specific subject (ie., biology, chemistry). This is not to suggest, however, that each autobiography presents one or more experiences at each grade level. Table 1 reveals, for example, that experiences at the elementary level (4-6) are reported in 37 of the 80 autobiographies, experiences with high school biology are reported in 50 of the 80 autobiographies, and experiences with college level science courses are reported in 34 of the 80 autobiographies. In addition, 35 of the autobiographies include the similar claim, "The first memory I have about science in school was when I was in the seventh grade, so my story needs to start there."

Table 1

Number of Autobiographies Reporting Science Experiences per Grade Level

K-3	4-6	7	8	9	Biology	Chemistry	Physics	College
8	37	37	26	24	50	50	17	34

Of the eighty autobiographers, 60 included experiences with science that were described as out-of-school experiences. The length of these out-of-school experiences varied greatly from one paragraph to five pages. Structurally, these out-of-school experiences were separated out from the school experiences; presented at either the beginning of the autobiographies (n=8) or at the end (n=52). In presenting this data, I will do what the majority of the students did - describe these out-of-school experiences after the presentation of recorded science experiences in school.

In terms of depth, the descriptions of individual experiences within whole autobiographies varied between thin and thick descriptions. Thin description was most evident when only a partial account of an experience was presented or when experiences were named but not described. For example, "The two most memorable experiences I had during fifth and sixth grade were the annual spring field trips to the Boston Museum of Science. This gave me the opportunity for hands-on science experiences that were missing from my daily science lessons" (William, February, 1992). We know that William was provided something in the way of hands-on experiences while on this field trip and that he did not have hands-on experiences in school. We can infer that he probably enjoyed going to the museum on both of these occasions but we do not know any details about those experiences. Most of the thinly described experiences within the autobiographies were those experiences situated within the elementary grades and those at the college level.

A thick, descriptive account of an experience, on the other hand, was found to have one or more of the following characteristics;

1. It describes one small slice of interaction in detail;

2. It focuses on an individual or a relationship within a situation;

3. It re-creates the sights, sounds, and feelings of persons and places;

4. It provides interpretation of the experience being described.

An example of thick description is provided by Laura (February, 1992);

"My first experience with "real" science came in seventh grade. Rumors had circulated about Miss Kelley for years. "Try not to get Miss Kelley for science" the older students would say. "She's a real witch." "She's a crazy old maid." "She's really weird." Well, I got Miss Kelley for science. We sat on stools at black lab tables instead of desks. Surrounding the room were skulls from every kind of animal you could imagine; skunks, squirrels, cows, rabbits, etc. There were snake skins, stuffed owls, and aquariums full of fish. The room had that strange odor of formaldehyde. In the back room there was always a pot boiling on the stove with who knows what inside. We were all scared to death.

Miss Kelley never called us by our first names. The boys were Mr. and the girls were Miss. But, if you were to ask me how I felt about science at that point, I would have said I loved it. She was a little weird and a bit scary, but we *did* more science in that class than any other I can remember. We built our own terrariums, dissected worms, starfish, and frogs, measured rainfall, studied the swamp next to the school for plant and animal life, examined snowflakes, grew bacteria from the boys and girls locker rooms, and hatched fruitflies. The next two years paled in comparison." (page 2)

Thickly described experiences were found in each of the 80 autobiographies. A limited number of thickly described experiences is available for elementary science experiences due to the fact that only 37 out of the 80 students reported having any experiences with science at the elementary level and even then, thin description is used more frequently.

The Findings

Recorded Science Experiences

The Elementary Years.

"Okay, everyone. Put away your math and take out your science books. Turn to Chapter 5 on electricity. What experiment were we reading about yesterday?"

Hands shoot up into the air all around me in the classroom as Mrs. Burns turns to her teacher's manual.

"Jenny?"

"We were on experiment 5.4 on conducting electricity."

Mrs. Burns proceeds with explaining experiment 5.5 and asks us to read the lesson and answer the questions.

"Are we going to do the experiment today?" I ask quietly.

"No, we don't have time. It's almost half way into the year and we're supposed to be finishing Chapter six by now. We are the farthest class behind schedule. Any more questions?"

I turned to the next experiment and set to work independently in silence as I read about an electricity I couldn't see, hear, or feel except on the pages of my textbook." (Kelsy, June, 1992)

The most predominant theme running through the reported experiences with science during the elementary school years (K-6) is that science was experienced as a series of reading assignments. Each of the 37 students who reported experiencing science in one or more grades at the elementary level remarked that science meant textbooks, workbooks, and/or worksheets that had science material to be read and memorized. For variety, they answered questions at the ends of chapters. Success in science was measured by the number of right answers the students had to these questions or to the quiz and test items that appeared on Fridays.

Similar to what Kelsey (June, 1992) reported earlier in Mrs. Burns' class and what 25 other autobiographers remembered about science in the elementary school, Tracey (September, 1992) offers her description:

"We never performed science experiments in my elementary classes. We would read about them in a book or in *Weekly Reader.* Sometimes we would talk about the experiments we read about, but we never actually *did* them. I thought about doing them at home, but what child has a bunsen burner or magnetic crystals at home?" (page 2)

Of those who remembered *doing* science experiments or being actively engaged in scientific activities (n=10) as part of their elementary schooling, five recounted the setting for these experiences as being outside of their classroom. Christopher (June, 1992) claims his "actual involvement in science" started with tide-pools on the salty beaches of New England. During this week long experience he says, "We dug up snail shells and crabs. We drew what we saw, classified and compared them. We carefully observed the ecosystems in each little world of tide pools." (page 3) His early exposure to "real science", as he calls it, was in third grade. Maureen (February, 1992) and Patty (September, 1992) also recall their experiences with "acting like a real scientist" as having happened in the third grade, at the beach, and studying tide-pools.

Amy (February, 1992) and Paula (June, 1992) attended a science camp in Maine with their respective fifth grade classmates. As it turns out, Amy and Paula who attended different elementary schools in the same home town went to the camp at the same time, met while learning how to make ice cream from seaweed, and have been friends ever since. Each reported that "... we ate, breathed, and slept science while at the camp." Among the specific activities they reported to have engaged in were soil tasting (it tasted like orange peels), wading through the marshes in big rubber boots, dumping leftover food into a collective pile at the "waste-o-meter, and eating their homemade ice cream (with fresh-from-the-ocean seaweed).

Other than reading about science in textbooks while in their elementary classrooms and their one outside-of-the-classroom excursion during the third or fifth grade, Maureen, Patty, Amy and Paula made no further references to having elementary school science experiences in their autobiographies. Chris' recollection of the tide-pool experience ended with his claim that "... it was the first and last time I remember leaving the elementary school building during the day for any reason other than a fire drill." (page 3)

Field trips were reported by 10 of the students as science experiences during the elementary years. Based on their descriptions, the term field trip was used by the students to mean travelling at least 15 miles away from the school by school bus during the school day and returning to school in time for regular dismissal. By this definition, the trips by Amy and Paula to the science camp in Maine were not included. The Boston Museum of Science was identified a total of 13 times due to two students reporting having gone at three different grade levels and one student reporting having gone two years in a row. Other places that students remembered by name were the Aquarium in Boston (identified twice), and Odione Point in Rye, N.H (also identified twice). Other field trips included going to "some beach to collect 'stuff'", to "a farm to learn about agriculture," and to "a nursery to study the variety and needs of various plants." Three students declared that the only science experience they could remember from all of their elementary school days was the one field trip they went on in the spring of their sixth grade year.

Each of the students who reported participating in science experiments or activities in which they thought they were scientists within their elementary classrooms (n=5) stated that they had been involved in one or more of the following experiences; collecting milkweed and studying the development of monarch butterflies, hatching chickens, collecting and classifying rocks, experimenting with magnets, building volcanoes, and growing either bean or tomato plants in milk cartons (neither of which grew).

Fifteen students reported that they had witnessed demonstrations conducted by one of their elementary teachers. Neil's (June, 1992) most vivid memory was his fifth grade teacher demonstrating how a magnet works. "He had left a screwdriver on a large magnet over the summer and the screwdriver had become a magnet itself! How could a screwdriver become a magnet? I just had to find out. He wouldn't tell us, so I found out on my own". (page 2) Alfred (February, 1992) recalled when Mr. Patriaca demonstrated how gasses expand and contract. "For materials he used a hot plate, a cooler of ice, and a gallon can. It was fascinating how the can grew and shrunk before our eyes. It was like magic. I wanted to see more, and do more, but nothing followed." (page 2) This pattern of isolated and discrepant events exists in each of the autobiographies identifying teacher demonstrations.

Writing science reports was reported in 24 of the 37 autobiographies that included elementary science experiences. Kymberly (September, 1992) remembers the end of her third grade year as having to do thirteen science reports. "We had fifteen reports to choose from: Sound, Machines, Frogs, Electricity, Chemistry, Insects, The Earth, Measurements, Prehistoric Animals, Reptiles, Fishes, The Ocean, Plants, Rocks and Minerals, and Water and Its Properties (the last two I did not have time to do). We had to answer questions such as: In what way are all sounds alike? How do our telephones work? How many legs do insects have? In addition to answering these questions, we had to draw pictures, trace from the encyclopedia, use pictures from *National Geographic,* and write about any experiments we conducted at home. Mrs. White gave us eight weeks to do these reports. My mom remembers helping me with each and every one of these reports and has kept them all." (page 2) While no other student reported doing more than one or two reports in any one elementary grade, Mrs. White had only needed to add "The Solar System" and "Weather" to make Kymberly's list of report options a perfect summary of all the topics the other students identified.

Almost as popular as the report writing was the reported sixth grade science fair (n= 20). Joe (June, 1992) remembered the day he thought of the topic for his science fair project. " We were driving over the Sagamore Bridge on our way home to Cape Cod over Columbus Day weekend when it hit me. I'll do my project on bridges. I took and developed photographs, wrote descriptions about different kinds of bridges, and built models that actually worked... I won first place in the fair." (page 2) Science fair projects that students wrote about in any detail included growing charcoal crystals, conducting controlled experiments with spider plants, building models of volcanoes, collecting and classifying rocks, shells, insects or flowers, forming clouds, conducting electricity with lemons or potatoes, and experimenting with magnets. Eight students remembered doing a science fair project but had no memory as to the content of those projects.

For those preservice elementary teachers who reported having experiences with science in the elementary school, they remember science as being mostly reading and writing assignments. While complimented occasionally by a teacher demonstration, few students reported having conducted any science experiments themselves that were related to the content of their assigned reading or writing. Sixth grade marked a point where experimentation was expected to be done at home; the results of which were brought to school and judged. Few students reported having gone on science related field trips and no student reported having a mix of reading, writing, demonstration, experiment, and field trip experiences in the elementary grades.

The Junior High Years. Thirty five autobiographies describe science in school as beginning in the seventh grade and five have "formal" science beginning in the eighth grade. Several students remarked that it was in junior high school that science had its own scheduled daily time block which they believe helped them to remember these experiences. Others, like Jane (June, 1992) assert, " Seventh grade - the beginning of junior high and a whole class period designed just for science. I thought to myself, "Wow, it must be important!" (page 2)

Life science (biology) was reported to be the 'subject' of seventh grade science in 36 out of 37 autobiographies. While two students recall these experiences in terms of reading textbooks and answering end of the chapter questions, the other 34 students named insects, worms, turtles, fish, eels or frogs as the main characters in their stories. Connie (February, 1992) recalls her seventh grade biology course:

In this one class I learned about vertebrates, invertebrates, mammals, birds, amphibians, fishes, insects, the food chain, animal behavior and adaptation, cells, and human anatomy. Aside from listening to lectures three times a week, the class worked on experiments at least once a week in the laboratory (ie., dissecting, observing animal behavior, human anatomy studies with our skeleton named Mary). We each designed a model of a human cell, as well. Rather than simply memorizing the structures of a cell from a textbook for a quiz or test, we constructed our "own" cell. For my model I used jello for both the protoplasm and the cytoplasm, macaroni for the chromosomes, olives for the ribosomes, and blue yarn for the mitochondria. This assignment took four weeks but was well worth the effort. It helped me remember both the structures and the functions of a cell. As a matter of fact, I am still able to recall the definitions of a ribosome, chromosome, chromatid, cytoplasm, protoplasm and mitochondria. (page 2)

Only one student mentioned going on an 'off-school grounds' field trip during her seventh grade science experience. Seven students reported having to collect insects around the school grounds during their science class. This was followed by mounting and researching the specimens. The research papers accompanying these "bug collections" and the written lab reports completed at the conclusion of the experiments they conducted constituted the bulk of reported writing assignments. Only one student reported having to produce any type of project for a science fair.

Science became highly specialized in the seventh grade in the area of biology and included an abundance of laboratory/experiment activities. Dissection was the most common experience in the lab setting. Students found science scheduled into the school program on a daily basis and reported less about the excessive reading and writing in science class that they had at the elementary grades.

There was an even split between earth science and IPS (introductory physical science) as the 'subject' in eighth grade science for the 26 students who mentioned science at this grade level in their autobiographies. There was a dearth of rich descriptive data for this grade level as a whole. However, testing soil, collecting, identifying and classifying rocks, building volcanoes, and creating weather instruments and studying weather maps were outlined as activities students remembered in eighth grade earth science.

For those taking IPS, only two students identified particular learning activities. One described an activity in which the teacher passed out a pile of materials with which to create a closed circuit and make a bulb light up (which she recalls being unsuccessful in doing) and the other reported eighth grade science as a reading and writing assignment. Deanna (February, 1992) offers an adolescent twist to her story:

> Our entire eighth grade curriculum was straight from the textbook and all we did was read and answer the questions. I don't even remember much lecture. One assignment in science sticks out clearly in my mind, though. We had to do reports on some of the elements and a certain number of completed reports would earn an "A". Well, a friend and I decided we wanted "A's" so we started out doing the maximum amount. As we went along we discovered how much work was involved and then thought about how many reports he'd be reading. Figuring he'd never read them all, we began inserting little stories in the middle of our reports and made things up just to see what would happen. Our desired outcome happened! He was looking for quantity NOT quality and we each received an "A" for not doing much work at all. (page 3)

Ninth Grade. Students took one of three paths when it came to taking a science course in the ninth grade. Some students reported not having to take science in high school until the tenth grade at which time they took Biology (n=14). Some students claimed to be 'honor' students who were eligible to take sophmore Biology as freshman (n=12). Other students simply reported that they had to take earth/environmental science in the ninth grade without explanation about the 'honors' vs. 'non-honors' distinction at their school (n=24). I am including only those students who reported having to take earth/environmental science under the category of ninth grade science.

Students reported that earth/environmental science in ninth grade began a time when science was scheduled seven times a week; two days a week there would be back-to-back classes in order to provide extra lab time. Deanna (February, 1992) recalls her first high school science course:

Freshman year earth science... All we did was sit and listen - not only in our lecture part of the class, but in most of the labs as well. That means we sat for two 50-minute periods in a row listening to straight lecture. (page 3)

Michele (June, 1992) found these extended lecture sessions as occasions for "... my girlfriends and I to brush each other's hair, paint our fingernails, and write notes to our boyfriends." (page 2)

Andrea (September, 1992), on the other hand, found earth science to entail more than sitting and listening. "We went on field trips to see how the glaciers of the last ice age affected our geographic area, to observe the layers of rocks that were exposed when the highway was cut through (Route 93), and to understand the placement and need for land-fills and recycling centers. We had to design our own model town as a class and each group of students in the class had its own area of specialty. My group had to design the transportation system for the town. We had to keep in mind the effects our choices would have on the land, the surrounding environment and ecosystems, and also consider how our choices would limit other groups in their work, such as the housing and development group. It was extremely complicated but very practical." (page 3)

Field trips made a return in the ninth grade science program with nuclear, coal burning, and hydroelectric power plants being among the destinations. Only 2 students reported doing an experiment of any kind in his or her ninth grade earth/environmental science course although it had been reported that time had been scheduled in for this purpose.

Biology. At the time of their enrollment, 12 students were freshman; the remaining 38 were sophomores. The high school biology experiences that the students shared in their autobiographies, by far, provided the richest in-school descriptions. The major theme that ties all 50 high school biology stories together is that these experiences were "real" science, presented and done the way "real scientists" do it. Beverly (June, 1992) explains;

My "real" learning of science started when I was in high school. It all began that first day when I walked through the door to Biology class. I couldn't believe that Mrs. Florio was going to actually let us touch her things! I had never even seen or used a real microscope, I had only seen pictures. I was amazed. I learned about amoebas, plants, our bodies, cells, and genetics just to name a few. We could even ask questions in this class. We dissected worms, frogs, and other people dissected the fetal pig. Ellen, my best friend and lab partner, and I cried instead. I guess my vegetarian values started forming that day! But that was alright with Mrs. Florio, she understood. (page 4)

Marcia (June, 1992) claims that her clearest memories about science come from Mr. Pratt's biology class and proposes her good memory about this experience was "... because of all the hands-on work we did in the lab. Biology was an interesting subject for me. I could apply everything I learned to myself, everything was so relevant." (page 4)

Of the 50 stories about biology experiences, 45 portrayed hours of work each week in the lab during which time they remember preparing slides for viewing under the microscope and dissecting organisms. They also remembered working with classmates in both laboratory activities (lab partners) and in the less mentioned lecture portions of their biology course.

When lectures were described (n=20) they were called "discussions", "talks", "story shares" or opportunities where "we were allowed and encouraged to ask questions" by the majority of students. In only four cases, was biology described similar to Jackie's recollection (September, 1992) where, " The class consisted of doing reading during class and at home, filling out worksheets, and taking exams every other Friday. In class, not much biology was discussed except when we reviewed the worksheets." (page 4)

In addition to experiments, discussions, and tests, three other activities that were mentioned by students as associated with their experiences in biology were the "detailed" lab reports that accompanied the experiments, doing oral reports, and the construction of DNA models. Amy (February, 1992) describes her model;

The thing I emember most vividly (in Biology) were the DNA molecules we had to construct as an out of class project. I made mine out of appetizer picks and diced sponges. I have never had as much difficulty building anything in my life as I did that molecule!" (page 4)

Of the fifty students who reported experiences in biology, 38 went on to offer stories about their junior year chemistry class in their autobiographies. The remaining 12 students continued their stories with either college science courses or out of school science experiences.

Chemistry. A total of 50 stories depicted experiences with high school chemistry; the previously mentioned 38 who shared their stories about their biology class and 12 students who had sequenced their stories from ninth grade earth or physical science directly to eleventh grade chemistry.

Joe (June, 1992) recounts his experience with chemistry as being "...project-based, doing experiments regularly that {he} understood and could actually explain to other people." (page 3) MaryAnn (June, 1992) also found that "... mixing chemicals and forming solutions made so much sense. Besides, everything balances out – one hydrogen plus two oxygen equals water. It's finite, it's explicable." (page 3)

The students who described their experiences with chemistry in detail mentioned the two activities of memorizing the periodic table of elements and balancing chemical equations most often. Anna (February, 1992) remembers "... all those chemical equations and drawing atoms on top of circles." She continues with "... there were about seven other kids in my class who met at my house twice a week to do these problems together, that we never ended up doing right anyway." (page 4)

Other activities cited include watching demonstrations of chemical reactions, performing experiments once or twice a week, solving problems at the board in front of the class, reading the textbook, and wearing goggles and lab coats. Only five students reported their memory of chemistry in terms of writing lab reports.

Brenda (September, 1992) recalls she, ".... made peanut brittle and learned a million formulas and what happens when you spill hydrochloric acid on your lab coat." She ended her story with the question, " Are you sure there wasn't a loss of mass here?" (page 4) The question Hannah (February, 1992) posed that continues to "confuse" her was, "Why do we put salt on icy roads to help melt ice when we put salt in the ice surrounding the ice cream maker to help thicken the batch?". (page 2) The questions about scientific phenomena that students asked in their autobiographies were limited to their stories about chemistry.

Experiences in chemistry fell naturally into three categories; experiences that were described as struggles, battles, or exhaustive efforts to understand the content (n=32); experiences described as meaningful, relevant, or engaging (n=12); and, experiences that were depicted as "... just something to get through in order to go to college" (n=6).

Of the 50 students reporting chemistry experiences, 13 stated the grades that they received on their report cards for the chemistry course (two A's, one B, nine C's, and one D). Of the students reporting their grades, only the two students who received an "A" grade went on to take Physics in their senior year.

Physics . "I remember my physics teacher because I learned about levers and pressure by building things and experimenting with different contraptions. We were constantly building and exploring, a bridge for pressures, a mouse trap car for levers, a musical instrument for sound. In this class we conducted activities and then learned their application to the real world. " (Tonya, September, 1992)

Twelve of the 17 students taking Physics reported experiences similar to Tonya's. These students recall designing their own experiments; some even built the necessary equipment for those experiments. Descriptors used to illustrate their experiences in physics were "practical", "relevant", and "useful".

Two students reported going on a field trip to an amusement park to solve "real life" physics problems. Only one student described her experience with physics as one of memorizing formulas and taking notes. Three students questioned whether of not their physics teacher could speak English and made no reference to conducting any experiments or making connections between concepts and "real life" application. No student indicated that physics was a high school science course required for either graduation or for entrance into college.

College Science Courses. Thirty four students talked about their experiences with science courses at the college level. Because the University of New Hampshire requires three science courses as a general education requirement for its students, it was possible for 102 courses to be identified. Table 2 shows the 60 courses students reported in their autobiographies and their frequencies. Eighteen different science courses were mentioned by name. Eleven of these courses can be classified as Life Science courses (*) and three as Earth Science courses (+). Each of the other four courses can be classified individually as an introductory course in computer science, a chemistry course for citizens, a history of science course (Inventions) , and an engineering course.

Table 2

College Science Courses Taken by Pre-service Elementary Teachers

Food and People*	10	Botany*	6
Astronomy+	6	Geology+	5
Intro Computers	5	Human A & P*	4
Animal Science*	3	Chem for Citizens	3
Nutrition*	3	Oceanography+	3
Zoology*	3	Envir. Conserv.+	2
Invert. Zoology*	2	Biology of Aging*	1
Civil Engineering	1	Icthyology*	1
Inventions	1	Ornithology*	1

The data provided about college science experiences is disappointingly thin in description. Other than naming the courses they took and giving a brief statement about how they felt about the course as a whole, 26 students offered no specific activities in which they were engaged in their courses. They read like Kelley's (February, 1992);

In college I took Biology because we needed to take a lab science. I then took Chemistry for Citizens, a course that really was as easy as the name implied. Then I took Astonomy because I have always had a passion for it. I love to look at the stars and think about how old they are. (page 5)

Students consistently stated which of their college science courses had a laboratory component to it. Class sizes in the lecture portion of these courses reportedly ranged from 160 - 425 students. Lab sections were limited to 24.

Eight students stated they were involved in one or more of the following activities; field trips or on-site labs (n=8), taking an abundance of notes (n=7), analyzing and changing their diets (n=7), doing experiments in the lab (n=5), and taking tests (n=3).

Suzi (February, 1992) describes her college experiences;

In my Ornithology course we would get up at 4:30 in the morning and go out looking for owls. We trampled through all kinds of different habitats looking for that mysterious bird on the check list. We learned how to recognize birds in flight and even how to stuff them. In Invertebrate Zoology we played with little critters for hours and tried to identify them under the microscope. We had treasure hunts in the rocky intertidal zone at Rye Beach and enjoyed cookies and cider during exams. In Icthyology class we went on many field trips which involved looking totally stupid in a pair of waders that were three times too big for me and trying to catch some fish. (page 4)

Martha (February, 1992) remembers,

In geology, Bruce took us outside to see rock formations, he showed us slides of real places that exemplified glacial activity and evidence of shifting plates in the earth's crust. We got to feel an earthquake, and discuss what was happening within the earth's core to cause such movement and ultimately damage. We learned to identify the different rock families and explain their origins. (page 5)

Although I had asked for details, both on their first drafts of the science autobiographies and during the interview sessions, most of the students offered little additional information about their college science courses. I found this unusual, expecting the recency of these experiences to provide rich description. But then again, 46 students did not include any reference in their autobiographies to their most recent in-school science experiences .

Outside of school experiences. There were 60 autobiographies in which out-of-school science experiences were featured. Of these, 8 students limited their out-of-school experiences with science to one activity in which they are currently engaged, as adults. Examples given by these students are building a house, recycling bottles and aluminum cans, bird watching, watching television programs (ie., Nova; PBS special programming), and growing vegetables for canning and consumption. These students were among the group of 24 students who listed, without description, their science-related activities. The remaining 36 autobiographies included the kind of rich detail that Suzi (February, 1992) offers here;

Thank God for my grandfather. He made science come alive for me. Everyday was a new discovery. We visited farms with dairy cows and newborn piglets. He showed me where to find catepillars and how to care for them until they transformed into beautiful Monarch butterflies. We would go hornpoutin' with homemade fishing poles and worms we had dug up ourselves. He would let me navigate his boat out in the river while we were flounder fishing. Some days we would collect trash on the side of the road and turn the aluminum cans in for money. Other days, and these were usually my favorite, we would take long walks in the woods. We had a secret spot where we used to go to and look at the Great Blue Herons with his spotting scope. He taught me about animal tracks, edible berries, and song birds. He showed me how to clean a gun and even how to arc weld. Most importantly, above all, he treated me with respect and always answered my questions. He had the patience of a saint and took the time to explain everything he did, whether he was changing the oil in his car or filleting a fish. Gramp spent hours and hours reading to me, too. I know for a fact that the time my grandfather spent with me as a child, and even as an adult, has had a strong impact on me and my views towards science. I feel lucky to have had someone to show me how GREAT science can be. (page 1)

The number of experiences that Suzi reported having with science outside of school was among the highest of all the autobiographies. It should be noted also, that Suzi's autobiography included only those science experiences that she had out-of-school and in her college science courses. After reading her experiences with Gramp, it was interesting to see that the college science courses she chose were Ornothology, Ichthyology and Invertebrate Zoology.

There were 8 students who stated that they had never thought about their out-of-school experiences as being "science" until they were writing the autobiography. As Sandra (February, 1992) said, " I enjoyed many science experiences when I was a young child, but I didn't see them as relating to science at all. When I entered school and was introduced to 'science' I didn't equate my out of school experiences with those in school. They simply didn't feel the same to me and I didn't see any parallels. It wasn't until now that I realized the amount of science related activities I was involved in outside of school. (page 1)

Kelley (February, 1992) seemed to realize she was involved with science related activities out-of-school from an early age:

I grew up thinking Geology was a language like French or German. My parents spoke it often, especially on trips. I remember hearing them talking about alluvial fans once, and being sick of not understanding the conversation, asking them to please speak English. They would take me to places like Alaska and bring back rocks. One in particular was too big to leave laying in the camper so they put it in the engine compartment of the pick-up truck and brought it home that way. I believe we still have it. Their fascination with geology became my introduction to science. (page 1)

Kelley continued her out-of-school experiences for another four paragraphs highlighting the scientific discoveries she made at her grandmother's farm in western New Hampshire, with prisms her father gave her that she hung in her window, with broken appliances she was able to fix after an apprenticeship in her father's workshop, and on many other trips with her parents to the mountains and forests throughout the country.

The phrase, 'out-of-school' was interpreted by most students to mean 'outside'. Students reported being 'out in the backyard', 'out in the woods', 'out in the barn', 'out in the tobacco fields', ' out under the stars', and/or 'out in the vegetable garden', during their experiences. Museums, planetariums, libraries, and their rooms were also settings for some of the reported science experiences, however the majority were clearly experienced 'outside'. Table 3 lists the science related experiences that were identified in the 60 autobiographies and shows their frequencies.

Some of the experiences listed in Table 3 required a long-term commitment by the students. Some are recurrent experiences. As such, reporting the out-of-school experience of growing up and working on a farm is an experience of a different quality and magnitude than is the experience of visiting a science museum.

Courtney (June, 1992) grew up on a dairy farm in New Hampshire and she claims to ".. take for granted the animal and life science that {she} learned at a young age: baby animals being born, heifers coming into heat and having to be bred, cows giving milk, the food chain, are all examples of things {she} watched and learned about daily." (page 1) She was also a member of 4-H for ten years, and during the end of her tenure she won trips to compete in dairy cattle judging in Wisconsin and was later one of twelve finalists in a "Distinquished Holstein Contest" in Ohio. As she said, "To get there I had to be able to explain the different foods our cows eat (we're talking ratios of this and that!) and how to choose the artificial mates for our cows. There is so much science to serious dairy farming!" (page 2)

Table 3

Out-of-School Science Experiences Reported by Pre-Service Elementary Teachers (n=60)

Animal Tracking	1	Fishing	2
Aquarium (at home)	2	4-H	2
Bird Watching	3	Gardening	6
Birth of Child	1	Horse Care	4
Boating	2	Library Visits	2
Building a House	1	Microscope Work	1
Camp Fire Girls	1	Museum Visits	9
Camping	2	Reading	6
Collecting	7	Recycling	2
Computer Games	1	Science Camp	2
Experimenting	10	Sports	1
Exploring Woods	8	Star Gazing	4
Farming	10	Television Viewing	8
Farm Visits	4	Whale Watching	2

The total is 104 because some students reported more than one activity/experience.

Many of the stories featured only one or two experiences with science outside of school. Jack (September, 1992) remembered spending hours with his microscope kit that his father, who lives away, sent him in the mail. Jack never got into the telescope that his dad sent him though, ".. probably because it felt too passive and not participatory enough... not like the brine shrimp {he} raised and watched under the lens!" (Jack, page 1) He currently has an aquarium in his apartment and works at a pet store.

Denise (February, 1992) remembers her outside-of-school science experience as revolving around the book, Prove It. It was a small paperback with an orange cover that contained an array of simple experiments that required only household items to conduct. She remembers making lots of messes in the bathroom and on the kitchen table but also learned which items float and sink and how to make condensation. When she was in high school, she brought the book on all her babysitting assignments.

The summer between sixth and seventh grade was when Kelsey (June, 1992) decided she wanted to be a marine biologist. She had just watched Jacques Cousteau on television while on summer vacation at Martha's Vineyard with her parents when she told her mother of her plans. The following summer she attended Acadia Institute of Oceanography in Bar Harbor, Maine. Here's her description of the camp experience:

The camp teachers let us get dirty, they let us take home our specimens to put in our tanks, they let us talk and ask questions and do as many experiments as we could handle. If we learned about the earth's currents, we did an experiment about it in our boats. We didn't just look at pictures of whales and sharks, but saw them. The teachers got us a real shark to dissect not a plastic fake one to just show us where the parts are supposed to be. I touched its eyeballs and its teeth and then thought about its anatomy because it was right in front of me. We didn't just talk about the ocean floor but got samples and tested its pH balance, salinity minerals, etc. I still remember the first starfish I felt. I've got pictures of it in my hands right now. It was a wonderful way to discover science. I'm extremely grateful I got the opportunity to attend camp there. The more I was able to explore, the more real marine science became for me. I finally had the science I needed and wanted. (pages 4-5)

Not all of the 60 students had the opportunity to live on a farm, grow gardens, go on lengthy vacations/excursions with their parents, attend multi-week science camps, or have equipment at home with which to experiment. But every one of the students identified him or herself as a child who naturally asked questions, hypothesized about things, and wanted to test the world around them. Some students found that their outside of school experiences were the opportunities to do just that. Beverly (June, 1992) asserts, "I must admit my science education for the most part was my backyard, acres of woods, the pond behind my house, and my brother. Was it "formal" science education? No, but it was certainly the best education I ever got!" (page 1)

As can be seen, a variety of experiences with science were reported by the 80 students in their science autobiographies. Patterns of experiences emerged from the data and many of the patterns were found to be situated at particular points along their school journey (ie., seventh grade; chemistry). Still more patterns emerged from their out-of-school science experiences.

Within many of their reported experiences with science, the preservice elementary teachers identified specific contextual variables that influenced their attitudes toward science and science learning. Some of the contextual variables within their experiences with science were stated as having influenced positive attitudes; others were identified as having influenced negative attitudes. The variables that were identified, as well as the attitudes related to these variables, are discussed in the next section.

Variables Within Experiences Related to Expressed Attitudes

In order to report the variables within experiences with science that students identified as having been related or linked to their attitudes toward science and science learning, all experiences reported in each of the 80 autobiographies were considered for analysis. As stated earlier, not all autobiographies contained the same number of science experiences. For some autobiographies this meant that as few as four experiences (ie., three college courses and one out of school experience) needed to be considered for analysis. For others, it meant considering as many as eight experiences (ie., seventh grade life science, eighth grade earth science, biology, chemistry, physics, one college course, and two outside of school experiences) for analysis. The total number of science experiences reported in the 80 autobiographies that were considered for the analysis of contextual variables and their influence on attitudes was 413.

An experience was deemed appropriate for analysis when, in the description of the experience, the preservice elementary teacher identified the specific contextual variable(s) that had a direct influence on his or her attitude toward science and science learning. An example is provided to illustrate how one student linked contextual variables within an experience with science to his attitudes toward science and science learning. Neil (June, 1992) offers this description;

"... it was not until my sophomore year in high school when I discovered how exciting classroom science could be. The course was biology, and I was warned ahead of time, by other students, how tough the course was, but I was also told that he was an excellent teacher. Even though I only received a C+, it was one of my favorite classes during my four years of high school. The same teacher, who was conservative and calm outside the classroom, was just the opposite once class began. He was very enthusiastic about the subject matter and was always interested in what his students had to say. He not only valued the students' input but encouraged it from all his students. This was something my other science teachers did not do. The time spent in his classroom seemed to fly by. Experiments were conducted by the students in groups of two, three, or four. The experiments and the questions asked by the teacher helped develop my critical thinking skills and increased my curiosity for science. There were rarely any straight yes or no answers in his classroom." (page 3)

Neil identifies many contextual variables within his biology experience that had an influence on his positive attitude toward science and science learning. There was an enthusiastic teacher who valued his students and their thinking. There was the use of instructional methods that raised Neil's curiosity about science and helped him to learn science. The students in the class had the opportunity to work together in their activities, something that Neil reports elsewhere in his autobiography never happened in his other science classes. For Neil, " No other science class could compare to the biology class during {his} sophomore year, " (page 4) even though he reports to have received higher grades in other science courses.

Of the 413 science experiences that were identified in the 80 autobiographies, 353 (approximately 85%) were deemed appropriate for analysis. The 60 experiences that were not deemed appropriate for analysis were those experiences that were identified but not described in detail (ie., did not identify the contextual variables of the experience and/or a related attitude). Each of the 80 students had at least one experience that was deemed appropriate and is represented within the 353 experiences. The range of appropriate experiences for the current analysis is from 1 to 7 experiences per student.

Because a student could have reported more than one experience that was deemed appropriate for the current analysis, it was also possible for a particular contextual variable to have been identified more than once by an individual student. For example, Neil (June, 1992) identified the contextual variable of the teacher's enthusiasm for the subject twice; once in his previously mentioned biology experience and once in his story about his physics class. This situation influenced how the data are presented in this section of the report. Both the variables that were identified within science experiences and the frequency with which each variable was identified are reported. In Neil's case then, the variable of teacher enthusiasm is reported and is given a frequency of two because it was identified in two different experiences with science. What this means is that the number of individual students reporting a particular variable is not reported. What is presented with the identified variables is the frequency with which each variable was identified. This is reported through the number of positive and negative attitudes related to each of those variables.

I grouped the contextual variables that were reported to influence positive and negative attitudes within school science experiences into three categories; *Teacher Variables, Curriculum Variables,* and *Social/Peer Variables.* Table 4 shows the *Teacher Variables* that were identified as having influenced attitudes in positive or negative ways and shows their frequencies. A total of 221 links were made between teacher variables and their influence on student attitude toward science or science learning.

It is readily apparent from Table 4 that the teacher variables that were reported most often to influence students attitudes toward science and science learning in a positive way were the teacher's enthusiasm for the subject, providing encouragement for students to succeed (ie., continue taking science courses; do extra credit projects), valuing what the student had to offer to the class or the activity, showing a personal interest in the student, and being supportive of the efforts that students put forth. These five teacher variables accounted for 70% of the variables linked to positive attitudes toward science and science learning.

The teacher variables that were reported most often to influence student attitudes toward science and science learning in a negative way were the lack of enthusiasm shown by the teacher for the subject, reacting in a negative way when students responded with an incorrect or unanticipated answer to a question, discouraging students from pursuing science courses or a career in science, having no sense of humor, and showing preference to some students (unfair). These five teacher variables accounted for 47.5% of the variables linked to negative attitudes toward science and science learning.

Table 4

Frequency of Teacher Variables Identified by Pre-service Elementary Teachers as Having Influenced Attitudes Toward Science or Science Learning

	No. of Responses			No. of Responses	
	(+)	(-)		(+)	(-)
Teacher Enthusiasm	25	0	Lack of Enthusiasm	0	14
Encourages Students	20	0	Discourages Students	0	9
Values Student Input	20	0	No Value for St'dnt Input	0	6
Shows Personal Interest	10	0	Shows No Pers'nl Int'rst	0	3
Supportive of Effort	9	0	Non-supportive of Efforts	0	4
Reaction to Errors	8	12			
Sense of Humor	4	0	No Sense of Humor/Mean	0	9
Positive Attitude	5	0	Negative Attitude	0	6
Teacher Patience	6	0	No Patience	0	5
Fairness to Students	2	0	Showed Preference to Some	0	8
High Expectations	5	0	Low Expectations	0	3
Teacher Feedback	4	4			
Discipline	2	5			
Teacher Lacks Clarity	0	6			
Qualifications	0	5		(+)	(-)
Judgmental of People	0	2	Total	120	101

What can not be seen in Table 4 is the combinations of teacher variables that were identified as having influenced attitudes in either a positive or negative way. For example, Neil's description of his biology teacher showed that there was a combination of teacher enthusiasm and valuing student input that influenced his positive attitude. Combinations of teacher variables (ie., a lack of enthusiasm and responding in a negative way to incorrect answers) were also reported to influence negative attitudes. In no case was a combination of opposing or competing teacher variables such as, enthusiasm for the subject (which was linked to positive attitudes) and being negative to the student for giving an incorrect answer (which was linked to negative attitudes) identified. Within any one reported experience with science, teacher variables were identified as having influenced either positive or negative attitudes.

Admittedly, some of the identified variables could have been collasped into one heading. For example, the teacher variables of *Encourages Students* and *Supportive of Efforts,* in my mind, have similar meanings. The variables of *Reaction to Errors* and *Teacher Feedback* could be considered related, with reactions considered a type of teacher feedback. I think it is also reasonable to expect that teachers who are enthusiastic about their subject or topic of teaching to display positive attitudes; those who are unenthusiastic to display negative attitudes; those who are supportive of their students' efforts to be patient with their students; and those who are not supportive of student effort to display little or no patience. Collapsing them however, does not change the overall numbers of variables linked to positive and negative attitudes nor would it present them in the 'separate' way in which they were reported in the students' autobiographies.

I was surprised to see that the teachers' science expertise was linked to attitudes only 5 times. It could be that the level of difficulty at which the science content was presented was associated with the teacher's expertise in science content and in his or her ability to get it across (ie., clarity). It is also possible that the teacher's enthusiasm for the subject was associated with his or her having expertise in the subject. These relationships were not examined.

The number of links between teacher variables and attitudes toward science or learning science was 221. There were more links to positive attitudes than to negative attitudes; the percentage of teacher variable- positive attitude links was just over 54% (n=120) and of teacher variable- negative attitude links was just under 46% (n=101).

It is teachers who ultimately make the decisions about what the content of their science classes will be and the method(s) of instruction they will employ in their attempts to have students learn the content. The nature of the science content and the kinds of activities in which the students were engaged while learning the science content, constituted the *Curriculum Variables* linked to attitudes toward science and science learning in positive and negative ways. There were 611 links made between curriculum variables and student attitudes. Table 5 shows the curriculum variables that were identified as having been influential to attitudes in positive and negative ways. Again, it is not possible to see the combinations of variables that were reported to have been influential to attitudes.

Table 5 reveals that when the science curriculum was presented as a body of facts which needed to be memorized and regurgitated on a test or during class, students' attitudes toward science or the learning of science were influenced negatively. Lectures were also identified as being curriculum variables that were linked to negative attitudes. However, it appeared that it was the 'quality of use' of the lecture method, and not the lecture method itself, that was linked to negative attitudes. For example, students used the descriptors, "dull", "vague", "used too often", and "too long" to describe their lecture experiences. Those students who identified the curriculum variable *Discussions* may have simply called the 'effective' lectures they experienced by another name. Discussions were linked to positive attitudes 100% of the time they were identified.

In addition, when these discussions were about interesting topics and/or issues that were relevant to the students' lives, they were linked to positive attitudes. There was also a link between students having a choice as to the topics the class would cover/discuss and positive attitudes toward science and science learning. Conducting science fair projects was related to positive attitudes when student choice of the science fair topic was allowed.

Activities described as "doing" science as opposed to "listening about" science had the greatest influence on attitudes toward science and science learning in a positive way. Conducting experiments (both teacher designed and student designed) and building models were reported to make the concepts under study more easily understood, also. When describing these types of activities students often referred to themselves as scientists.

The reported absence of laboratory experiences was linked to negative attitudes. In place of laboratory experiences, listening to lectures and taking notes, reading from textbooks and answering questions, or sitting quietly and filling out worksheets, were the curriculum variables identified and these were linked to negative attitudes.

Table 5

Curriculum Variables Identified by Pre-service Elementary Teachers as Having Influenced Their Attitudes Toward Science and Science Learning

	# of Responses (+)	# of Responses (-)		# of Responses (+)	# of Responses (-)
Information to Memorize	0	44	Dissecting	36	7
Lectures	0	36	No Labs	0	38
Topics Rel'vnt to Students	32	0	Experiments		
Boring Topics	0	31	Tchr. Designed	20	3
Grades	10	20	Stdt. Designed	12	0
Discussions	28	0	Writing Reports	8	17
Interesting Topics	24	0	Field Trips	19	5
Level of Material			Demonstrations	9	13
Too Difficult	6	18	Rdg/Answ. ?'s	1	16
Too Easy	0	1	Doing Worksheets	0	15
Appropriate	8	0	Science Fair	9	6
Student Choices Included	23	0	Designing Models	14	0
Straight from Textbook	0	23	Problems at Board	0	6
Right/Wrong Questions	0	15			
Topics Not Rel'vnt to Stdts.	0	14			
Open-ended Questions	8	0			
No Student Choice	0	8			
Irr'lvnt to Topic of Study	0	5		(+)	(-)
Organization of Lesson	1	2	Total	268	343

The level of difficulty of the science content was a curriculum variable linked to attitudes. This curriculum variable-attitude link was identified at the secondary level most often, and chemistry and physics content were cited as being the most difficult. Interestingly, when the difficulty of the science content was identified, the grade(s) received in these courses was also stated. Students who reported that when they liked/disliked a science topic or area, they did well/did not do well in it made these reports with equal frequency to students who reported they did well/did not do well and therefore liked/disliked the subject. There were a few students who reported they did well in a science topic or area but still disliked it. A few did poorly in a science topic or area and still liked it. No causal link from attitude to achievement or from achievement to attitude can be stated from these data.

It was surprising to me that the use of demonstrations was not linked to positive attitudes more often than it was linked to negative attitudes. When negative attitudes were related to demonstrations, the demonstrations reportedly either did not make the related concept more clear or were presented in isolation and therefore had little or no meaning. The five times that field trips were linked to negative attitudes, the field trips were either not connected to anything that was being studied in class at the time or had no stated purpose or expectations.

The curriculum variables of solving problems at the board in front of the class and asking questions that had either right or wrong answers, were associated with the teacher's reaction to a wrong answer (teacher variable). In every reported case where these types of classroom practices were linked to negative attitudes, the students felt the teacher had embarrassed them, made them feel stupid or less confident in their abilities, made them angry, and/or influenced their decision to avoid taking science courses in the future.

Links between social/peer variables and attitudes were made fewer times than I had expected based on the amount of research that has been conducted in this area. It could be that these variables, although probably present during the times the students were experiencing science, just were not seen as influential as the teacher or curriculum variables to these students. Table 6 shows the variables within this category that were reported to be influential to attitudes toward science and science learning.

As reported earlier, a large number of laboratory experiences (which usually have students grouped together) were reported and linked to positive attitudes toward science or science learning, but links between working together with other students and positive attitudes were made only 24 times. Working in isolation from other students and working in competition with them was linked to negative attitudes toward science and science learning more often than to positive attitudes. In only two cases was it reported that the opportunity to work alone was related to positive attitudes. In four cases, it was reported that having a lab partner really helped especially during particular science activities; three cases reported the lab partner was the person who actually performed the required dissections in biology and one case reported it was the lab partner who knew what to do during the experiments in chemistry.

Table 6

Social/Peer Variables Identified by Pre-service Elementary Teachers as Having Influenced Their Attitudes Toward Science and Science Learning

	# of Responses	
	(+)	(-)
Working with Partners or Small Groups	24	0
Being Isolated from Other Students	2	17
Peer's Negative Attitude	0	10
Being Able to Share Answers	10	0
Having to Compete with Other Students	0	9
Being Embarrassed by Other Students	0	8
Being "Saved" by Lab Partner	4	0
Peer's Positive Attitude	1	0
Total	41	44

The negative attitudes of peers toward science was linked to attitude in a negative way. What should be clarified here is that no student who had previously reported having a positive attitude identified being influenced by other students to have a negative attitude. It seemed that a negative attitude already in place was simply reinforced by the peers' negative attitudes. This was the case for the students who reported being embarrassed by other students, also. Being embarrassed was associated with competition with peers in the science classroom. Competitive environments in science are seen as promoting negative attitudes toward science and science learning.

A total of 917 links were made by the preservice elementary teachers between classroom variables (*Teacher, Curriculum,* and *Social/Peer*) and their attitudes toward science. Of these, 488 (just over 53%) were linked to negative attitudes and 429 (just under 47%) were linked to positive attitudes.

The contextual variables within outside-of-school science experiences and their links to positive and negative attitudes toward science and science learning were grouped into two categories; *Significant Others* and *Nature of Experience* variables. Table 7 shows the reported contextual variables within outside-of-school experiences with science that influenced student attitudes positively and negatively and shows their frequencies.

Of the 382 links made between outside-of-school variables and attitudes toward science, 98% (n=374) were related to positive attitudes and 2% (n=8) were related to negative attitudes.

Table 7

Outside-of-School Science Experience Variables Indicated by Pre-service Elementary Teachers as Having Influenced Their Attitudes Toward Science and Science Learning

Significant Other(s) Variables	(+)	(-)	Nature of Experience Variables	(+)	(-)
Provides Materials	36	0	Independent Work	32	0
Answers Questions	30	0	Depth of Experience		
Enthusiasm for Science	28	0	Intense	24	0
Provides Time w/Student	26	0	Overview	14	0
Models Scientific Inquiry	22	2	Utility of Experience	20	0
Respects Intelligence	22	0	Level of Responsibility	16	0
Level of Communication	14	2	Group Work	16	0
Makes Relevant Connections	14	1	Integration of		
Encourages Exploration	14	0	Skills and Knowledge	12	0
Encourages Questions	14	0	Expertise Required	2	0
Apprenticeship Relationship	7	0	Pressure for Perfection	1	2
High Level of Expectation	6	1			
Patience	4	0	Total	374	8

It should be remembered that of the 80 autobiographies, only 60 featured experiences with science outside-of-school. Of these 60 stories, there were 10 stories in which a significant other was not identified. Fifty stories named one or more significant others: 10 identified mothers exclusively; 11 identified fathers exclusively; 14 mentioned two parent figures; 5 mentioned siblings exclusively; 6 identified grandparents exclusively; 2 identified a spouse exclusively; and 2 named a neighbor.

The *Significant Other* variables are overwhelmingly linked to attitudes toward science and science learning in a positive way. Providing the students with materials, answering their questions, and modelling an enthusiam for science were seen as important variables separately and in combination.

Candi (June, 1992) offers the following description of her mother explaining to her where babies come from;

I was brought up by a woman who loved science and loved to teach curiosity. When I was young (about 8, I think) I recall asking her about where babies come from and instead of getting the usual "they come from a mommy's tummy" I got a detailed explanation of sperm and ova and how a fetus develops in a woman's uterus. Then I asked about how it became a boy or a girl and got a description of X and Y chromosomes. She never thought I was too young to know sophisticated science. She must have figured if I asked, it must be time for me to know. (page 1)

Having a respect for the student's intelligence was closely associated with the level of communication the significant other provided the student. Being considered intelligent enough to learn things that adults knew was linked to positive attitudes. Providing encouragement was a variable identified in outside-of-school science experiences that was also linked to positive attitudes. Negative feedback was not a *Significant Other* variable identified in outside-of-school science experiences. In fact, the time the significant other spent with the students in the reported 'activities' was stated by many to be the best quality time they had spent in all their science learning experiences.

With so many *Significant Other* variables being related to positive attitudes, I was curious about the few times that these variables were linked to negative attitudes. These variable-negative attitude links were limited to two autobiographies. The two students, William and Robert, who identified the variables within out-of-school experiences as having a negative influence on their attitudes toward science, identified their fathers as the significant other. Both of their fathers were, in their words, stereotypic scientists. One was a doctor, the other an engineer. William and Robert depicted images of their fathers in solitary work, spending hours behind closed doors, and providing a level of communication that was not useful to their own learning of science. They admit their fathers were both highly successful in their fields, but failed to model the kind of scientific inquiry that they wanted or needed. The perceived need to be perfect in their respective home environments influenced their negative attitudes toward science. Unfortunately, neither Robert nor William reported having good science experiences at school to counterbalance what they experienced at home.

The *Nature of Experience* variables were also found to be overwhelmingly linked to positive attitudes. The independent nature of outside-of-school science experiences was one variable linked to positive attitudes. The freedom of choice to investigate areas of personal interest (ie., insects; rocks; flowers; water) was associated with this variable. This sense of freedom was expressed whether or not a significant other was present during the experiences.

The farming and gardening experiences that students shared depicted these experiences as being both useful to the family (Utility of Experience) and requiring a high degree of responsibility from them. Whether it was caring for animals or being in charge of the vegetable growth for the season, these students had a need to learn 'real' science. Kymberly shared her need to know this way;

I was in charge of the horses when I was eleven years old, so I had to learn the workings of these magnificent creatures, not simply ride them anymore. From head to toe I had to know these horses: all the parts of the body, major muscles, parts of the eye, diseases, and how to care for and feed them (which is a science in itself). They were *my* responsibility. (page 6)

The science content that these students reported to have learned was not seen by them as representing separate areas of study such as, botany, entomology, and chemistry. When Sandra (February, 1992) wrote about her responsibilities in the garden (at age 10) she stated she had to know about soil composition, growing cycles, and pestilents as they interrelated one to the other, not independent from each other, in order to have a healthy crop and a productive season. Again, she reported that she had a responsibility and was entrusted to fulfill it.

I was somewhat surprised to find no difference in the influences of having a few overview experiences (ie., one trip to a museum and going on a whale watch) and having an intense long-term experience (responsibility for the garden for 6 straight summers) on their attitudes. Both kinds of experiences influenced positive attitudes. The influence of the significant other in the experience may be more important overall than the depth of the experience. The difference in the amount of science terminology used in describing their experiences was substantial, however. Those with a depth of experience exhibited a depth of knowledge that those with only overview experiences did not.

Overall, the experiences with science that the preservice elementary teachers had outside of the school setting influenced their positive attitudes toward science and science learning to a greater extent than did their science experiences in school. There were some similarities between the two kinds of experiences, however that should be recognized. When teachers and significant others displayed an enthusiasm for science and were encouraging of the students, positive attitudes were fostered. When the science curriculum in school and nature of the outside of school science experiences had students "doing" science, positive attitudes were fostered. It will be interesting to see which of the in-school and out-of-school variables these future elementary teachers will incorporate into their goals for teaching science.

Their Goals for Teaching Science in the Elementary School

I asked the students to include in their autobiographies, a statement about how they see themselves teaching science at the elementary level at this point in their teacher preparation. Structurally, 76 of the 80 autobiographies concluded with these statements, written in the form of teaching goals or behavioral intentions. Rarely did the students declare an action plan for the goals they stated. I think the rudimentary nature of these goals should be expected if we keep in mind that they were writing these goals as they began the formal study of elementary science pedagogy.

When stating their goals, many students made specific references to experiences they had described in their autobiographies. Several of the goals say as much about what they will not provide in the way of science experiences for their own students as what they will provide. Kris (September, 1992) offers her reflection:

"In thinking back on my experiences, it is not hard for me to understand why I can remember moving rocks in a brook to create a dam, but have no idea who taught fifth grade science. I enjoyed the hands-on experiences because they were real to me. Sitting in a classroom reading about the atmosphere of planets, I did not feel any sense of relevancy. I learned and memorized the information for the test and forgot everything soon afterward. I gained no appreciation for the natural world; I just learned to dread science class. My students will remember who taught fifth grade science and how they learned it because it will be hands-on and relevant." (Kris, September, 1992)

The elements within stated goals that students included most often were hands-on activities and personally relevant or 'real life' experiences. Sandra (February, 1992) relates her classroom goals for science to her outside of school experiences:

As I look back over what I've written, I can see why it was so easy for me to remember so many childhood science experiences. I was provided with an environment which encouraged a hands-on technique of learning about science. I was given the opportunity to conduct experiments and to see and do things first hand. As a teacher I will create an environment similar to the one I had. Science in school can and should consist of the types of experiences I had outside of school. (Sandra, February, 1992)

Steve (June, 1992) indicated early in his autobiography that science seemed to be afterthought at his elementary school, getting squeezed into the schedule if time allowed. The remainder of his autobiography revealed how his lack of success in his high school science courses turned him off to pursuing a career in the health field. His science teaching goals are clearly related to his past experiences. He contends:

Science in my classroom will not be taught in isolation, as a separate subject that gets placed in the afternoon schedule if there's enough time. I will integrate science more with other subjects throughout the day especially with reading and writing. I will provide activities that have students feel successful, building the self-esteem necessary to avoid the apathy about science that I felt (page 6).

Meg (September, 1992) intends to engage her students in exploring topics that are of personal interest to them, another way of providing relevant experiences. Group work is also included in her goals, as it is in 54 other autobiographies.

Not one of my teachers asked me what I wanted to learn and what I had questions about. I remember flipping through the textbooks we received at the beginning of the year, skimming through the pages, looking at the activities and checking out the pictures. There were always sections that caught my eye, but we never studied those sections. I will find out what my students are interested in and what they want to know more about and plan my program around the concepts involved in those topics. I will also have them work together to communicate what they are learning from the activities and to learn from each other. (Meg, September, 1992)

Fifteen students identified that their science teaching would be modeled after their most effective science teachers. In addition to hands-on activities and 'real life' experiences, these students included goals about developing critical thinking and providing a safe environment in which to explore new or difficult concepts. Three examples follow:

I believe I can learn alot about how to teach science by remembering the lessons of my best high school science teacher. There are three critical techniques that this successful science teacher used. First, she engaged us in hands-on experiments which excited and inspired us. Second, she followed up on those experiments by helping us draw conclusions and make critical connections between our thinking and our observations. Third, she used many real-life anecdotes that showed us how meaningful our studies were. These are techniques I will use. (Helene, February, 1992)

I want my students to remember me the way I remember Sister Lillian. A little off-beat, unconventional, and exciting. She made me feel good even when I got the wrong answer, the important thing to her was *how* I got my answer. I also want my students to remember the concepts and answers to questions that we learned together like I remember from her class. I want to instill the hunger for knowledge, the need to know, in all my students that she instilled in me. (Arlene, February, 1992)

I hope to share my enthusiasm with the life sciences with my students just as my college professors did with me. I can definitely [sic] see myself teaching with a discovery approach. I want my students to have as much hands-on experience in learning science as possible. I know there are many different types of learners, but I think everyone benefits from experiential learning. As long as my students feel like they can take risks in a safe environment, I think we should be able to explore science and have fun at the same time. (Suzi, February, 1992).

Due to her science history, Fran (September, 1992) doesn't believe she knows very much science and believes "... it will be a challenge for {her} to be a successful teacher of science." However, she said it is her lack of science knowledge that compels her to build a better science background for and with her students. She hopes to develop an exciting and hands-on approach to teaching science in which she will be learning concurrently with her students. Other students (n=9) feel similar to Fran and a selection of goals related to this feeling of content knowledge inadequacy is provided:

I do not feel competent with the subject nor am I particularly fascinated with science. I guess it isn't written anywhere that I must know this subject like the back of my hand. Maybe I could just create a yearning within my students to want to find out more about a topic and their excitement could motivate me to find out more, too. All I know is I do not want to pass on my fear and lack of enthusiasm for science. (William, June, 1992)

I wish I had experienced science differently in high school. I don't feel that I learned much at all and I also avoided taking Physics because of my dislike for Chemistry. Due to this I feel my background is insufficient in these areas. My biggest fear is that this will affect the way I teach. I sure hope the activities we do and the experiences we have in this course will make me feel better about teaching science next year. (Carrie, June, 1992)

It is probably fairly obvious that science has not been a very positive part of my education. But, I think I'm looking forward to teaching science because it will be an opportunity for me to actually learn science. I requested a book of science experiments for Christmas and I hope to try some of the things out with my students in the class I'm interning in right now. I hope I will develop a positive attitude about science... soon. (Donna, February, 1992)

Science fascinates me, but that is not to say I understand it. Through the years I have convinced myself that I do not have the mind to deal with scientific matters. As a result I gave up trying. I still enjoy the talks I have with my friend Bryan, the science whiz, because he takes the time to explain and I know that I am not being graded on my comprehension. If you had asked me a few years ago how I plan to teach science in elementary school I would have said, "However the teacher's manual instructs me to!" However, after taking my other education courses, I think at this point I will integrate science with the other subjects until I know more about how to teach science by itself. (Karen, September, 1992)

There were many variables within the students' science histories that influenced their goals for teaching elementary school science. The first was the use of hands-on activities, seen by them as one of the best instructional methods employed by their science teachers. Their goal is to design memorable learning experiences with science for their students through the use of hands-on science activities and programs. The second variable that influenced their goals was the use of relevant 'outside of the classroom' experiences with which to connect concepts that are introduced inside the classroom. Their goal is to present relevant topics and concepts in their "real life" applications. The third variable was a safe environment in which students can share their thinking instead of being made to feel stupid or embarrassed. Their goal is to avoid harming a student's self-esteem. The fourth goal had to do with their perceived lack of content knowledge due to their science histories. Although no action plans were described, they held great promise that both the elementary science methods course in which they were enrolled at the time they were writing the goals and their future students would help them learn enough science to present accurate and clear information.

Case Studies

The following four case studies include all of the science autobiography information provided by four students, Melissa, Melanie, Robert, and Evelyn. I present each story in its entirety without altering the sequence of events as written by the students. An introduction of each student precedes each case study. A commentary highlighting the most significant features of each student's experiences follows each case study.

My intention in reporting the students' science autobiographies without interrupting comments is to portray a seamless image of each student as the meaning maker of his or her own experiences. As the students document their past experiences with science and describe the meanings they have made from them, the individuality of each student becomes readily apparent. At the same time, several of the patterns derived from the 80 autobiographies become evident in each of the four case studies but are seen in the context of the whole of their experiences. As should be expected, none of the four case study autobiographies contains every pattern that was outlined earlier. Collectively, they reveal the most prominent themes related to the influences of contextual variables on expressed attitudes toward science, science learning and science teaching.

Intertwined with their comments about their experiences with science are their self-reflections about their learning within those experiences. The efforts that they put forth to connect their own learning history to the knowledge they have gained in other education courses to is also apparent.

Melissa

Melissa is a first semester senior majoring in English. She plans on applying to the teacher education program at UNH later this fall and hopes to teach at the primary level, either first or second grade. Melissa, at age 20, is single, lives off-campus with three other women and works part-time at a local outlet store. In my class, she consistently sat next to Meg. It turns out, Melissa and Meg have been best friends since junior high school and they have taken pretty much the same course in life (ie. the same courses in high school, the same college, a career in elementary teaching, the same current address).

Unlike Meg, Melissa chose the interview/autobiography option for writing her story. To the interview she brought what she refers to as "the suitcase". Her pride in this collection became more and more evident with the unpacking of each new artifact. I didn't mind that we had unsustained eye contact most of the time - her focus was on the examples she could give as evidence of an event she had included in her story or for an interpretation she had made or was making during the interview. As she unpacked, I was conscious of her organization of "the evidence". Her science history unfolded chronologically on my desk, in the same way it appears in her autobiography.

Some people don't do windows. I don't "do" science.

(Melissa; September, 92)

I never thought about my dislike of science in any depth before; I just accepted it as a part of me. Some people don't do windows. I don't "do" science. But, why? Was I born without the ability to think scientifically, with a natural propensity towards English? That's how it works, right? You're either an English/history person or a math/science person. Everyone knows you can't be both.

Being an interactionist by nature, I am leery of assigning all of the responsibility to biology. Surely the environment must play a part in learning, otherwise, what's the purpose of school? I also know that early experiences in childhood help shape the growth in subsequent years. However, I never thought about my own experiences in this way.

Naturally, the most accessible memories are the most recent and the most defined. But what were my science experiences in early childhood upon which all subsequent experiences have been built? Knowing my memory would not retrieve distant experiences without tangible stimulation, I dug into the suitcase of my school life. Trying to make some sense out of this, I decided to organize the documents of my development chronologically. So now, let us trace my development from early childhood to the present to discover how I arrived at my dislike for science.

The earliest documentation that I possess is a worksheet from second grade on John James Audubon. The objective was to find the hidden animals in the picture. Not scientific in the true sense, but it was an exposure to a historical, scientific figure and his contributions to society. I had limited exposure to science during second and third grade, and the information I did receive was from similar worksheets. I remember science was worksheets and textbooks with information to memorize.

Fourth grade marked the beginning of my career as a scientific researcher, as I wrote my first research report. It was on the "great Purple Hairstreak," or so the title says. Actually it is on butterflies in general and doesn't say much about the title character. Another report I wrote that year was on the Red-Winged Blackbird. I remember the most important part of doing this report was the title. I spent hours thinking it up: "...And now for a beautifully colored bird, the Red-Winged Blackbird!" In my mind, I was an announcer introducing some celebrity. I didn't care about the rest of the report. I enjoyed the creative part, t he freedom of expression. As far as I knew, that didn't exist in science. I remember I simply reordered the sentences in the encyclopedia and changed only a word or two. Did I know where Nova Scotia is, or what "gurgling" means? Was I comprehending anything that I wrote, or was I simply going through the motions? Did science have any meaning at that point? Sadly, I know the answer is, "No!"

My first memory of practical, hands-on experimentation is also from the fourth grade when I was introduced to magnets. I remember discovering the polarity of magnets, their attraction to opposites and their tendency to repel similar poles. In addition to the pile of magnets, we were given iron filings and I made line designs and pictures. I think I remember this experience because it was the first experiment that *I* controlled. I can't remember that we had any special procedure to follow and I have no worksheet here in the suitcase saying what to do. I think we just got to play with the magnets and the filings which resulted in the pictures I drew and have in front of me now.

Fifth grade. Another year, another report. This time it was on the Siamese cat. I learned how to write an outline and bibliography, as well as compile information from various sources. But again, the main focus of my attention was the picture I drew on the cover. Art was my thing then and I was more excited about drawing than researching.

Middle school brought a more in-depth study of science, including the dreaded science fair and lab reports. Science became increasingly technical, and much of the information went "over my head". Looking at my report cards, it was my worst subject, earning me only Bs and Cs. This was very frustrating for a conscientious student like myself and the division between between me and science widened.

In seventh grade, the teacher made us dissect frogs and I hated him for it. The formaldehyde smelled, the poor frog was dead, and I may as well have been the murderer. The insides of our frog did not even remotely resemble that in the lab manual. I could not distinguish the kidneys from the lungs. What was I gaining from cutting up a frog anyway? Practice with a dinner knife and a guilty conscious?

That year, my science project was a report on chiropractic medicine. I remember not being able to think of a topic and choosing this one after my father made his visit to the back specialist. This report has a table of contents, glossary, appendix and bibliogaphy. The form is good, the content is weak. I wonder if this is when I started to be so form conscious and more concerned with syntax than content. I decided I was too old to decorate the cover, making a clay model of the human spinal column instead. Besides, I had to present my report to the whole class so I needed something to show. The oral presentation was tragic, my worst nightmare. The fear of public speaking, so common in the middle school years, combined with my disinterest in the technical, factual part of science, was a deadly pair. My model was good, but I hadn't learned anything to share. I was knocked down before I entered the ring.

The second paper that year was a group project with Meg. We researched the Mesozoic Era and were proud of our accomplishment until we received the graded paper. There's nothing more disappointing than getting an 85% on a paper you feel you have devoted all of your time and energy to. The only comment on the paper reads, "Your report was informative but it appeared to be just a reporting of facts." How was this meant to help? That's what I had learned from the first experience - know the facts when you do a science report! This pushed me further away from the subject and the teacher for quite some time that year.

A bright spot in the seventh grade was the trip to Bear Brook State Park. The entire cluster (1/3 of the entire seventh grade) went on a camping trip for three days. We learned survival skills, including first aid, shelter building and cooking. We went fishing and swimming, we watched stars and picked flowers. The classroom teachers were there, but they were not the teachers here. The Park teachers made everything exciting. They asked for our questions. They helped us figure out the answers by looking, touching and doing. The most exciting event for me was the "bog jog", a day's hike through knee-deep swamps and marshes. We listened to a talk about their formation and experienced their mushy mud through our sneakers. It was the most memorable "feet-on" experience I ever had.

Eighth grade marked the beginning of what I call my "interpersonal science" experience. By this I mean the teacher was becoming an increasingly important and positive element in my education. My earth science teacher, Mr. W. was a caring individual, able to read the blank faces of confused students and willing to take class time to redirect us. He was concerned that we understand the subject matter and took various approaches to be sure we understood the content. For example, he would ask a student what he or she already knew about the topic and then ask the rest of us to add to it in own words. He would then write what we said on the board. He usually drew pictures to make sense of the concept and planned an experiment for the next day to make the concept even clearer. Science, although still difficult for me to grasp at depth, was slightly easier to accept because I felt supported and encouraged.

It should come as no surprise that my chemistry teacher taught in a similar manner, Mr. Watkins had been Mr. Robinson's student teacher many years before. Mr. Robinson was less directive with his teaching, as he grasped for the thinker in all of us before presenting any information. He felt a student would understand and remember a concept better if he had discovered it for himself. I found this frustrating at times, but never impossible, as Mr. Robinson was constantly encouraging me that I could think for myself. "Keep plugging away, Melis!" With his support, I continued my college prep studies and enrolled in physics the next year.

Unfortunately, Mr. Monty's class became the straw that broke my aching back. Here was the classic madman scientist, evasive in all of his answers, rational beyond belief. I swear he never heard the question that was asked because he would repeat what he had said before the question was asked. His favorite word was "explain" and he would remind us that when we answered his questions we must explain everything we said. One day he threw an eraser at the blackboard before we started a test and shouted, "EXPLAIN!" Clearly this would frustrate a student who already felt alienated and estranged from the science world. He was not helping matters any. The next course in sequence was Physics II with the mad scientist. I was no fool.

During this same time, I became interested in science outside of school. Perhaps I was unconsciously filling a void in my academic life of just continuing in the area of science I felt most comfortable, chemistry. I chose an after-school job in a pharmacy, assisting the pharmacist in filling prescriptions. I played with the idea of becoming a pharmacist but as the pharmacist taught me more, I realized how much there was to know. I was amazed that this job demanded eight years of college and the knowledge equivalent to a PhD. I immediately discounted myself from ever being able to understand that much.

As I read this over, it seems as though I blame my teachers (except Mr. W. and Mr. Robinson) for my lack of knowledge and positive experiences in science. While I was in school, however, I did not blame my teachers. I always felt that there was something deficient within me, something that prevented me from being science-literate. I used this as an excuse for my poor performance. After all, would anyone like to admit they weren't doing their best because of reasons within their control?

In college, I've taken three science courses for my gen ed requirements. I tried to pick the easy ones based on what other students had experienced. In the process, I've had my eyes opened to scientific thought and my knowledge base has expanded. In oceanography I learned that biology, chemistry, physics and geology are interrelated - I never knew that. In botany, I learned more than I ever thought I'd want to know about the moss on the south side of our house. In environmental conservation, I became aware of the problems that plague our planet and other people's solutions to them. I'm aware that some of my behavior contributes to these problems and have taken certain action to be less wasteful (ie. recycling glass and cans and delivering them to the Center; keeping lights off and shades up when the sunlight is enough to read by).

Reviewing my past has helped me start thinking about the kind of teacher I want to be and kinds of experiences I hope to be able to provide for my students. I've also been thinking like the second grader I was at home, the one who loved nature and animals; the one who was an avid tree climber, gracing the limbs of willow and apple trees.

Each night at dusk, when I was seven years old, I was armed with a baby food jar, holes punched in the cap, ready to house fireflies. Their lights amazed me. They were signs of summer, live lanterns. That year, I remember being introduced, along with my family, to my first example of ecology and interdependence among species. The predator was gruesome and evil: the infamous gypsy moth. I was disgusted by the vile nature of this fuzzy creature, even more so by its green guts. I did learn however, that every living thing makes an impact on every other. I was acutely aware of the life around me back then and I observed it with wide eyes and open ears.

Through reviewing my past experiences with science, I know that I want to avoid providing the kind of disastrous science education that I experienced. I say disastrous because, for the most part, during the early years I felt unmotivated to learn science, was not given many opportunities to explore and discover concepts, and rarely did science come across as enjoyable or relevant to me. Instead, I felt I could not do well in science because it was too complicated for me to understand. I learned that most of my questions were viewed by teachers as public admissions of my ignorance and not as my attempts to better understand the subject.

I hope to define science as a way of looking at the world, as a discovery, exploratory thought process. I want each child to retain his curiosity, wonder and excitement. I want to foster their awe of nature and feed their hunger for exploration. I want to keep the observer inside alive and encourage the participant to come out. I want to do this by valuing each individual learner, instilling confidence and a sense of pride. I want to build a classroom community where ideas can be expressed freely and safely. I want to encourage them to think critically by seeing that there is no one way to do something or think about something.

Science in the elementary school has got to be more than the research I encountered. Children should be exposed to science that places the student first, not the content. When content is presented, it should be relevant to the students' lives, and not just their lives in the classroom.

Melissa spent some time "warming up" before describing her experiences with science in school and explaining her dislike of science. Her story is rich with description and reveals her attempts to make sense of these experiences and find her place in them.

The elementary years held memories of worksheets, textbooks, facts to memorize, and many meaningless reports to write for Melissa. While she loved the freedom of expression, she found only drawing a couple of pictures and sculpting a model as isolated means to incorporate her creativity into science. As she said, creativity and science didn't seem to go together.

Melissa was one of the few students who really disliked dissecting organisms. Combined with information that was presented at a level too complicated for her to grasp, negative and useless feedback, and a disastrous oral speaking exercise, meant she spent the first seven years of school having had only two positive experiences. The field trip experience had many of the variables identified as influencing a positive attitude, but it was an isolated event.

She did have two teachers who influenced her attitude toward learning science in a positive way. Through encouragement, support for her efforts to understand the material, and by providing a mix of activities in which Melissa could learn the material, she started to feel better about science and about her own ability to learn science. It was unfortunate that she ended high school science on such a sour note with a teacher who was not receptive to her questions. Even after two years of very positive experiences, she felt she should take courses that were not overly difficult.

She intended to choose easy courses in college for her general education requirements. Maybe they were easy, we can't be sure. We know she feels she learned quite a bit in those courses, but we have no sense as to what the activities were in the classes or the teacher variables that may have influenced her attitude or her achievement.

Melissa started her story by saying she disliked science. Yet, we know she had a couple of teachers along the way who exhibited the kinds of behaviors and provided the kinds of environments that have the potential to influence positive attitudes. The negative experiences she had early on were hard to overcome. In many ways, her story reminds me of Norma, who's story of Mr. Wilson, got me started on this research.

Melissa appears to be more willing to remove the image of herself as being somehow genetically science disabled and is looking more closely at the influence the teachers and their curriculum choices had on her current attitude. She seems to be looking at her past experiences with a perspective different from how she has previously viewed them.

Her goals for teaching science in the elementary school are reflective of her past history with science at that level. She recalls the child who was curious and full of wonder chasing down fireflies at home but who was not engaged in any activities in elementary school that raised her curiosity, (save the magnets in fourth grade). The greater influence on her goals are from her two best science teachers, the ones who valued her efforts, tried to instill a lost sense of confidence, and encouraged her thinking in an emotionally safe environment.

Melanie

Melanie is a first year, first semester graduate student in the M. Ed. program focusing her studies in elementary education. Her undergraduate degree in Family Studies was earned at UNH. She has elected to take courses this academic year, post-poning her full year internship in an elementary school until next year. She has lived in New Hampshire all of her 22 years, lives at home with her mother and maternal grandfather, and commutes fifteen miles to campus each day. She has one sibling, an older brother Tim who no longer lives at home.

I remember two things about Melanie from the first night of class. First, she's the only student I have had who has both asked the question, "Are we going to be doing any physics in this class?" and shreiked with delight when I said that we would be. Second, I was unusually aware of her eyes being fixed on me; they followed me everywhere in the room for a full two-and-one-half hours. While I am not sure how well she could repeat anything I said that night, I am confident that she could describe me, my immediate classroom surroundings, and the props I used *perfectly.*

> Mr. Davidson was my (physics) teacher, and boy was he a good one. He was always in a good mood - problems outside of the classroom were just that. He looked a lot like a tall, brunette, Bozo the Clown, but was a lot funnier and lot more interesting. He was a very patient teacher who explained things thoroughly and clearly, and encouraged people to ask questions. He was always willing to give his free time to students who were confused or who wanted to learn more.
>
> (Melanie; September, 1992)

For me, science has been a mix of experiences. Sometimes things were fun, other times things were not so fun, and other times were not memorable at all. Unfortunately, I cannot comment on my science experiences between kindergarten and the fourth grade simply because I cannot remember studying anything science related. I'm not saying that it wasn't studied, I'm just saying that it did not have any impact on me because I do not remember a thing about science during that time period.

In fifth grade I had a teacher named Mrs. Donahue. We used to call her Mrs. "Donapu" because we thought she was vain and "pooh-poohed" anyone and anything that was of no concern to her. I remember doing a lot of ditto sheets and other forms of busy work in her class. The one memory of her that sticks out in my mind is her can of static guard. She could be in the middle of handing out an assignment and drop everything because her skirt was clinging to her - her perfect appearance was being wrinkled. I was so glad it was Joe Gould who asked her how the static guard worked because not only did she not tell us, she made Joe stay after school.

My sixth grade science teacher was Mrs. White. She was a heavy-set, fifty-year-old science fanatic who made class challenging, yet very stimulating. She wanted us to be just as enthusiastic about science as she was. She never played favorites - she made sure that each student had at least a grasp of what we were discussing before we moved onto the next topic. I remember studying rocks and minerals, and having to do a report (with visuals) on a rock/mineral of our choice. I chose mica. She noticed that I was intrigued by and interested in mica, and gave me a fairly large piece to keep. She wrote me an encouraging note at the end of that school year, and passed away shortly after. By the way, I still have that piece of mica and the note.

The science teacher I had in the seventh grade was Mr. Petro. He was a fun, understanding, and easy teacher. I had fun while my partner and I dissected a worm and a fish in his class. He made us understand what we were about to do (set a purpose) and made it interesting enough to me that I lost my initial squeamish thoughts. I also remember doing "blue questions" as homework. "Blue questions" were the blue printed questions in the right hand margin of our science textbook. We had three weeks to read an assigned chapter and do the blue questions. He gave us plenty of time to do our homework.

One event that happened in relation to Mr. Petro that has me say he is understanding was the day I received a note from a friend who was passing by my classroom. The hallway monitor (a teacher) grabbed the note, brought it to Mr. Petro, told him what had transpired, and that he ought to read it in front of the class. I was mortified at the thought. Luckily, Mr. Petro was kind - he handed me the note and smiled. I couldn't thank him enough.

My eighth grade teacher, Mrs. Shelby, looked a little like my fifth grade teacher, minus the self-awareness scam. She handed out a lot of ditto sheets and she played favorites. I remember this didn't bother too much because I was one of the lucky few. What I remember most about Mrs. Shelby is that she was a very moody person. Once, in the middle of a story she was telling and we were enjoying about the time she and her boyfriend were kissing and their braces locked, she turned into this psycho-beast from hell. She started yelling at us to stop talking and get to work and then passed out one of her many busy-work packets. Her mood swings were unexplainable and unpredictable. I remember thinking back then that she wasn't pregnant and nobody has her period year round.

When I got to high school, students were allowed to choose their science courses. We were required to take only two, but considering the fact that I wanted to go to college, I took four. Although I had the choice of which science courses I wanted to take, I did not have an option of which teacher I wanted. I don't know of too many students who have that option, but my gripe is that all of the A level (college preparation) courses are assigned to one teacher, all of the B level to another, and so on, instead of assigning assorted levels to teachers. That way, if you got placed with someone, for example, who you just couldn't learn from, you had the option to switch teachers and not levels.

For my freshman year science course, I took Environmental Science with Mr. Orwell. He was neither a good teacher nor a bad teacher - I feel pretty neutral on this one. I remember taking a field trip to the Seabrook Nuclear Power Plant during the time we were studying electricity and energy. I don't remember that trip as a science learning experience, rather I learned about freedom and control. We all walked around aimlessly and did almost anything we wanted to do. We had no assignment or focus for this trip and we didn't talk about it when we came back to class either. In fact, I remember little in terms of science that year.

My sophomore year, I had the misfortune of having Mr. Meyers as my biology teacher. On the first day of class, he went around the room trying to get to know people. He would ask if so-and-so was someone's brother or sister and comment on what a good student or nice person their sibling had been. When he got to me, he asked me if I had a brother named Matt. I said no. Then he said, and I quote, "You're not Tim Edwards' sister, are you?" I said yes, and he moved on to the next person after he sighed in disgust. My brother was a bit of a trouble-maker in high school, but he is still my brother and I love him. I didn't appreciate the assumption that I was going to be exactly like him. I didn't really help my case any when I interrupted him and said, "Is there a problem? My brother is Tim Edwards and I have no problem admitting that. I do have a problem with your display of disgust, and even though I love my brother, I resent being compared to him because I am a totally different person." I never liked the man from that day forward and he never showed me any warmth either. Fortunately, he was hardly ever in school that year - he was too busy being arrested for protesting the nuclear power plant. He was obsessed with closing the place down and would consume class time talking about his views. Many of these spontaneous lectures would start right in the middle of some other topic we were discussing. He even gave us tests that we would fail if we tried to argue a different position on nuclear power. This teacher and the next teacher I am going to discuss are my two least favorite teachers, not just science teachers but in general.

Mr. Neally, the jerk who should have been working for NASA and not teaching, was my Chemistry teacher for the first semester of my junior year. The material he taught was college level, not college prep. He had absolutely no patience for any student who did not immediately understand what he was talking about. He made me feel stupid for asking the questions I dared. It only took me a few times being told in front of the class that my question was "so easy a child could answer it" and that I was "so stupid" that I didn't belong in the A level class before I stopped asking questions. I held out as long as I could. I switched at mid-year.

What I remember most about Mrs. Cashman, my B level Chemistry teacher for the rest of that year, was her patience. She never went onto another topic or even a more difficult level of the topic we were studying until everyone in the class understood what was going on. I remember feeling somewhat frustrated with the brakes being put on so rapidly, but at the same time I was relieved to have a teacher who did not tell me my questions were stupid and that I was stupid. Mrs. Cashman took her responsibility as a teacher more seriously than Mr. Neally, or she just saw her responsibility a whole lot differently.

The science course I took in my senior year was Physics. Mr. Davidson was my teacher, and boy was he a great one. He was always in a good mood - problems outside of class were just that. He looked a lot like a tall, brunette, Bozo the Clown, but he was a lot funnier and lot more interesting. He was a patient teacher who explained things thoroughly and clearly, and encouraged people to ask questions. He was always willing to give his free time to students who were confused or who wanted to learn more. He also gave out special study guides and helpful hints for assignments and tests. He had a special system that encouraged students to participate. These round pieces of wood with the word "TUIT" printed on it (when I get around to it) entitled the recipients to extra points for any assignment we chose. These "tuits" were handed out not only when a 'hard' question he asked was answered correctly, but when we asked a good question or helped each other try to figure out a problem. We solved many problems together that year. These problems were the highlight of the class and we were always rewarded for our efforts. For example, one of our assignments was to build a bridge out of cardboard and glue that weighed no more than fifteen ounces when it was completed. Each person in the group designed and built a bridge and then the group took the best qualities of each bridge and made a group bridge. Each group received a certain amount of tuits based on the amount of weight the bridge could hold with the group who's bridge could hold the most amount of weight getting the greatest number of points.

One of our end-of-the-year field trips was to an amusement park at Canobie Lake. We had a packet of questions and experiments to do - finding the height of the tallest peak on the roller coaster, defining centrifugal force, finding how fast the log ride was traveling down the last drop-off, etc. We had a blast! It was also the first field trip my mother chaperoned which made it even more fun for me! I would have to say by far, I learned the most science, had the most fun, and felt the best about science in Mr. Davidson's class.

College science courses were not my forte. In fact, these courses and my math courses are the courses that have had the greatest negative impact on my grade point average.

During my first semester at UNH, I took Food and People (aka: Food and Dudes) with Mr. Swift. The class had 425 people in one lecture hall, a big change from the physics course which had 16 students. The class was split up into smaller lab sections (approximately 24 students per lab), but I was always known as 022-46-3249. We took a lot of notes during lecture and Mr. Swift ran through these faster than I could write let alone understand. Even in the lab classes, none of the work was hands-on, unless you count the computer work that simulated what could have been fun and interesting as an experiment.

I took Oceanography with Professor Bronson because it came highly recommended by my friends. I later found out that I could have taken Geology, something I was always interested in. The Oceanography class was smaller than Food and Dudes (approximately 160 students) but it was an intense course. There were fewer notes, they were more complex, and there was alot of bookwork. I liked this course for a couple of reasons, however. We went on an interesting field trip to Dover Point where we rode on a boat and collected and studied material from the floor of the bay. I could actually see what it was that Professor Bronson was talking about in lecture and I did better on the test that came after this field trip. I went to Professor Bronson and told him that I was having trouble with the other tests even when I studied hard and long for them. He gave me some helpful hints about how to approach his tests, told me to come back anytime, and told me he appreciated my effort. I chose to go back for some help before the final. At the end of our study session, he handed me a miniature Chunky candy bar and said, "I have confidence in you. All you need is a little more confidence in yourself." The highest grade I earned in that course was on the final exam.

The third and last science course was Plant Biology with some professor. I don't even remember his name which is about as much as I can say about the course other than that I have two notebooks filled with notes and no recollection of doing any lab work at all.

As far as my out-of-school science experiences, there are a few things that stand out in my mind. First, I learned how to garden from both my grandfather and my mother. I know the proper way to plant many different flowers and vegetables and I know how to test soil for acidity level and drainage. I know how and what to weed and what signs to look for to tell when vegetables are ready to be picked. Our gardens were a family affair and we each had particular jobs to do in them. Second, I learned the affect the sun has on dirty blonde hair when lemon juice is added to it and what my mother had to say about my experiment. Third, I learned what happens to a bowl of unfinished ice cream that is stashed away under a bed for two weeks.

I see myself doing activities with elementary age children that have them actively working with their hands, their minds, and each other. I want them to be interested in what they are doing because it is personally meaningful to them. I want them to feel safe to ask me questions and trust that I will not humiliate them or make them feel stupid or believe they are unable to think or do science work. I want them to say they 1) learned science; 2) liked what and how they learned science; and 3) can give specific examples of the activities and concepts they learned (with me).

Melanie used thick description effectively. She described the physical characteristics of her science teachers in such a way that I could picture them in my mind. This was a characteristic of her autobiography dissimilar to most of the other seventy-nine narratives.

Melanie was one of a large group of students who could not recall having science in the first four grades of elementary school. The image of ditto sheets and busy work in the classroom with a teacher who showed no interest was her introduction to science in school is also representative of the group of autobiographies featuring experiences with science at the elementary school.

Melanie had two teachers in middle school who were enthusiastic, encouraged her interests and attended to her emotional well-being. Both teachers presented material at a level that was comfortable for her to understand. She enjoyed the hands-on activities, including dissecting organisms, and enjoyed science at this point in her education.

These positive experiences were followed by 4 years of science with teachers who displayed attitudes and behaviors linked to negative attitudes toward science for students. These teachers gave special attention to certain groups of students, usually the brightest students in the class. One teacher in particular made judgments based on family members. Topics covered in these classes were sometimes off the subject and more relevant to their own political causes than to the interests and needs of their students.

Negative feedback, a lack of patience, not allowing for student opinions or questions, and material that was presented at an inappropriately high level were variables that eventually caused Melanie to change to a lower level class. She suggests that she could have handled the material at the upper level, but could not handle the embarrassment. She offers the scheduling situation at her school as the reason for her not being able to stay on level. The better choice for her in this school was a safer environment at a lower level. Her attitude appears negative toward particular teaching techniques and science teachers. She does not explicitly state that these teacher and curriculum variables influenced her attitude toward science in a negative way.

The teacher and curriculum variables present in her physics class are overwhelmingly influential to her attitude toward science and science learning in a positive way. Humor, patience, encouragement, positive feedback, enthusiasm, interest in students, field trips, model building, group work, field trips, and relevant, real life activities combine to have Melanie say how much she loved the course.

It was surprising that Melanie could not remember the name of her plant science teacher. She took the class only two years ago and based on the rest of her autobiography, recalling details of people and experiences is not a problem she has. Even though Melanie could not remember doing anything except taking notes in her plant science class, she had learned quite a bit about plants and plant care from her experience with the family garden she was responsible for at home with her mother and grandfather.

The goals that Melanie has stated for her future teaching of science in the elementary school are based on providing the kinds of experiences that she had with her best science teachers and avoiding the kinds of teaching behaviors of her worst science teachers.

Robert

Robert is completing the last two graduate level courses for his degree, one in elementary social studies methods, the other in elementary science methods, during the summer session immediately following his full-year internship in a fifth grade classroom. He is 28 years old and holds an undergraduate degree in Art History. From the moment he entered my class Robert displayed a deep desire to get the child inside of him out. I was also conscious of Robert as a teacher.

He was generating questions with his group about the materials they might use to solve the problems that were posed, probing into the reasoning behind the group members' choices, and sharing his own thinking. As a teacher, he effortlessly facilitated the group in synthesizing what had been learned in one activity with the next. As a child, he couldn't seem to stay in his seat longer than 10 minutes. As both teacher and child, he always had materials or equipment in his hands to either explain his thinking or ask if he was understanding what another group member was explaining.

He remained in the classroom for at least an hour after the class was over. He was tinkering with the supplies I had available and seemed perfectly content to be alone. He eventually asked if he could take some of them home. Upon arrival to class the next day he was toting a large box of 'goodies' that he offered to the class and said, "I found some of this stuff useful last night when I was creating my design of the rescue device and thought maybe some of you could use more stuff to choose from to make your's." At this point he turned to me, smiled, and said, " Besides, I got to clean up the garage a little bit!"

> As I have grown and reflected on my experiences I find that there is an extremely thin line that separates science and art. And if the majority of young adults are experiencing the field of science in the classroom as I have, and test scores seem to bear that out, then I would suggest that an apparent deficiency in the definition of "science" be acknowledged. The sooner we realize science as the highly creative process it is, the sooner we will have populations of excited individuals who are able to open new doors, answer questions, and ask new and challenging ones!
>
> (Robert; June, 1992)

The Missing Factor

The "science teacher" in my life has been an ellusive one. If I were asked to list the names or recall particular lessons, I could not do so. This is certainly not due to attending "bad schools", or being a girl, or that following in the footsteps of my physician father was negatively reinforced. To the contrary, I attended private schools and was the son of a prominent hemotologist in the community whose mother would be *so* proud if their son had become a scientist (ie. doctor).

In those early years, if I had been asked to draw a picture of a scientist and to describe his character I would have shown a white male dressed in a lab coat, a pair of glasses and a plastic pen holder placed in his breast pocket, hovering over beakers of boiling liquid and taking copious notes. There would be one or two assistants cleaning tubes and wiping counters. They would be fastidious characters, compulsive and, more likely than not, workaholics. I, on the other hand, was not that way and had no real desire to be so. The notion of laborious testing and re-testing of hypotheses behind some locked door was boring and probably led to frustration and disappointment, the latter two with which I was all too familiar from trying to compete for my father's attention. I need not go into this further than to say that my disassociation with and dislike of science was partially due to the personal relationship that I had living with a scientist.

My interest had always been a more free-wheeling investigation of nature. Like all children I was curious and exploratory. The "scientific process" had never entered my mind even though, in retrospect, it was in what I was absorbed. If I was not outdoors constructing puddle-dams, stick-houses, or animal traps, I was block-building, fly-tying, or folding planes in my bedroom. I was as inquisitive as the next kid and loved what I saw around me.

So it was in my nature to be interested in scientific things, but they were best explored when given the freedom to do so in an unencumbered setting. The classroom was always loaded with tests and worksheets, and the atmosphere was competitive and solitary. There was limited sharing of ideas and group work was practically non-existent. My classroom experience had little to do with what today I would call the "scientific process". That is, observing a phenomena that is exciting, wondering about it, having an idea to figure it out, and "running with it". That freedom to decide what was personally meaningful had never been allowed. The answers were always given before the questions were posed. There was little need for investigation.

I would suggest that the reasons why my experience in the science classroom have been as described might be that, historically, science has been alienated from art. Scientists have never (except perhaps amongst themselves) been referred to as artists and that artists have never (especially amongst themselves) been referred to as scientists. It seems that the creativity, which is the foundation of any scientific discovery, is never the part that is promoted. In fact, it may rarely be spoken of at all in schools. (During the Middle Ages and Early Rennaisance there had been intense debate over whether the "fine arts" (i.e., painting; drawing; sculpture) should be considered one of the "liberal arts". Leonardo was of great influence on the acceptance of the latter as a worthy pursuit. Yet, today we still seem to schlep this elderly cultural baggage around.) The initial questioning of some natural or even unnatural activity does indeed require the spark of creativity. And certainly, to then design the procedures and settings in which those questions might be "truthfully" answered, is in itself an artistic endeavor.

On the other hand is the artist who, by all means, is involved in a similar process; that is, questioning what he or she experiences and trying to resolve the issues that are raised. As the scientist is not seen for his or her creativity, the artist is not seen for his or her deliberating approach. And although the end product is, in either case, what the public consumes, they are viewed as lying at very different points on a spectrum (perhaps even at extremes). I do not mean to suggest that the artist and the scientist are interchangeable with respect to either role or perspective, but their processes are very similar and certainly facilitate the successful execution of either one's invention.

As I have grown and reflected on my experiences I find that there is an extremely thin line that separates science and art. And if the majority of young adults are experiencing the field of science in the classroom as I have, and test scores seem to bear that out, then I would suggest that the apparent deficiency in the definition of "science" be acknowledged. The sooner we recognize science as the highly creative process it is, the sooner we will have populations of excited individuals who are able to open new doors, answer questions, and ask new and challenging ones.

When I was young I know that I was ripe for being "grabbed", but no one grabbed me. People showed me different things, some answered a few of my questions, but no one really drew me in. "Grabbing" students is where the key lies; making it so that they voluntarily turn their heads and listen, and empowering them to be the creative force behind discovery so that a healthy sense of self is nurtured and they will have no fear of asking questions.

It took many years for me to overcome my anxiety of questioning. Most likely it was the competitive atmosphere of the classroom and the peer pressure that accompanied it. These are characteristics that in certain circumstances can be positive, but I think that the majority of children have difficulty expressing their ideas in public. The fear of being "wrong" is strong in our culture but can be overcome if we embrace individual creativity and realize that very little in this world is either "right" or "wrong".

Robert represents the group of students who participated in this study and who waited until the end of their graduate studies in education to take the elementary science methods course. He displays a high level of synthesis in his thinking, offering both personal and cultural reasons for his dissociation with science.

Robert was one of only two students who mentioned gender bias and its relationship to science. He suggested that it was not because he was female that he was alienated from science. His experiences with science, both in school and at home, did not foster positive attitudes toward science.

He had a potentially rich home environment in which to learn science. But as he said, he was not "grabbed". He was isolated from even developing a strong personal relationship with his father. He was an only child and from the description of the activities in which he engaged, they were independent explorations.

Robert reports the products of his outside of school science experiences; puddle-dams, stick-houses, animal traps, block-buildings, fly-fishing flies, and planes. That he finds the common ground for scientists and artists to be creativity is not surprising.

The curriculum variables that Robert identifies as meaningful to him in a negative way are consistent with the findings overall. Worksheets, limited discussion, no group work, no experiments, having to compete with other students, right or wrong answers to questions, and lack of student choice, all contributed to Robert's alienation from science.

Robert does not state goals per se for his teaching of science in the elementary school. It can be inferred, however, that he plans to use a healthy dose of open-ended questions and provide experiences in which students can be creative. Cooperation will most likely be stressed in his classroom and, based on my classroom observations of him, he will have student interest and their emotional safety as the guiding forces in his curriculum design.

Evelyn

Evelyn is a second semester senior who has been accepted into the M. Ed. program as an "early admit" student, meaning that she can take the science methods course (and any other course in the graduate program) as an undergraduate and receive graduate level credit. This is the only graduate course she has elected to take this semester. She hopes to complete her year-long internship in a third grade classroom next year.

Evelyn is 33 years old, married and the mother of two sons, ages 12 and 13. She and her husband were married shortly after their high school graduation. Her husband went to college directly after high school. Evelyn waited until both children were in school before starting her undergraduate degree at the age of 26. Her major is Family Studies and her degree has taken six years to complete.

My initial impression of Evelyn was that she is a very structured and serious woman. Every other question that was asked on the first day of class was a question from her. She wanted exact directions about each part of each required assignment for the course immediately and seemed frustrated with me. I thought it would be reasonable to let people read the syllabus over at their leisure and come back next week with any questions they had about the assignments. But, Evelyn needed answers immediately. Undaunted, I continued with my plan of action but had to do so with "But, what are we supposed to do, I don't get it," still ringing in my ears.

Later, during the class activities I heard her discussing her confusion with her group members and this interaction seemed to help her become more relaxed and even lighthearted. She stayed after class to tell me she was just nervous about taking a graduate level course as an undergraduate and to say that she's trying to take her work seriously, but not herself.

> All of a sudden Mrs. Caldwell called out, "Evie, stop looking at the celery and get to work. I told you we would look at the celery this afternoon. If you can't wait I will move it!" I sighed and got back to work. I had been in school almost two years so I knew better than to point out my observation to Mrs. Caldwell.
>
> (Evelyn; February, 1992)

I have been thinking about writing this paper for a few days now and I jotted down a few notes about the things I remembered about science. As I read my notes today I realize I still see science as something you do in school. I don't think of science in relation to my daily life. I can't recall one incident when I was doing something not connected with a science class and thinking, "Hey, this is science." Certainly my elementary education never inspired me to see science as an integral part of my life.

I entered elementary school six years after the Russians had launched Sputnik. The call resounded through the land to have students achieve more in math and science. I don't know whether the teachers and the administration in my small town just refused to heed the call or never got the word. The result was we did not do science in school. My father saved some of my old report cards and science isn't mentioned. From first grade on we received letter grades in reading, spelling, writing, language, citizenship, math, social studies, music, and art, but science was not a subject in elementary school. If the school felt science was important then you bet we would have received a grade. I'm not advocating grades in elementary school, just explaining what I think the philosophy was for the teachers and administrator at my school.

The only time I remember anything vaguely scientific was in Mrs. Caldwell's second grade class. It was the proverbial celery in water with some food coloring experiment (demonstration). Mrs. Caldwell stood in front of the room with the glass of water. She then put a few drops of food coloring in the water. She said, "Class pay attention. I am placing the celery into this colored water. We will look at it this afternoon." She then placed the glass on the window sill, very near my desk.

The classroom had those huge windows which started waist high on an adult and almost grazed the ceiling. The classroom had southern exposure. On sunny days the enormous institutional green shades were pulled down three-fourths of the way. Outside the windows was a playground and on beautiful spring days I would frequently gaze out the window hoping for sweet release from the stuffy classroom. The day of the celery experiment was such a day. Unfortunately, the stupid stalk of celery was in my line of vision and I wasn't able to achieve my self-induced daydream of playing outside.

As I looked at the celery with disdain, I noticed something. It looked like an individual ray from the sun was touching the glass of water. In this single beam of light were these little pieces of dust dancing around. I looked to see if there were any other beams of light with dancing dust. I could see beams of light in other places, but not as distinct as in front of the glass.

I became quite absorbed in watching the dancing dust. All of a sudden Mrs. Caldwell called out, "Evie, stop looking at the celery and get to work. I told you we will look at the celery this afternoon. If you can't wait I will move it." I sighed and got back to work. I had been in school almost two years so I knew better than to point out my observation to Mrs. Caldwell.

My experience with science in elementary school was rather bleak. Unfortunately, it was not any better in junior high. I know in jr. high I had a science class which met 4 days a week, but I remember nothing about the content. The image the class brings to mind is reading the text book and answering the questions at the end of the chapter. I can't remember the names or faces of my teachers. I have no recollections of any experiments or demonstrations. At least in elementary school we stuck the celery into water.

After such a disheartening beginning to my story, all is not lost. I got quite excited about science in high school. In the ninth grade I took an earth science class which I really enjoyed. The instructor's love was forestry, so we spent a lot of time outdoors looking at trees. The class went for walks in the woods and we examined a variety of trees and vegetation. We would have discussions during these walks and examinations about how our consumer way of life affected the environment. We learned how to read signs of disruption in the woods, especially how people and pollution were ravaging the area.

While it was not required, I liked the earth science course so much, I signed up for biology the next year. Dissecting the frog and worm was a little gross, but I was excited to learn about cells and how organisms are able to live. My lab partner Jan and I made it through the dissecting part. We comforted each other as we bent over the inside of the frog, hoping we might get high off the fumes of formaldehyde. I began to think science was pretty interesting stuff. Little did I know of the horror which lay ahead.

In my high school, like many others I suspect, you had to take chemistry before you could take advanced biology courses which I definitely [sic] wanted to do. I wasn't thrilled about taking chemistry, but I felt confident I could get through the year. I lasted one week. I remember the day I gave up like it was yesterday.

The first few days of class had seesawed between being boring and utterly confusing. On the day I gave up the teacher, Mr. Lester, was lecturing about scientific notation. He informed the class, "You had better get this down or FAIL!" I never had any difficulty understanding math operations, but I made lots of mistakes in computation. The calculator has been my lifesaver for doing any type of computation. Unfortunately, I was in high school before the proliferation of hand calculators.

After Mr. Lester had lectured for a while he put some problems on the board. He selected a few students to go to the board and work them out. I was one of the unlucky few. As we dragged our bodies out of our seats and sulked to the blackboard [sic] the teacher informed us, "These are the easy ones! The real hard stuff is yet to come!" My answer was wrong the first time and Mr. Lester told me to try again. By this time my hands were shaking and my head pounding from the rush of blood to my face. The second answer was even further off than my first attempt. Mr. Lester said, "Go back to your seat and think about paying attention for a change will you please?" I knew I had to get out of this class. I could take being bored for a year, but the combination of boredom and shame was just too much.

I had lunch during the next period and I went to my guidance counselor's office. I told Mr. Quick I needed to change my class because I was having trouble with Chemistry. He said, " I understand, a lot of girls don't like science. Take a psychology course instead." So I did. That was the end of science for me in high school. There was alot to the joke about how slow Mr.

Quick was. I don't think he would have ever been able to see the problem with his solution to my chemistry predicament.

I didn't take another science class until I was 26 years old. I had to take three sciences to fulfill my general education requirements in college. I began with botany. There was a lecture two times a week in one of those large lecture halls which hold a few hundred people. That was pretty boring, but non-threatening. The lab part of the course was great. The lab instructor was a graduate student and she understood the panic a lot of the students felt when the word science was mentioned. People were allowed to talk and share their findings during the lab.

Everything was going along wonderfully and although the class demanded a lot of memorization, I was confident about my ability to do the work. When we came back from spring break, the instructor told us we should "bone-up" on our high school chemistry. The course was going to be looking at the process of photosynthesis and some basic knowledge of chemistry was recommended. I immediately came down with a stomach ache and a pounding headache. I went home and told my husband I would never receive my B. A. because there was no way I could pass the course. He said, "Oh, you'll do fine."

He was right. The chemistry part of the class was quite simple. I understood what was happening during the process of photosynthesis. The lab instructor went over the problems or confusion people had and there was no call for scientific notation. After I passed the course, I was really angry with both my high school chemistry teacher and guidance counselor. I'm not sure if I would have considered science as a career option, but I would have continued the confidence I know I had in earth science and biology. The combination of intimidating teaching methods and profound gender bias, lead me to believe science was something I could not do on a serious and advanced level. And so, I didn't.

I've been thinking, I really should begin one of those internal dialogues with myself about science. When I make pizza dough and bread for the family and add yeast to the warm water, I have to tell myself - this is chemistry. Perhaps if I start seeing how science is an integral part of my life, I can begin to share that with my students.

Evelyn represents the group of students who had returned to school after a break to pursue other interests. She, like so many others, did not recall having science in her elementary school. Her telephone call to her father reinforced the fact that she wasn't having a partial memory block.

The one vivid memory that she shared from elementary school was the experience with the celery stuck in the water. This experience reinforced the idea that she was not supposed to be curious or ask any questions. By the description she gave of the physical environment, she was nonetheless an observant student.

The contextual variables of her first two high school science courses influenced her attitude toward science and science learning in a positive way. One teacher was enthusiastic, had the students study the concepts in natural settings, and held discussions with the class. The focus in his class was on relevant, real life phenomena and Evelyn enjoyed the class very much. Her biology class involved dissection, working with another student, and she continued to be interested in science until her chemistry course.

Evelyn is among the group of 32 students who had a difficult experience in chemistry. The contextual variable she identifies as being most influential to her attitude about science learning was the negative feedback she received from the teacher in a public setting that caused her to feel ashamed. She is the only student to report dropping out of chemistry. She is the only student to give an example of gender bias. She is by no means the only student who, after their experience in chemistry, avoided taking another science course for as long as possible.

Evelyn's re-entry into science at the college level turned out to be quite positive due to the laboratory portion of her botany course. The lab instructor was encouraging and supportive of her fears. She was allowed to discuss and share her experimental findings with other students in the lab. The information was presented at a comfortable level and she regained the confidence in her abilities to handle science content that she had lost 9 years earlier.

Evelyn started her autobiography by claiming that she doesn't think of science in relation to her daily life. She had always thought of science as something that happens in a classroom, but not anywhere she lived. She offered no goals about how she might teach science in an elementary setting, but suggested that if she makes a personal connection with science herself, she may be able to help children connect with it, also.

CHAPTER FIVE

Conclusions and Implications

In this study I have explored and presented the science experiences that eighty preservice elementary teachers shared with me in their science autobiographies. The contextual variables within their experiences with science and the influence of these variables on their attitudes toward science and science learning in positive and negative ways were identified. Emergent patterns of significant variables from their stories of experiences with science both in and out of the classroom were described. The goals that the preservice teachers had for their future teaching of science in the elementary school at the time they wrote the autobiographies were also presented.

In this final chapter I will present the conclusions that I have drawn from the results of the 80 science autobiographies. In order to temper these conclusions, I will identify what I consider to be the major limitations of this study. I will conclude this research by suggesting some implications for both science education practice and teacher preparation.

Conclusions

One major finding of this study relative to the kinds of experiences that students recall having in school is that science was presented in ways that do not consistently represent the nature of scientific inquiry. This was especially true at the elementary level where, if science was taught, it was predominantly presented as a body of facts that needed to be memorized. There was overwhelming evidence that teachers who taught science in elementary schools persisted in having their science programs driven by textbooks. Students read about science more than they did science and few attempts were made to relate what was read to the lives of the students. Facts or information that had no use in the students' lives became what William Glasser (1990) refers to as "... throwaway information, because, after they do the work to learn it, that is just what the students will do." (page 225)

If we assume that the majority of students in this study did not have collective amnesia, it can be concluded that science at the elementary level was, for the most part, either not taught at all or was not taught in ways that were memorable (meaningful) to students. These results support earlier works about the quality and quantity of science teaching at the elementary level. (Goodlad, 1984; Weiss, 1987).

Students' life science experiences more closely and more consistently approximated the nature of scientific inquiry on a consistent basis. At both seventh grade and (usually) tenth grade, students used the tools of scientists, worked together in laboratory settings, and did more science than read about science. But, more was involved in these experiences. While becoming significantly more specialized, the science at these two grade levels was perceived by these students to be less technical and more approachable as they became immersed in exploring concepts they found personally meaningful. Students liked the work they did in these classes and remembered the content that was presented through relevant activities that had them using their hands, voices, and minds.

Experiences with science in the eighth and ninth grades varied widely. While some students took earth or environmental science, evidence showed that many students did not take science courses at this level at all. Many of the students could opt out of taking any earth or environmental studies if they had been academically successful in their life science course. It can not be expected that students, who have had no background in the earth and environmental sciences, will elect to take courses in these areas when attending college.

The students in this study saw chemistry as a make or break point in their science education. For students who experienced chemistry as a mix of activities in which the content was presented in multiple ways, students did not make the claim that chemistry was drudgery. In fact, it had a good reputation among those students. However, the majority of students found chemistry to be presented as a series of formulas to memorize and a series of meaningless pre-fabricated labs that have only one right answer. Some students found the mathematics involved in chemistry to be problematic, most stated their frustrations with the abstract nature of the content and/or the lack of personal relevance. For a large majority of students, chemistry was the last science course they took before their science requirements in college. They did not voluntarily take another science course. The few students who did elect another science course took physics and found, more often than not, that it was practical, useful, and relevant.

It is possible for students to get through school without taking both an earth science course and a physics course. This means a fair number of students could experience success in biology, have limited success in chemistry and no exposure to earth and physical science. It should not be surprising that preservice elementary teachers choose to take mostly life science courses and/or easy courses at the college level. It should also be less than surprising that so few elementary teachers feel qualified to teach anything but life science. This finding suggests a cause for the inadequate content background of elementary teachers that previous research has cited (Cox & Carpenter, 1989; Jones & Wheatley, 1988; Weiss, 1987).

Brophy and Good (1991) suggest, "There's a bit of Tom Sawyer in all of us. If the teacher doesn't like to paint fences, why should we?" (page 472). Results show that when the teacher appears to enjoy science in general and certain topics in particular, students develop similar interests. When the teacher shows no enthusiasm, neither do the students.

Teacher variables found to influence positive attitudes regardless of grade level or area of science specialty were found to be the teacher's enthusiasm about the subject, the amount of encouragement that the teacher gives to the student, and the value the teacher places on the student's ideas about the topic under study. Most of the teacher variables that were reported to influence attitudes toward science and science learning in a positive way for the students in this study were reported to be variables present in the teachers of seventh grade life science, biology, and certain courses at the college level. Fortunately, there were pockets of these teacher variables present at all levels, which suggests that teachers are not doomed to be unenthusiastic, discouraging or unreceptive to students because of the nature of their subject or grade level.

Teacher variables consistently reported as having an influence on attitudes in a negative way were a lack of enthusiasm for the subject, discouraging students and reacting negatively to students who don't have the one right answer to a question. Although there were pockets of these variables present at all levels, the predominant place these variables were linked to negative attitudes was in high school chemistry. There were, however, five examples that were counter to this pattern; these students identified their chemistry teachers as the best teachers they ever had. In fact, these teachers reportedly influenced their positive attitudes toward science and science learning more than any other science teacher. In addition to the teacher variables that were reported to be influential to positive and negative attitudes toward science and science learning, certain curriculum variables were also present.

Curriculum variables, which admittedly fall under the control of the classroom teacher, were reported at a higher frequency than teacher variables in influencing attitudes toward science and science learning regardless of grade level or subject area. Results indicate that a variety of activities related to a given topic need to be included in the curriculum to influence positive attitudes. A heavy emphasis placed on providing relevant topics, real-life applications, laboratory investigations, discussions (as opposed to ineffective lectures), and student choice have attitudes influenced in a positive way.

A combination of teacher and curriculum variables that influenced positive attitudes had students interested in the subject, putting forth great effort, and being interested in further study. A combination of teacher and curriculum variables that influenced negative attitudes had students bored, disinterested, and avoiding science courses in the future.

Students who work in the science classroom in isolation for extended periods of time do not have positive attitudes toward learning science. A cooperative environment where students are allowed to freely express their thinking to one another, work out solutions to problems, and in which the teacher encourages different points of view, is an environment in which students have positive attitudes toward science and science learning. Positive attitudes are not promoted when students are in an exclusively competitive environment.

There were 917 connections made by students between classroom variables and their attitudes toward science and science learning. More connections were made to the development of negative attitudes (488) than to positive attitudes (429). The results show that particular variables were present at different times for different students and influenced their attitudes accordingly. There was no pattern showing that as students progressed through their schooling, their attitudes became more negative toward science. This finding does not support those of other researchers (Yager & Yager, 1985).

Students with histories of science experiences that influenced positive attitudes appeared to need only one (severely) negative experience to choose to avoid science in the future. The opposite situation was also found to be true.

One excellent experience seemed to counter years of negative experiences. However, the attitude object was not as general as science itself in these cases, but a specific area of science (ie., chemistry) or a particular activity within a specific course (ie., memorizing the periodic table of elements). Assuming that the students' perceptions of their experiences are accurate indicators of the curriculum and instruction, the results of this study support the view that what science teachers do in the classroom makes a profound difference in a student's attitude toward specific areas of science.

Experiences with science outside-of-school were found to start early in life and students' curiosity and wonder about the world was nurtured in a variety of contexts. Experiences outside of the school setting were described as being quite different from the experiences with science encountered at school, especially in the elementary years. Students reported that two kinds of science existed for them at that time, school science and 'real' science.

Outside-of-school variables influenced attitudes toward science and science learning in a positive way 98% of the time. The experiences that students have had outside of the school with science were consistently reported as being better science experiences than the ones they had in school. The influence of the significant other in these experiences was seen as important to the attitude formation. Respecting a student's intelligence and communicating on a level that made the student feel competent, as opposed to inferior, were important variables. Providing materials for students to use in the pursuit of their science interests, answering their questions, modelling enthusiasm for the study of science, and providing time with and for the child were seen as the most influential significant other variables. There were students who did not identify a significant other but reported similar positive attitudes. The nature of the experience itself influenced their attitudes.

Those students who had a long-term, in-depth experience with science outside the classroom revealed a level of expertise in the particular area of science involved in the experience. A high level of responsibility was also associated with their in-depth experiences outside-of-school. This finding supports Eliot Wigginton's argument (cited in Wood, 1992) that students really learn when they " are given responsibility of an adult nature and are trusted to fulfill it. " (page 63)

Limitations of the study. The subject matter of this study has been the biographically meaningful science experiences of 80 preservice elementary teachers. The science stories that the students have told may or may not be true in any objectively verifiable sense. It is possible that they simply told me what they thought I wanted to hear. I tried to address this concern by having the students write their stories within the first two weeks of the course. I wanted to reduce the possibility of them describing events in my words, and not their own. It is equally possible that they chose to be less than truthful because they felt threatened by an imagined negative reaction I would have to an episode in their history and that I would somehow hold it against them. I tried to address this concern by indicating that the assignment would not be graded. I am confident that the students reported their stories as they remembered them happening. The students' candid and often critical responses suggest that they were not writing to please me. I also feel the use of

80 stories over three semesters allowed constant checks to be put on the data. The interviews were further opportunities to ask questions about the consistency of their stories.

I was the reader of their stories as well as the writer about their stories. As a reader I brought my own meanings to the stories I read. I have had my own experiences with the experiences about which the students wrote. My memories of my science experiences were with me as I was reading their stories. I also brought my own understandings and interpretations of the words they used in their stories. I may have had a different idea about, let's say, what a hands-on activity entails than the student who wrote the story and used the term. As a reader I also interacted both emotionally and cognitively to the stories, being bored sometimes, amused other times, in agreement with their arguments, and the like. My choices for the vignettes and case studies I presented were influenced by my interactions with their stories. I presented what I was able to make meaning of in the science autobiographies. It is quite possible that another reader may see different things or see the same things differently.

Another limitation of this study that I would like to acknowledge concerns the way in which I presented the science autobiography exercise to the students. In retrospect, it would have been beneficial to have directly asked the students in this study to state what they think "science" is or what constitutes a positive or negative "science experience". Having defined "attitudes" as having general or specific referrents, it would have been helpful to know the relevant beliefs that the students had about the particular referrent(s) or attitude object(s) for which they expressed their positive and negative attitudes (ie., science "knowledge" in general; chemistry "knowledge" more specifically; the methods used to present and learn science "knowledge"; the people associated with the teaching and learning of science).

The students participating in this study were enrolled in one of three sections of an elementary science methods course offered at the University of New Hampshire. This particular methods course is one of a series of required methodology courses in the integrated undergraduate/ graduate teacher education program at UNH. The students have to meet high academic standards to be admitted into the program. Of the 80 students participating in this study, 85% (n=68) had completed a baccalaureate degree in a field outside of education before being enrolled in the course. As such, the results of this study have a limited generalizing capacity to populations of preservice elementary teachers enrolled in similar programs as the students in this study.

Implications

The goal of science education is for all citizens to become scientifically literate. For this to happen, students need to see that they are connected to science both in school and out of school at all times. It is not productive for students to receive different messages about the personal relevancy or usefulness of science. They need to be engaged in activities in school that compliment the natural connections they've already made and the curiosity they've brought from home. The evidence shows that attitudes toward science and science learning are more consistently positive for students when engaged in science related activities outside of the classroom than when engaged in science related activities offered in school.

If students learn more science from experiences and interactions with science outside-of-school and display more positive attitudes toward science than they do in the insulated and isolated classrooms of most schools, we should consider the advantages of involving students in experiences more similar to their outside-of-school science experiences. This suggests that models for school science programs need to include as many of the variables from outside of school experiences found to be influential to positive attitudes toward science and science learning as possible. Many programs have been developed under the name of 'real' or 'practical' science, however, most are placed at the middle school and secondary levels. We should consider the benefits of such programs for students in the elementary grades and at the college and teacher education levels. These science experiences would be those that have utility, place the students in highly responsible positions, involve extended periods of time, and provide them with good role models.

The goals that these preservice elementary teachers set for their future science teaching tell much about the instructional strategies and environments that had the greatest influence on their attitudes in relation to what was presented to them as science. They tell much about their assumptions about science, science learning and science teaching, as well. The preservice elementary teachers in this study consistently hope to model the behaviors of their best science teachers, many of whom were the significant others in their out of school experiences. They consistently hope to avoid the kinds of teaching behaviors and environments that influenced them in a negative way, most of which were in their in-school experiences. Through analyzing what the variables were in both their positive and negative experiences we can help them address not only their hopes and fears about teaching science, but identify the assumptions they have about the effectiveness and ineffectiveness of certain science teaching strategies.

Teacher educators in the business of helping future elementary teachers of science improve the quality of science education for all students, need to provide quality science experiences for the preservice teachers enrolled in their own courses. By providing them with experiences known to influence both positive attitudes and meaningful science learning we can capitalize on the positive variables that were present in their past science learning. This necessitates that we ask them about the nature of their past science experiences.

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APPENDIX A

Request for Review of Proposed Research

Informed Consent Form

Approval for Proposed Research

UNIVERSITY OF NEW HAMPSHIRE INSTITUTIONAL REVIEW BOARD

REQUEST FOR REVIEW OF PROPOSED RESEARCH PROJECT

Introduction

The purpose of the proposed research is to identify factors which contribute to the formation of attitudes of preservice elementary teachers toward science and science teaching. The quality of science instruction at the elementary and secondary school levels is currently a topic of great national concern. We are continually reminded of the poor performance of U.S. students in the area of science when compared to students of other nations. Clearly, improvement of science instruction at the elementary level could be key to the improvement of science generally.

While there have been studies that have identified negative attitudes towards science and science teaching in prospective elementary teachers, there have been few if any, which have examined the source of these negative attitudes. This study is designed to use student science autobiographies as a tool to analyze the sources of attitudes toward science and science teaching. Increased knowledge in this area can be related to interventions to improve these attitudes.

Specific Aims

Research goals include the following:

1. To examine the variety of science experiences that students enrolled in elementary science methods courses have had;

2. To consider how these experiences might impact their perceptions of science, their attitudes toward science, and their perceptions of their abilities to teach science.

Research Protocol

Field work will be conducted in the Department of Education at the University of New Hampshire, Durham. Participants will be students enrolled in the course EDUC 703F/803F Teaching Elementary School Science. The researcher will employ ethnographic methods, utilizing student science autobiographies complemented by interviews. Data will be analyzed for preestablished and emergent themes.

Document Analysis will be conducted through the use of science autobiographies prepared by students enrolled in science methods courses. Enrollment in the Spring, 1992 class is 28 and the estimate for the Summer, 1992 class is 32 for a total of 60 students. All students will be informed of the research and can choose to participate or opt out. Document analysis will begin for the Spring, 1992 class on or after April 30, 1992 and for the Summer, 1992 class on or after June 18, 1992.

Students will be asked to write about their life-long experiences with science. The parameters will not be restricted to the formal science experiences they have had in their schooling, but will extend to include other possible influencing agencies, such as family, community, travel. There will be no set minimum or maximum length for these autobiographies.

Ethnographic Interviews will be conducted with students enrolled in the methods courses who elect to prepare their science autobiographies. Interviews are expected to commence on May 1, 1992.

Informed Consent

Informed consent will be formally obtained via the attached consent document. Students will be informed that the preparation and subsequent use of prepared science autobiographies and participation in interviews is completely voluntary.

Risks and Benefits

The researcher's responsibility is to protect the confidentiality of those who participate in the study. The anonymity of all informants will be preserved at all times throughout, and after completion of, the research. Pseudonyms will be used for informants, and any persons and places identified in the autobiographies and interviews. To help ensure the confidentiality of the data, the researcher and her advisor (Michael Andrew) will have sole access to field notes kept throughout the study.

Informants who consent to participate in formal interviews will have the opportunity to have the aims of the interview explained to them. They will have the option of saying things "off the record" which will not find their way into the final account. Persons in the immediate setting may be able to identify specific events or individuals contained in the final account. However, no material will be included in the study which would jeopardize the well-being of individuals in the setting. As such, risks associated with participation in this study are minimal.

Informed Consent Form

Purpose: The purpose of the research project being conducted by Stacey A. Gauthier in EDUC 703F/803F Science in the Elementary School is to use Science Autobiographies as a Research Method to Investigate Attitudes Toward Science and Science Teaching.

Description: Each participant in the course will be asked to write a science autobiography which reflects his/her experiences with science both in and out of the formal setting of school classrooms. Each will be asked to explore how these experiences with science, science teachers, and other significant persons have impacted his/her life, and to indicate how each sees him/herself relating science to elementary aged children.

Other points:

1. I understand the scope, aims, and purposes of this project and the procedures to be followed.

2. I understand the confidentiality of all data and records associated with my participation in this research, including my identity, will be fully maintained within the extent of the law.

3. I understand that my consent to participate in this research is entirely voluntary, and that my refusal to participate will involve no prejudice, penalty or loss of benefits to which I would be otherwise entitled.

4. I further understand that if I consent to participate, I may discontinue my participation at any time without prejudice, penalty or loss of benefits to which I would otherwise be entitled.

5. I confirm that no coercion of any kind was used in seeking my participation in this research project.

6. I understand that if I have any questions pertaining to this research, or my rights as a research subject, I have the right to call Dr. Michael D. Andrew at 862-2371 and be given the opportunity to discuss them in confidence.

7. I understand that any information gained about me as a result of my participation will be provided to me at the conclusion of my involvement in this research project.

8. I certify that I have read and fully understand the purpose of this research project and its risks and benefits as stated above.

____ I, ______________________ CONSENT/AGREE to participate in this research project.

____ I, ______________________ REFUSE/DO NOT AGREE to participate in this research project.

____
Signature of subject

____
Date

UNIVERSITY OF NEW HAMPSHIRE

INSTITUTIONAL REVIEW BOARD

FOR THE PROTECTION OF HUMAN RESEARCH SUBJECTS

I R B   R E Q U E S T   F O R   R E V I E W

GENERAL INFORMATION:

Name: Stacey A. Gauthier
Department and Campus Address: Department of Education
Morrill Hall, Durham, N.H. 03824
Home Address (if no campus address) ______
Day Phone 862-3166 Home Phone 224-8599

****

Date: March 23, 1992
Title of Research Project: Science Autobiographies as a Method to Investigate Attitudes Toward Science and Science Teaching
Duration of Project: From April 30, 1992 to April 1, 1993

****

Status of this project:
New X Amendment to new project ____
Continuation of previously approved project ____
Modification of previously approved project ____
Funding Agency ______ Do they require notification from the Institutional Review Board? Yes ____ No ____

****

If proposal has been submitted to a review board at another institution, provide date of review and recommendations. Attach relevant correspondence.
Name of Institution: ______
Date of Review: ______

****

This form and all pertinent information should be returned to the Office of Sponsored Research, Room 107, Second Floor, Service Building. Questions can be directed to 862-2000.

Page 2

SUBJECT INFORMATION:

1. Site of Research: UNH Department of Education
2. Number of Subjects: 60
3. Type of Subjects (check all that apply):
   ____ Newborns/Infants
   ____ Children (aged 2-12)
   ____ Adolescents (aged 13-18)
   ____ Emancipated Minors (minors living independently)
   _X_ Adults (over 18)
   ____ Pregnant women
   ____ Mentally handicapped
   ____ Prisoners
   ____ Other special populations (Specify________________________)
4. Time commitment for each subject: 4 hours
5. Compensation (Indicate how much, if any, and the form of compensation, i.e., cash, course requirement, or mileage, etc.): None

****

SIGNATURES:
The undersigned accepts the responsiblity for assuming adherence to DHHS, FDA, and UNH policies relative to the protection of the rights and welfare of patients/subjects participating in this study.

______________________________ Signature of Project Director

______________________________ *Faculty Advisor Signature (Required for Student Projects)

March 24, 1992
Date

____ Faculty

____ Undergraduate*

_X_ Graduate*

____ Staff

Project Director must assume responsibility for the study. If another individual will conduct the study, indicate that person's name and position.

______________________________ Name

______________ Position

(REV. 11/90)

UNIVERSITY OF NEW HAMPSHIRE

Office of Sponsored Research
111 Service Building
Durham. New Hampshire 03824-3585
(603) 862-2000
(603) 862-3564 FAX

March 31, 1992

Stacey Gauthier
Department of Education
Morrill Hall

Subject: IRB #1093

Dear Ms. Gauthier:

The Institutional Review Board for the Protection of Human Subjects has reviewed and approved the protocol for your project, "Science Autobiographies as a Method to Investigate Attitudes Toward Science and Science Teaching," as Exempt as described in Federal Regulations 45 CFR 46, Subsection 46.101(b)(2). The IRB reviewers ask that you keep your files in a locked cabinet to further protect confidentiality.

Approval is granted for one year, expiring on March 31, 1993. If your project is still ongoing at that time, you may then apply to the IRB through this office for an extension.

Sincerely,

Kathryn B. Cataneo /lm

Kathryn B. Cataneo, Director
Research Administration
(for the Institutional Review Board)

KBC:lmm

APPENDIX B

Research Proposal

ATTITUDES TOWARD SCIENCE AND SCIENCE TEACHING AS REFLECTED IN THE SCIENCE AUTOBIOGRAPHIES OF PRESERVICE ELEMENTARY TEACHERS

Dissertation Proposal
by Stacey A. Gauthier

Department of Education and Teacher Development
College of Liberal Arts
University of New Hampshire

Submitted: December 7, 1992
Approved: December 21, 1992

Table of Contents

INTRODUCTION

One facet of science education is the development of positive attitudes toward science and science teaching among elementary preservice teachers (Caprie, 1973; Carin & Sund, 1975). The rationale for this emphasis is based on the assumption that teachers who possess positive attitudes about science and science teaching not only promote science in the classroom but also cultivate similar positive attitudes in their students. However, elementary teachers continue to express negative attitudes toward science and the teaching of science, a condition that science educators consider to be a deterrent to the effective teaching of science (Buzrow, 1973; Jenkins, 1971; Westerback, 1982).

Purpose of the Study

The purpose of this study is to explore the variety of science experiences that preservice elementary teachers enrolled in an elementary science methods course have had throughout their lives and how these experiences have impacted their perceptions of science, their attitudes toward science and science teaching, and their perceptions of their abilities to teach science to elementary children. Through the use of the students' science autobiographies, I intend to examine the contextual variables of their experiences, not as background variables, but as immediate concerns inextricably linked with their efforts to understand the content of science, the processes of scientific inquiry, and their attitudes about teaching science.

Science autobiographies will be generated by approximately eighty (80) preservice teachers and are expected to provide a richness of detail about what experiences had meaning for them and how the meaning they have made of those experiences relates to their present development as teachers of elementary school children. I will focus on their experiences both in the formal context of schooling (K-16) and in their lives beyond the walls of school. I will direct attention to the students' interactions with science as a body of knowledge - as a subject so to speak, with teachers, parents, peers or significant others, and how these interactions might relate to their attitudes about science and science teaching and their sense of efficacy in teaching science. The usefulness of the autobiography for this research rests on the premise that current and future behavior and attitudes are rooted in prior experience.

Background

One of the major educational curriculum reform efforts currently underway is attempting to address the questionable quality and limited quantity of science being taught in the elementary schools. The American Association for the Advancement of Science (1987) deems the teaching of science in the elementary schools to be of critical importance to the future scientific and technical literacy of this country. Research indicates that science experiences at the elementary level form lasting impressions on students (Vannan, 1971). Westerback (1982) further noted that preservice elementary teachers cited a former science teacher as the most important single influence on their attitudes towards science, and one-fourth (1/4) of those 'influential' teachers taught elementary grades.

The limited quantity of science teaching in the elementary classroom is not new. Based on results from a study of New York teachers conducted two decades ago, Washton (1971) concluded that the 100 educators he researched felt that their own elementary teachers disliked science and so, for them, it was contagious to dislike science. As a result, they were afraid to teach science to their own students and avoided teaching science whenever possible.

It is this concern that science be taught in the elementary schools by teachers who have a positive attitude toward science and science teaching that fostered many studies between 1966 and 1989 on how to effect a change in the attitudes of students in elementary teacher education programs toward science and science teaching. It appears that these studies assumed that achieving a positive attitude toward science was a logical first step toward ensuring that they are open to acquiring a positive attitude toward teaching science.

The studies I have reviewed met with varying degrees of success in finding the factors which effectively bring about positive attitudes of both elementary preservice teachers and experienced elementary classroom teachers. A majority of the studies involved varying the approach by which elementary science methods courses were taught. Most of the studies reviewed involved the administration of an attitude scale both prior to and after taking a science methods course.

In the search for factors influencing attitudes toward science teaching, investigators have examined many variables related to teacher preparation. While a fuller accounting of these studies will be offered in the review of previous research section (Chapter II) of the dissertation, included are the contributions of early field experiences among student teachers (Weaver, Hounshell, & Coble, 1982), demonstrated science knowledge (Shrigley, 1974), and proficiency in what are now called the process skills of inquiry (Kennedy, 1973).

Following a review of such studies conducted over the fourteen years from 1966-1980 however, Morrisey (1981) suggested that insufficient attention has been given to dimensions of personality and teacher-background variables that may influence expressed attitudes. Attitudes are surely influenced by a complex milieu of interests, values, understandings, life experiences, and perceived abilities. Little has been done to investigate the direct or indirect effects on attitudes toward science and science teaching that these variables have.

Reviews of studies focusing on personality and teaching (Balzer, Evans, & Blosser, 1973; Brophy &Good, 1986; Simpson, 1978;) reveal the dominant theme of such research to be the effects of student and teacher characteristics on student performance and achievement. Seldom considered are the intervening relationships, particularly between life experiences and teacher behaviors or expressions of attitudes. Furthermore, attitude toward science, distinct from other science related affective constructs, is vaguely defined, making the task of assessing the effects of any attitude change approach hard to document, much less explain. What specifically is it that the designer of the change experiment seeks to improve?

Attitude toward science may be viewed as a learned, positive or negative feeling about science that serves as a convenient summary of a wide variety of beliefs about science and is important because it permits the prediction of science related behavior (Koballa & Crawley, 1985). Attitudes toward science are not inherited traits but are learned predispositions acquired over a period of time, perhaps years.

The influence of significant others on the formation of beliefs, attitudes, and subsequent behavior has been overlooked by researchers involved in the study of attitudes toward science and science teaching. For the most part these researchers have focused on the attitude object (i.e., science) without regard for the influence of others, known to mediate attitude change. Several social psychologists have suggested social arrangements, situations in which people subconsciously, intuitively, or deliberately perform for others, should be considered as determinants of attitude formation and change (Ajzen & Fishbein, 1980).

One recent study in teacher education employing a retrospective research methodology investigated who the significant adults were for preservice teachers during their K-12 school years (Galbo, Demtrulius, & Crippen, 1990). Results indicated that approximately one-half of all significant adults named in their retrospectives were teachers. Further, those students who were planning on becoming elementary teachers, chose elementary teachers most often as their significant adults. While these findings might be expected to be high, the nonteaching students to whom the preservice teachers were compared in this study selected teachers at an even higher rate than those who wanted to become teachers. The study gave inconclusive support for the idea that people go into teaching because of the positive influence of a teacher. Nonetheless, teachers appear to make lasting impressions on their students.

Citing the limited amount and differing views of researchers regarding the methodological weaknesses that generate recall data, the authors of the above cited study found particular advantages in its utilization. They believe that more precise explanations were given during the retrospective interview sessions regarding why teachers were and were not chosen as significant, and more detailed explanations were provided regarding the qualities perceived to be important in significant teachers.

Different from a retrospective interview, the use of the autobiography or life history, involves the attempt at recording and documenting of an individual's entire life experiences. It is one of several qualitative research methods that have been used to help better understand particular groups of people in our society. They often reveal a link between biography and social forces (Mehaffy, Sitton & Davis, 1979). Capturing the worlds of meaning of those being studied in a particular social context is a key element separating qualitative from quantitative methods. Capturing the essence of an individual within the context of his or her collected life events distinguishes the autobiography from other qualitative research methods.

Sheila Tobias began using autobiography at Wesleyan University in Connecticut in the late 1970's after conducting interviews with liberal-arts undergraduates considered "math avoiders" . During the interviews Tobias (1985) found that " confidence in mathematics, especially in females, is not a necessary outcome of exposure to the subject or even achievement in it. Instead, what appears to link students of very diverse mathematical "ability" is a collection of what might be called ideological beliefs or prejudices about the subject. Students' early experiences with mathematics typically give them false impressions not only of the nature of the subject, but also, of the kinds of skills required to master it (and) ..most come away from their exposure to mathematics believing they do not have the *sine qua non* of mathematics, namely a "mathematical mind."

The "math autobiography", part of the Wesleyan University Math Clinic System (1978, 1980) was discussed individually or in groups and was intended to give students as much information as possible about what had happened to them in learning math when young. Also incorporated in the system was the "divided page exercise" where students learned how to articulate and to keep a record of their feelings and thoughts - including their "irrelevant" mathematical ideas - on one side of a page while doing their problem-solving on the other. This involved a systematic self-observation and monitoring of feelings where students noted thoughts such as "This is just the kind of problem I can never solve."

The use of reflective journal writing and the use of autobiographical texts in the preparation of teachers has been suggested as a means of making values, beliefs, and choices in practice accessible to prospective teachers (Ayers, 1989). While I have found no reports of 'studies' which use reflective writing with preservice elementary science teachers, Wedman and Martin (1986) advocate the use of reflective writing to give preservice secondary language arts teachers the opportunity to reflect upon observations and theoretical constructs in terms of meaningful practice. For them its the type of writing "... which allows for the possibility of thinking about the relationship between self and institution, theory and practice, and daily routines and teaching effectiveness."

Madeline Grumet's use of autobiographies in her methods course at the University of Rochester enabled her to examine the student's educational experiences as well as "the assumptions that they would bring with them to the classroom". As Robert Graham (1991) reviewed Grumet's work, he calls it "..radical in the sense that it eschews the lesson-plan-and-teaching-gimmick- format of traditional methods courses in favor of autobiographical work..." and goes on to say, " Grumet's autobiographical project involved both theoretical and practical elements."

Grumet's course, which was based heavily on autobiographical and journal work, met with some resistance from students who had expected to be given a set of gimmicks to bring to their classrooms. How she managed this resistance and power provides insight about a teacher's influence on student attitudes toward both the subject and the teaching of it. As Graham points out, " This is not to argue against Grumet's attempt, but rather to keep before us the possibility of a law of diminishing returns as instructors, considering a move to autobiography, calculate the availability of net educational gains when the amount of aggravation and distrust is divided by their uncertainty as to a satisfactory outcome for the majority of students."

Peter Abbs (1976) articulates the value and role of autobiography in teacher education programs: The student who is given the opportunity of writing autobiographically, will, it is asserted, become a more responsive and responsible teacher, since this attempt to re-create the past will reveal "the intimate relationship between being and knowing, between existence and education, between self and culture."

Significance of the Study

To briefly review the problem statement, research has consistently found elementary teachers and preservice elementary teachers to have negative attitudes toward science and science teaching. These veteran and prospective elementary teachers continue to exhibit what can be termed "science phobia". Claims of insufficient content knowledge and inexperience with inquiry or process approaches to teaching science have been documented as reasons these teachers give for their apprehension to teach science or to teach science in ways that are considered meaningful by science educators. Studies conducted to address these concerns have had varying success rates on improving the attitudes of these teachers. None of the studies investigated the relationship between prior life-long experiences with science and the attitudes held about science and science teaching.

Current demands in the fields of science and technology are such that science teaching needs to stimulate and sustain student interest from the time children begin schooling (AAAS, 1987). From the results of research cited, these demands are not usually compensated for by elementary classroom instruction. Results of nationwide assessments of attitude toward science indicate that as early as Grade 3, 50 percent of the students no longer show an interest in studying science (NAEP, 1979).

The study of attitude change has become an important focus of science educators. The research in social psychology suggests that attitudes influence future behaviors. For science educators such behaviors as career choices and abilities to deal with technological changes can be associated with attitudes toward science. For elementary science teachers, attitudes toward science and science teaching can mean the choice to teach or not to teach science to students in their classrooms.

William Ayers (1989) suggests that whatever else teachers teach, they teach themselves and that teaching involves a meeting of subjects, a meeting of different intentions, agendas, maps, dreams, desires, hopes, fears, loves, and pains - and in that meeting teachers necessarily model what they themselves value. Good teachers tend to be aware of this and so work to make explicit, at least to themselves, their own values, priorities, and stories, because they know these things will impact teaching practice. Being aware of oneself as the instrument of one's teaching and aware of the story that makes one's life sensible could allow for greater change and growth.

For centuries pedagogues have assumed that learning consisted mainly of the passive accumulation of knowledge - students learned by listening to lectures or reading texts, and their progress was measured by their ability to recite back what they heard or saw. But research in the past two decades has made it clear that learning occurs through an active process of interaction between the learner and the experience. Learners impose meaning on the basis of prior knowledge. This implies not only that a given experience may be interpreted by different people to mean different things, but that people differ in the kinds of experiences from which they learn.

This new understanding of learning has stimulated an interest in how teaching practices might be altered to better promote student learning. Many researchers are altering their ideas about how students in school learn. As Mary Kennedy (1991) states "...the findings from cognitive science apply equally well to teachers. We can no longer assume that teacher learning occurs solely through receiving new knowledge. Teachers, like other learners, interpret new content through their existing understandings and modify and interpret new ideas on the basis of what they already know or believe."

To understand how teachers learn to teach, therefore requires an extension of findings about students as learners to teachers as learners and definition of teacher learning as a function of both what the teachers bring with them to new experiences - what they already know, believe, or value - and the new experiences themselves - the features that are likely to promote learning the new ideas or practices offered them.

Research investigating preservice elementary science teachers' attitudes toward science and science teaching, and their sense of efficacy to teach science through the use of their own reflective accounts depicting how they came to have those attitudes is wanting. The autobiographical texts will reveal the conceptions that the students have about science and science teaching and provide insight into how they formed. Their hopes, fears, and feelings of adequacy about science and their teaching science will also be revealed. This opens the possibility of dialogue between student and teacher and should help both to develop abilities to reflect on teaching practice, including their own.

If science teacher educators and teachers are to address and treat the condition of limited and poor science teaching in the elementary schools, we need an accurate diagnosis. I see autobiography as a method for teachers and teacher educators to improve elementary science teaching practice.

Specific Focus of the Study

This study will attempt to both identify contextual variables from the body of each autobiographical essay and relate these contexts to the formation of attitudes toward science and science teaching. As such, the quiding questions in this research include:

- What are the specific contextual variables, both in and out of the confines of school classrooms that have meaning to preservice elementary teachers, and do patterns exist within or across autobiographical texts?

- In what ways and to what extent do these experiences influence the attitudes they now have about science, science teaching, and their ability to teach science to elementary school children?

METHOD

Description of the Research Method

The phrase 'qualitative research methodology' refers in the broadest sense to research that produces descriptive data: people's own written or spoken words and observable behavior (Bogdan & Taylor, 1984). As Ray Rist (1977) points out, like quantitative methodology, qualitative methodology is more than a set of data gathering techniques, it is a way of approaching the world.

As an inductive process, qualitative research has the researcher develop concepts, insights, and understandings from patterns in the data, rather than collecting data to assess preconceived models, hypotheses, or theories. The research design is flexible and commences with vaguely formulated research questions. The qualitative researcher is encouraged to be his or her own methodologist (Mills, 1959), and although there are some guidelines to be followed, there are no set rules. "The methods serve the researcher; never is the researcher a slave to procedure and technique" (Bogdan & Taylor, 1984).

As a qualitative researcher, I will be attempting to understand the preservice elementary teachers' attitudes toward science and science teaching from *their* own frame(s) of reference, as reflected in their autobiographies or accounts of their science experiences. The general term 'autobiography' is seen as referring to an individual's written first-person account of the whole or parts of his/her life or his/her reflections on a specific event or topic. In this proposed research, the specific term 'science autobiographies' will refer to focused, self-edited accounts written by preservice elementary teachers expressing their life-long experiences with science and their interpretations of those experiences. The researcher's challenge will be to suspend, or set aside her own attitudes, beliefs and dispositions about science and science teaching, as much as possible.

In qualitative research, an "N of One" has been found to be quite illuminating. However, there are instances in which the researcher may want to sacrifice the depth of understanding that comes with focusing intensely on a single person for the breadth and generalizability that comes with studying a range of people. One method of constructing theories from qualitative data that requires a sizable number of cases is analytic induction (Robinson, 1951; Turner, 1953). Through analytic induction, Lindesmith (1968) developed a theory of opiate addiction based on studies (mostly interviews) with a large number of opiate users.

In order to identify a full range of contextual variables which may influence the attitudes toward science and science teaching held by preservice elementary teachers, this study proposes to use a large sample size. While getting to know each autobiographer well enough to understand all of what they mean in their writings will be sacrificed in employing this research method, I see it as well suited to the stated purposes of this study.

Collection and Construct of Data

The approach to data collection and construction will reflect a descriptive research approach and one that is exploratory in nature. The science autobiographies will constitute the bulk of the data. I hope to use as many of the estimated 80 essays as possible in identifying the kinds of experiences the students have had and if similar experience patterns emerge from within and/or among autobiographies. (I am somewhat apprehensive to take a sample for risk of sampling out the relatively few male students, older students, students of color and students with diverse ethnic backgrounds. I would be willing to consider reducing the total as long as it does not misrepresent the total population.)

Specifically, students in three sections of EDUC 703/803F Teaching Elementary School Science will be asked to write about their life-long experiences with science. The parameters will not be restricted to the formal science experiences they have had in their schooling, but will extend to include other possible influential agents or agencies (i.e., family members, friends, community members, clubs, religious affiliates, travel). The specific assignment will be stated as follows:

Each of us has a history with this thing called science. I encourage you to reflect in a critical way on the experiences you have had in your science history. For this assignment, write an autobiographical essay which highlights your experience with science both in and out of the classroom. Include as much as you can and feel free to get memory jogs from home. Tell me about the experiences you have had with your teachers of science, and any other person with whom you shared your science history. Please tell me how you see yourself relating science to elementary age students at this point in your teacher preparation. This assignment is due on the third class meeting.

All autobiographies will be read and returned. Questions of clarification will be asked if parts of the texts are unclear to the researcher. Upon the return of the clarified autobiographies, students will be asked if the autobiographies can be used for research purposes. In this way, students are assured that credit for completing the assignment was granted and questions or concerns about grading will be reduced. Having received prior approval for this research from the Institutional Research Board and a waiver/approval of the Informed Consent Form, students will be informed of the purposes of the research and of their rights as participants in this study. A copy of this form is attached to this proposal. (Copies of the request for approval and the acceptance letter from the IRB are available if requested.) As stated on the form, any participant can withdraw from the research process at anytime.

From the total population, a small group will be selected out for the investigation of the second research question. They will actually self-select because they'll choose to participate in the interview/autobiography data collecting activity, incorporating the methods course and its associated field experiences into their history. From this sample, data will be collected via a combination of a log-interview or a log-second autobiography. Because it will be recommended that students keep an anecdotal record throughout the course, students agreeing to these informal interviews or second autobiographies will have data from which to draw. These anecdotal records will be the sole property of the students and only the information provided during the actual interview or on the revised autobiography will become part of the researchers data base.

The data will be coded in ways which will help identify the attitudes they hold about science, science teaching, and their abilities to teach science. As these may be difficult to cull, it is anticipated that informal interviews will be used for clarification purposes.

Analysis

I will use the data collected in order to develop or actually discover theory as it emerges from the science autobiographies and interviews. Known as grounded theory, I will be involved in comparing, coding, and analyzing the data to be able to specify particular categories and relationships within the data which will yield theory. While I will not be trying to prove any one theory, it is expected the data will most likely provide support to one or more theories of attitude formation and/ or transmission, of learning, and of efficacy in teaching.

Glaser and Strauss (1967, in Taylor & Bogden, 1984)) propose two major strategies for developing grounded theory. I think its important to state them both as each has its place in the proposed research. The first is the constant comparative method in which I will simultaneously code and analyze data in order to develop concepts. By continually comparing specific incidents in the data, I will refine these concepts, identify their properties, explore their relationships to one another, and integrate them into a coherent theory. This seems like the appropriate approach to the first research question.

The second strategy proposed by Glaser and Strauss is theoretical sampling in which I will select new cases to study according to their potential for helping to expand on or refine the concepts and theory that have already been developed. Data collection and analysis proceed together. This seems to be a good approach to keep in mind in case the sample size dwindles while exploring the second question. In order to evaluate the developed grounded theory I will check to see whether or not it fits and works. For a theory to fit, the categories must be easily indicated by the data; for a theory to work, it must be relevant and able to explain the behavior under study.

I will not rely heavily on the quantification of qualitative data. I expect to use techniques, such as the "key incident" approach which involves the analysis of data leading the researcher to focus on certain extensively detailed incidents, using them as concrete instances of the workings of some abstract principles of human interaction. While avoiding statistics per se, I do think that summarizing the findings and contrasting those with data showing national trends, particularly in the area of gender differences in experiences and attitudes about science and science teaching would be interesting.

Participants and Setting

The participants for this study will be students enrolled in the Spring 1992, Summer 1992 and Fall 1992 sections of EDUC 703/803F Teaching Elementary School Science held at the Durham campus of the University of New Hampshire. This course is designed to meet specific objectives as one of a series of methodology courses offered by the Department of Education.

An estimate of 80 total students will be asked to be included in this study. All students will have self-selected their enrollment in one of the course sections and as such, groups will not have been formed through random selection or random assignment. It is expected that an estimated 30 percent (i.e., 24 students) of the total population will be concurrently experiencing the coursework in 803F while having daily classroom experience. These students will be either participating in their Internship requirement of their graduate program or are currently full-time teachers participating in re-certification activities. It is anticipated that the remaining 70 percent (i.e., 56 students) of the total population will not be involved in or exposed to daily classroom teaching. These students are either seniors or graduate students who are completing coursework prior to or upon completion of their Internship requirement. Data collected over the three year period from 1988-1991 further suggest that the female-male ratio to be at least 10:1.

Access to the population for the research is aided by the fact that the researcher is also the instructor for each of the three sections of the course. While it is expected that no teacher teaches the same course in the same way to different students providing as much consistency as possible will be a driving concern. As such, each section will have a similar structure and all assignments will remain constant throughout the research period.

A complete description of the course is available and will be included in the method section (Chapter III) of the dissertation. Briefly, EDUC 703/803F is designed to blend science content with inquiry-oriented "hands-on" laboratory and field activities to provide preservice and inservice teachers with a variety of science subject matter and instructional strategies, and an opportunity to improve their own science process skills. The theory of inquiry-oriented science is examined through interactive lecture, and it takes place through actual participation in inquiry-oriented activities designed for the elementary classroom.

The Spring and Fall sections of this course are taught in weekly, one hour and twenty minute sessions over a fifteen week semester. The Summer section of the course is taught in three days per week , two hour and twenty minute sessions over a three week period. Much emphasis is placed on discussing the advantages, disadvantages and logistics of various instructional strategies used or as pieces of a multi-strategy approach to teaching science.

The specific activities chosen are based on their appropriateness to the content material and are directly transferrable to the elementary classroom. All participants are required to engage in these activities as if they were elementary students. After each activity, the students generally discuss the science concepts that were taught and/or learned, the process skills employed, and the particular sequence of instructional strategies used. During this time they are also encouraged to share what was familiar, new, easy and/or difficult for them during the activities.

OTHER CONCERNS

Ethical Considerations

This research study involves the use of human participants. In addition, it is the human participant from whom and about whom the data will be collected. According to the National Research Act (1974) any person conducting research with human participants must have a proposal approved by an institutional review board certifying that the research will be conducted in accordance with the law and the individual university's rules and procedures. The proposal for this research was submitted and approved in March, 1992.

In addition, the stipulation of "informed consent" of research participants was followed. Although the requirement of informed consent was waived by the review board, I followed the guidelines and had the participants read and sign the form. They are on file and a copy is attached.

Any researcher is obligated to protect the participants from risk. Risk has a broad definition in the research how-to books but it means exposure to the possibility of physical, social, or psychological harm. While I do not think this proposed research will harm any of the students certain precautions will be taken. Basically I will follow the recommendations of Fowler (1984):

1. All people who have access to the data or a role in the data collection will be committed in writing to confidentiality.
2. I will minimize all links between data and identifiers (of respondents).
3. Completed interviews and autobiographies will not be accessible to nonproject members.
4. Identifiers will be removed from completed documents (and other protocols) as soon as possible.
5. During analysis, I will be careful about presenting data for very small categories of people who might be identifiable.
6. When the project is completed, I assume full responsibility to see the eventual destruction of the completed documents or their continued, secure storage.

Protecting the rights of participants and conducting research in an ethical manner are matters of common sense. Basically, I will protect the dignity and welfare of the participants. The participants may, at any time decline participation without reason.

Confidentiality of the data will be maintained. Being both the researcher and the instructor allows me two roles in which to be responsible for their well-being.

Another issue which may knock on the ethical door includes having sensitivity to students who have difficulty in writing a paper of this kind.The issue involves trust. Putting myself in their shoes I can hear myself asking: Do I, the writer trust you, the teacher with my feelings about science as revealed in my autobiography? Will you hate me because I hate your subject? Will the revelation that I used to collect insects just to pull their wings off have you embarrass me and squash my fragile ego? Will you fail me if you think I've blown off the assignment with an account about how everyday I've spent in relation to science has been ecstasy? I will be conscious of these kinds of concerns.

On a more serious note, autobiography is not without its negative aspects as Kenneth Stoddart (1991) alerts educators. He has found that from time to time particular lifestories reveal persons who are experiencing problems with self-concept, having serious doubts about relationships, and even contemplating suicide. He goes on to say that "...some students are quick to voice the opinion that these concerns were animated by the exercise itself, that they emerged not on their own but as a result of the massive amount of recollection and self-reflection required to prepare an autobiography."

The raising of such an opinion provides an occasion for addressing the morality of life history and associated research and for further explicating our ethical interest in protecting subjects.

Finally, the autobiographies will not be graded on content. They will not be graded at all. Students will be given credit for attempting to complete this assignment and will be advised they can opt for an alternative assignment.

Timeline

December, 1992: Proposal submitted and accepted by dissertation committee. Revise work plan and timeline previously submitted to advisor. Complete data collection for Fall, 1992 section of EDUC 703/803F.

January, 1993: Submit Chapters I and III and revise upon review by committee.

February, 1993: Submit and revise Chapter II

March, 1993: Focus on detailed examination of written sources of data and complete analysis, Chapter IV. Submit and revise.

April, 1993: Submit Chapter V and final paper to committee. Defend final dissertation on or before April 26th.

May, 1993: Submit revised and hopefully final dissertation. Graduate.

Limitations of the Study

Using autobiographies in general and science autobiographies in particular raises the problem of representativeness. When completed, how representative of the larger population of preservice elementary teachers will the population of three sections of a methods course be? I suspect, however, that if the study is detailed, certain theories thought to be universal could be questioned or could add to existing theories. At the least, the teacher-researcher in the methods course will know her students significantly better and have data from which to reflect and inform her own practice.

The timeline I've designed might be considered a limitation of the study and suggest less than a thorough analysis of the data. While I think there's a career full of questions for which the data in this study could provide insights, I am satisfied with the exploratory nature of this study which will, no doubt, offer several avenues for further research.

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