

ABSTRACT

Title of Dissertation: **FIVE MALE PRESERVICE ELEMENTARY
TEACHERS: THEIR UNDERSTANDINGS,
BELIEFS AND PRACTICE REGARDING
SCIENCE TEACHING**

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Many factors influence teacher choices concerning the frequency, instructional methods, and content of science teaching. Although the role of gender in science learning has been studied extensively, the gender of elementary teachers as it intersects their teaching of science has not been investigated.

In this ethnographic study, I focused on five male preservice elementary teachers as they experienced their student teaching internship, aiming to understand their underlying beliefs about science and science teaching and how

those beliefs influenced their practice. In an attempt to illuminate the complex interplay of personality, experience, interests, and gender in the professional lives of these men, this study emphasized the importance of context in the formation and expression of their science beliefs and pedagogy. For this reason, I collected data from a number of sources. From September, 2001 to May, 2002, I observed my participants in their science methods courses and on multiple occasions as they taught science in elementary classrooms in a suburban school district. I reviewed journal entries required for the science methods class and examined documents such as handouts, readings and teacher guides from their elementary teaching experience. I conducted semi-structured and informal interviews. I analyzed data from these sources using grounded theory methodology.

Although these five men had many similarities, they differed in their love of science, their exposure to science, their avocational interests, and their views of science pedagogy. This study, however, revealed a unifying theme: each participant had his own set of personal and academic resources that he carried into the classroom and used to construct a distinctive science learning environment. Some of these resources intersect with gender. For example, several men had science-related avocational interests. There was a common emphasis on creating a relaxed, enjoyable, hands-on teaching environment as reported in other studies of male elementary teachers. These findings have implications for elementary school science teaching and recruitment goals for elementary teachers that should be further explored in additional studies.

FIVE MALE PRESERVICE ELEMENTARY TEACHERS: THEIR
UNDERSTANDINGS, BELIEFS AND PRACTICE REGARDING SCIENCE
TEACHING

By

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Chapter 1 Introduction

Research Context

In contrast to instruction in core subjects like reading and mathematics which is often closely regulated by school districts, science teaching varies considerably from classroom to classroom in frequency, scope, and intensity. Because of the lower priority of science, elementary teachers are allowed considerable latitude in its teaching. It is usually within the elementary teacher's purview to determine on a daily basis if, when, and how long science is taught. Moreover, although the school district may prescribe a science curriculum, the teacher is commonly left to implement priorities concerning which material is covered in depth, which is glossed over, and which is omitted. The richness of the classroom science environment, including laboratory experiments that students perform, the instruments and equipment that students are encouraged to use, the auxiliary reading choices, and the connections made between science and everyday life are largely controlled by the teacher. Many factors including the teacher's knowledge of science content, previous practical experiences with science, and views of science teaching and learning may influence these teacher choices. Increasingly, student gender has been recognized as a foundational

factor that affects how science is learned (Weinburgh, 1995; Kelly, 1985; Erickson & Farkas, 1991). Since all teachers are former students, their gender may affect their previous science experience and hence their choices as science teachers. Teacher gender may influence both how science is taught and how it is learned. A few recent studies have examined the effects of teacher gender in general elementary and secondary education (Oyler, Jennings & Lozada, 2001; Hebert, 2000; Riggs, 1991; Hopf & Hatzichristou, 1999; Sargent, 2001). One study (McGinnis & Pearsall, 1998; McGinnis, 2000) focused on a male professor's experience of teaching a gender-inclusive university elementary science methods course consisting of mostly females with a view towards implementing gender-inclusive pedagogy and understanding the views of his students towards this kind of teaching. It is a logical step in this progression to look more closely at male elementary teachers and their teaching of science. This qualitative study will investigate how male preservice elementary teachers understand science teaching and learning and how they establish a science teaching environment in the classroom.

Rationale

Although elementary teachers are usually responsible for the teaching of science, it is not, on the whole, the subject that they value most. Weiss, Banilower, McMahon and Smith (2001) found that teachers in grades 4-6 spend, on average, 96 minutes a day on reading instruction, 60 minutes on mathematics and 31-33 minutes on science and social studies. In grades K-3, the differences

were more pronounced with 115 minutes spent on reading instruction each day, 52 minutes on mathematics instruction, and 23 minutes on science instruction. Studies show that elementary teachers feel uncomfortable teaching science and are so apprehensive about their capabilities in that field that only 9% report feeling qualified to teach science (Tilgner, 1990). Elementary teachers also consider themselves poorly prepared to teach the concepts of science or manage a class engaged in hands-on activities. (Weiss, et al., 2001). These self-judgments have deep roots that may not always be readily apparent. The education literature does offer some possible explanations for teachers' apprehensions about science. Elementary education majors at most institutions require zero to three semesters of college science courses and slightly more than half of colleges and universities require a lab science (Tilgner, 1990). With this college background, one can understand why teachers hesitate to carry out an inquiry-based approach to science (Downing, Filer & Chamberlain, 1997). It is possible, however, that the stage for uncertain attitudes about science is set long before a teacher's collegiate career.

The science education literature is rife with references establishing that boys are far more likely than girls to prefer science as a field of study. Girls begin losing interest in science in middle school. They often choose not to participate in science activities or opt out of science courses altogether by high school (Tobin, 1996). Males, on the other hand, choose to take more science courses in high school and are more comfortable with the tools of science (Rennie & Parker,

1987). Males, in general, express a greater familiarity with science, especially the physical sciences, and are more likely to pursue careers in science. However, if men outnumber women in science careers, women outnumber men in elementary education. The majority of elementary teachers are women; men represent only 15% of all elementary teachers in the U. S. (U.S. Bureau of Labor Statistics, 1998). It seems logical then to ask: When males choose to become elementary school teachers, what attitudes concerning science and the teaching and learning of science do they bring to the profession?

Rouchoudhury, Tippins and Nichols (1995) report that “Teacher educators who teach science and science methods for preservice elementary teachers are well aware of the apathy and indifference with which these students come to science classrooms” (p. 901). What is not plain, however, is whether male and female preservice elementary teachers hold these views similarly. Especially interesting is how their views of science influence the everyday decision-making process that establishes the instruction milieu in the classroom. This research project will address these issues examining the intersection of gender research in science education and by focusing on the influence of teacher beliefs on teacher practice.

This study will provide insight into how male, preservice elementary teachers are influenced by their own science knowledge, their beliefs about science, and their perceptions of how science should be taught. It will also provide a perspective on whether these understandings may facilitate improved

design and execution of both science methods courses and science subject content for prospective elementary teachers. Description of the resources that male elementary teachers bring into the classroom may also suggest innovations for teaching that could enhance the quality of science education for elementary students.

Research Questions

The purpose of this research is to examine the beliefs of a select sample of male preservice elementary teachers about science and science teaching/learning and to understand how those beliefs influence their science teaching.

Specifically, the research questions are:

1. What are the understandings of male preservice elementary teachers about science and the teaching of science?
2. What factors influence the male preservice teacher's understanding of science and the teaching of science?
3. What is the relationship among gender, scientific understanding and pedagogy in the professional practices of male preservice elementary teachers?

Key Terms

For the purposes of this paper, preservice teachers are those engaged in their final year of teaching preparation. At the university from which this study's participants are selected, these preservice teachers were in Stages II and III of their internship. Stage II included a semester of methods courses taught at the

university two days a week and field service in an elementary school under a mentor teacher two days a week. Stage III consisted of a semester committed totally to field experience in one class of the elementary school.

The environment established by the teacher in the classroom is perhaps best described by Fraser and Tobin (1996) as the organization and order that the teacher gives to the science curriculum as well as the teacher involvement with the class.

The term gender differences implies more than the sex of the teacher. Linn and Hyde (1989) state that “gender differences are not general but specific to cultural and situational contexts”(p. 17). In other words, gender implies more than just x and y chromosomes; it also encompasses differences in socialization that are, in general, characteristic of each sex. (Kahle & Meece, 1994).

Limitations

The following limitations were evident at the outset of this study:

- 1) This study was limited to 5 male preservice teachers in several elementary schools in a single district. This number of participants was chosen as large enough to provide sufficient data to generate grounded theory and small enough to study in the intensive manner required by qualitative research.
- 2) The preservice teachers in this study were selected from a group of elementary education majors taught in two separate groups, called blocks. The blocks chosen for inclusion in this study were taught by the same science methods’ instructor. The preservice teachers in these two blocks carried out their

practical teacher experience in the same school district. It was necessary to include participants from two different blocks in order to obtain a sufficient number of male participants. There are usually four or five blocks of Stage II and Stage III interns each year. The students choose their block, and these choices may be influenced by a variety of factors including the local county in which the schools are located, simple matters of convenience, or established friendships. A distinguishing characteristic of the block under study is that it is part of the Professional Development Schools Program (PDS). This program is a defined partnership between the elementary schools, the university, and a laboratory experience team that aims to provide quality academic and clinical training for preservice teachers. The PDS program requires additional effort by its preservice teachers who attend more workshops and other programs than do students enrolled in other university teaching blocks. Since preservice teachers who enroll in this program take on this extra commitment willingly, they may have more initiative than the “average” preservice teacher at this particular university. On the other hand, other factors, such as school location may also influence their decision to enroll in the PDS program.

- 3) None of the participants in this study were part of any special science and mathematics teacher training program although the university does have such a program available for interested students who qualify.
- 4) As the researcher, I bring my personality and experience to this study.

Bogdan and Biklen (1998) emphasize that researchers cannot divorce their

research from past experiences, personal identity and personal value systems. No matter how we try, we cannot separate who we are from what we value. My journey as a science teacher began when I pursued a college chemistry major. At the time I received my degree and pursued my first job as a laboratory technician in a research facility, I was among a minority of women in a predominantly male academic area. I was one of two women chemistry majors in my class at college and attended many science and mathematics courses in both high school and college with only one or two women. These experiences as a woman in a “man’s world” give me some insight into the experiences of the men in my study who work in a “woman’s world.” I then combined science with my love for teaching. My identity as a teacher who has spent more than 10 years teaching science to elementary and middle school students in both public and private schools has affected my choice of study environment and participants. My initial background in science greatly influenced my personal conviction that science is a critical and not an auxiliary component of every child’s education. My graduate university experience as a lecturer in an elementary science methods course led me to ask questions why elementary teachers teach science as they do. Specifically I wondered how some of the differences in approaches to science teaching that I observed between male and female preservice teachers in my methods course might play out in the elementary classroom. I believe that my history has informed, but not biased, my study. According to Strauss and Corbin (1998), objectivity means “openness, a willingness to listen and to “give voice” to

respondents" (p. 43). The essence of objectivity is to hear, see and represent the participants as accurately as possible. The considerable time that was spent in the field and the weight of the data that must support any personal interpretation should assure reflective judgments that can add to knowledge (Bogdan & Biklen, 1998).

Chapter 2 Literature Review

Introduction

Since this research project addresses issues that overlap gender research in science education and research on teacher belief and practice, I will review the literature in both of these areas. I will include literature that addresses the social construction of gender as well as studies that examine gender differences in science learning. The latter information is particularly relevant because a teacher's knowledge about an academic area and their degree of comfort when functioning within the boundaries of that discipline influence their classroom practices. Classroom practice is also influenced by teacher's beliefs about knowledge and the transmission of knowledge within an academic discipline will also influence how that discipline is approached within the classroom. The research that specifically addresses teacher gender differences as they affect teacher beliefs and practice will also be included in this chapter.

Gender Differences in Science Abilities and Science Background

Gender Differences in Science Abilities

The exact nature of gender differences as they relate to science learning and science participation among males and females has been a fertile field of investigation for many years. Our expanding knowledge in this area has led to changes in educational practices, which in turn have led to alterations in our views concerning the innate character of gender differences in cognitive abilities. This section begins with the literature about gender and science viewed in terms of dichotomies. There is information to be gleaned from this research, but it is not universally applicable to every male and every female. It imparts to the researcher a glimpse of the state of the research in the past, even the recent past. However, it is important to remember the evolutionary nature of literature. I also review the later gender research that emphasizes a deeper and more complex view of gender.

Several landmark studies are foundational to our general knowledge of gender differences as they relate to education. Macoby and Jacklin (1974) assembled a large body of evidence regarding the nature of cognitive differences between males and females. Their meta-analysis indicated that males and females differ in the areas of (a) general intellectual ability, (b) verbal ability, (c) quantitative ability and (d) spatial ability. In each of these areas, their research showed that males were superior. Macoby and Jacklin maintained that gender differences in students' spatial ability contribute to gender differences in science

achievement. Fennema and Sherman(1978) supported this conclusion with their research studying the process of reasoning about spatially presented information.

Linn and Hyde (1989) have taken a stance contrary to that of both Macoby and Peterson and Fennema and Sherman. Using a meta-analysis of 172 studies, they concluded that gender differences on spatial visualization tasks are minimal if one considers effect size. The effect size is the difference between the female mean and the male mean divided by the pooled within-groups standard deviation. Linn and Hyde (1989) concluded that gender differences on cognitive and psychosocial tasks are declining due to educational opportunities, changing social roles, and the changing demands of the workplace. They contend that the remaining cognitive skill differences can be explained by experiential difference and are easily changed by training. These later studies give a different context to the male/female cognitive differences that have been observed in the past. They show that factors other than gender, but possibly connected to gender, account for some of the findings of the gender-based educational research.

Seeking a reason for the differences in cognitive ability between males and females, Fennema and Peterson (1985) related male superiority in mathematics, especially on complex problem-solving tasks, to the ability to exhibit autonomous learning behaviors. Autonomous learning behaviors include the ability to work independently and to persist, choose, and succeed at complex problem-solving tasks. Fennema and Peterson found that girls tend to be less persistent and more likely to exhibit “learned helplessness” than boys. Dweck

(1980) related learned helplessness to a female style of attributing successes to unstable external causes and failures to stable internal causes. In his view, this behavioral style leads females to believe that they are unable to control either personal success or personal failure. Along these same lines, some have postulated that girls engage in rote learning modes as opposed to more meaningful learning modes used by boys (Ridley & Novak as cited in Meece & Jones, 1996). For the most part, such theories are currently in disfavor, largely due to more recent research findings. In their study of over 200 fifth and sixth grade students, Meece and Jones (1996) found little support for the theory that girls engage in rote learning. One can observe in the work of the more recent researchers here cited a change in research focus. This current research focus is not on innate cognitive gender differences, but on a social-psychological framework for gender difference that is complex in origin.

Gender and Science Learning

In this section I will look at the research that explores the progress of males and females through the world of school science. This is significant because a teacher's past links to science shed some light on their teaching of science. This story is also a study of contrasts. There are few studies that investigate the male school science experience. Instead, knowledge of males was deduced by comparison with females as gender differences in science became a focus of research from the 1970s to the present. The research shows that, although girls maintain an interest in science through elementary school (Johnson,

1987), by middle school boys claim science for their own (Kahle & Lakes, 1983).

Of all the subjects offered in high school, physical science is viewed by both boys and girls as the most masculine of all subjects (Sadker & Sadker, 1994). Science, in general, is often viewed as masculine by many segments of our society, including girls, boys, parents and teachers (Kelly, 1985). Kelly argues that science is masculine in four senses: (a) in terms of the numbers of participants, (b) in terms of the male packaging of science in all media, including books, (c) in the establishment of science as a place for males in the workforce and even in classroom interactions, and (d) in that the scientific world view is, primarily a masculine world view. Science is usually perceived as abstract, analytical, detached and objective. According to Kelly, these characteristics are stereotypically male and thus further encourage males to take advantage of the world of science. There are many practicing scientists today who adhere to this view of science as objective and abstract and who work in almost total solitude. However, the paradigm of science is changing to one that is not detached and solitary. Collaborations among scientists, especially scientists with very different skills, are common resulting in a concerted movement towards a single goal. For example, the National Institutes of Health has recently published a new document, “The NIH Roadmap: Building Interdisciplinary Research Teams” (2004). This document stresses scientific collaboration and states optimistically:

By engaging seemingly unrelated disciplines, traditional gaps in terminology, approach and methodology also are gradually eliminated. With roadblocks to potential collaboration removed, a true meeting of minds can take place....

Science is changing and, as it changes, it will not be the stereotypically male paradigm that Kelly describes, but one in which all kinds of people, with all kinds of personalities, can find a place to work. This evolution certainly will engender a change in attitude towards science even among girls and boys in school for it gives science a totally new look. This view will take some time to filter down through the total culture. It is not likely that, at this moment, either students or their teachers hold a common view of science, since the field is in considerable flux.

In addition to the views of science that are held by both male and female students (which later translate into views held by adults), males and females appear to experience science differently as they progress through school. While girls and boys may attend the same classrooms, live in the same communities and even grow up in the same families, they do not receive the same science education. Analyzing National Assessment of Educational Progress (NAEP) questions acquired from 9, 13, and 17 year old students across the country with regard to gender, Kahle and Lakes (1983) report some thought-provoking results. Across all ages, girls reported less experience with the objects of physical science such as magnets, mirrors, and electrical circuits. Girls had experienced more interactions than boys only with living plants, sound and human behavior. Amazingly, girls reported fewer field trips to places like an electric plant or planetarium. This study draws a connection between the girls' lack of science

experience and their confusion about the applications and uses of science and science technology. It is not surprising that the girls in the NAEP study concluded that science classes were boring and made them feel stupid. Males, in American society, clearly are afforded more opportunities to become confident about science both by seeing science in action and working with the tools of science.

Erickson and Farkas (1991) confirmed Kahle and Lakes' research about the experience of girls with science and added some new dimensions. In a science achievement test administered to 238 students followed by interviews with 15 of the participants, they found that females most often supported their test choices with knowledge gained from school experiences, although the knowledge may have been incomplete or faulty. Males, however, appealed to information gained from auxiliary settings, such as working with their fathers or a course taken through programs such as Boy Scouts. If males commonly have more science-related experiences, they have more information to incorporate into their science framework.

It is enlightening to look at the ways boys in general feel about their likelihood of success in science. In elementary school and even nursery school settings, boys often segregate themselves, viewing males as athletically and intellectually superior. Boys often believe that they know more about science and, by their behavior, form a link between masculinity and science (Kelly, 1985). Both boys and girls believe that girls' successes in science and mathematics are

less worthy than boys'. They think that girls succeed because of hard work, conscientiousness and following rules rather than real intelligence and understanding (Willis, 1996). All of these attitudes add up to future positive feelings about science, in general, for boys.

Jones and Wheatley (1990) studied gender differences in classroom interactions in 30 physical science and 30 chemistry classes. Their results showed that boys called out in class more than twice as often as girls in response to teacher questions. The girls appeared "more self-conscious and quiet" (p. 867). The boys received both considerably more praise and more behavior warnings. Their data show that the boys in their study are claiming the science class as their domain, an environment that they can control and in which they succeed.

Another factor in the science classroom experience of girls is the amount of instrument use allowed by teachers. Teachers will often do instrument manipulations for girls while they tell boys how to perform the manipulations themselves (Weinburgh, 1995). Thus, boys gain experience using the equipment while girls are relegated to the role of observer. As a consequence, boys become more comfortable with equipment and less afraid of trying new things with equipment. Experiences gained when young translate into resources that can be drawn on in adulthood in any occupation, including teaching.

Perhaps one of the most determining factors for a feeling of self-efficacy in science is assessment. Girls seem to differ from boys in their perception of problems. Often, girls do not abstract issues from their context while boys

usually tend to consider issues in isolation while dismissing the context (Murphy, 1996). Also, teachers themselves favor boys in the assessment process.

Murphy(1996) reported that teachers give lower marks to a science writing when it is attributed to a girl than when it is attributed to a boy (Murphy, 1996). It is difficult to accept Murphy's work and its implications. However, it speaks to a notion held by some men and women that the work of males in science has more worth and will be more readily accepted than the work of females.

This literature on the differential science experiences of boys and girls helps us to understand their differing attitudes towards science. In order to understand how these experiences may influence the science teaching of these males when they are grown and become teachers, we need to examine the literature on teacher beliefs.

Beliefs about Knowledge and Learning

Epistemological Development

There is a significant body of research about gendered epistemological beliefs and learning. These views influence how individuals deal with competing knowledge claims, evaluate newly introduced information and make decisions that affect their own lives and the lives of those in their sphere of influence (Hofer, 2000). Foundational to this research about epistemological understanding is the work of Perry (1970), who conducted a longitudinal study of Harvard students in the late 1950s and early 1960s. Although this study was begun as a

general study describing the evolution of students' interpretations of their lives and how they construe the nature and origins of knowledge, it is, in reality, a study of men, since Harvard was an all male school in the 1950s and 1960s and only two women from Radcliffe were included in the final results. One could spend time bemoaning the gender-biased intent of Perry's work, but it is more advantageous to mine it for the information it generates about men and their beliefs about the nature of knowledge. Perry found a development of epistemologic views progressing through nine positions. It is notable that science is often brought up by his participants as a field that is significant to note; these allusions to science will be emphasized in this review because they are so pertinent to my research questions. The first position Perry describes in his book is an authority-driven, absolutist position. Students holding this view believe that education plays out as memorizing facts through hard work so that one is capable of responding to an array of discrete items with correct answers. As a student is exposed to pluralism in the dormitory and college classroom, he progresses to viewing diversity as not so much alien to his community but as alien to him. Students in position 2 most often voice confidence in science as the place where they can be comfortable with absolutes. Notice the following student's comparison:

I'll tell you the best thing about science courses: their lectures are all right. They're sort of, they say facts. But when you get to a humanities course, especially – oh, they're awful – those lectures. Oh, I can't see any relation. You're reading a book, and, ah, to my way of thinking, anyway, the lecturer is just reading things into it that were never meant to be there. They say that, ah, I can't see how they can draw a conclusion that an

author living sometimes B.C. had any certain thoughts – predestination, whatever they read into it now, just made popular now-they seem to think for every word written down in the book, the author had a definite meaning, double meaning, ambiguous meaning. I don't know, I couldn't see that. (p. 79)

Perry points out that science and mathematics are a hope to these students because they perceive these two disciplines as procedural rather than interpretive. This grouping of science and mathematics as philosophically apart from their humanities coursework causes Perry to conclude that these students are granting some legitimacy to multiplicity. Perry, himself, singles out science as a tenuous place of respite for these students because it is open only to those who have the ability to succeed in science.

As the student progresses to position 3, rightness and hard work vanish as standards, but the student is still groping for some certainty. Again, science appears as the critical filter of this search:

I'd feel rather insecure thinking about these philosophical things all the time and not coming up with any definite answers. And definite answers are, well, they, they're sort of my foundation point. In physics, you get definite answers to a point. Beyond that point you know there *are* definite answers, but you can't reach them. (p. 89)

In positions 4, 5, and 6, these male students move into multiplism towards relativity, concluding by the end of position 4 that conflicting views are equally valid. By position 6, the students seek a continuity between what "I know" and what "I value" so that the stage is set for commitment. By positions 7, 8, and 9 the student is ready for commitment within his relativism. These last three

positions define an action mode rather than a philosophic development, and Perry found that few students reached this pinnacle.

What exactly does Perry's study offer to the story of male, preservice elementary teachers? Surely, it elucidates the development of male epistemological thought of students in an elite university decades ago. However, it is the foundation of all existing psychological work on epistemological beliefs (Hofer & Pintrich, 1997). Without intention, it is a gendered study that shows how males may view knowledge and specifically positions about science knowledge may interact with a student's espousal of relativism. It shows that males consider science existing in its own unique context and that their views of science's absolutism are resistant to change.

Feminist researchers such as that of Belenky, Clinchy, Goldberger and Tarule (1986) and Gilligan (1982) have studied women with the goal of understanding the ways that women understand the world. Belenky et. al. recognized Perry's work as foundational, but as male, and therefore separate from the experience of women. In essence, women's ways of knowing progress through stages, like Perry's stages, but they rely on relationships with other women. This separateness of women from men is a thread that runs through both Women's Ways of Knowing and In a Different Voice. While they have served to illuminate the world of women, they have also produced a dualism with two very separate worlds-one male and one female. Gilligan maintains that women have a separate voice, a relational voice that views autonomy, selfhood and freedom not

as “the *sine qua non* of human development but as the human problem” (p. xiii).

The male voice is not relational, and the world males live in is focused, rather than diffuse like the female world. Gilligan’s work has extended Perry’s work by expanding our understandings of ways of knowing for all people, not just females. This view of knowing that includes the relational components offers a broader vision for all.

Perry, Belenky et al. and Gilligan describe developmental models for epistemological growth. Individuals progress in a Piagetian way through assimilation and accommodation. These developments culminate with a view of one’s self as a constructor of knowledge and the belief that the context of the question and frame of reference of the person asking the question determine the answer to the question (Hofer & Pintrich, 1997). There are others who challenge the idea of individual consistency of epistemological positions across contexts. Some, such as Hammer (1994), maintain that an individual may be consistent within a context, for example, physics, but not in another context, like interpersonal relationships. Learning would then involve activating the structures already within a person to function in a new context. This theory has not yet addressed the question of unity or disunity of structures among males and females. However, Hammer’s emphasis on the importance of context introduces a new element in gender research.

This theme of context is pivotal in the research of Thorne (1993), who studied boys and girls in the playground of an elementary school for almost a year

with the goal of understanding “how children come together to create and sometimes challenge, gender structures and meanings” (p. 4). Her work led her to reject the hegemonic view of gender as oppositional dualism because this view ignores incredible variations in behavior. Contrary to the dichotomous culture stereotypes, Barrie observed that some girls played in large groups, argued about rules, hurled insults at both girls and boys, and got into physical fights. At the same time, some boys played in groups of twos or threes, engaged in creative play and eschewed large group games. Barrie’s emphasis is not on contrastive gendered culture, but on the contexts of behaviors, the complex social relations in which behaviors are constructed.

Barrie’s emphasis on social construction of gender shares a common strand with the work of R. W. Connell (1987, 1995). Connell stresses that the views of masculinity and femininity dominant in our culture, no matter how strong, do not determine individual behavior. There are, in fact, various forms of masculinity and femininity expressed and accepted in our culture. In fact, these multiple masculinities and femininities are so intertwined that teasing them apart is a much more difficult task than the dichotomous culture research would suggest. Connell emphasizes that the social division of labor, the distribution of power, and the degree of cathexis (the investment of emotional resources) are critical to the creation of gendered behavior. Gender, then, becomes a way to order social practice. As Connell states, “Gender is social practice that constantly

refers to bodies and what bodies do, it is not social practice reduced to a body”
(Connell, 1995, p. 71)

These various interpretations of gender and how it intersects with personal representations of knowledge and behavior help to lay the foundation for the interpretation of my research data. The emphasis on context redefines the data into a story with more nuance and complexity.

Teacher Beliefs

Nature of Teacher Beliefs

Kagan (1992) defines teacher beliefs as “tacit, often unconsciously held assumptions about students, classrooms and the academic material to be taught.”(p. 65). These teacher beliefs can be divided into two main groups: the teacher’s sense of self-efficacy and content-specific beliefs. Self-efficacy includes both the teacher’s ability to influence students and the teacher’s beliefs concerning his or her own effectiveness as a teacher. Kagan concludes her meta-analysis with this prophetic statement;

The more one reads studies of teacher belief, the more strongly one suspects that this piebald form of personal knowledge lies at the very heart of teaching. Teacher belief appears to arise out of the exigencies inherent in classroom teaching, it may be the clearest measure of a teacher’s professional growth, and it appears to be instrumental in determining the quality of interaction one finds among the teachers in a given school. As we learn more about the forms and functions of teacher belief, we are likely to come a great deal closer to understanding how good teachers are made. (p. 85)

Although teacher belief and teacher practice go hand in hand, beliefs cannot be inferred from teacher behavior (Janesick, 1982). Further complicating

the issue is the fact that teachers may not have the language to articulate their beliefs or may be reluctant to state their beliefs publicly (Cooney, 1985).

Not only are teacher beliefs the bedrock of teaching practice, these beliefs are stable and highly resistant to change (Brousseau, Book & Byers, 1988). Tosun (2000) in his study of the beliefs of female, preservice elementary teachers towards science teaching found that they used primarily negative descriptors to describe their reactions to both science and science teaching. This research maintains that such negative attitudes influence teachers' beliefs concerning their own self-efficacy as science teachers.

Belief and the Science Teacher

According to Smith and Neale (1989), teacher beliefs about science teaching can lead to four science teaching orientations: (a) a discovery orientation which defines school science as exciting and "hands on," (b) a process orientation which emphasizes the scientific method and process approaches, (c) a didactic approach which concentrates on content and memorization, and (d) a conceptual change approach which focuses on fundamental concepts and theories in science with opportunities for students to construct and reorganize their beliefs and preconceptions.

One might suppose that a rigorous background in science might predispose a teacher to one of the more desirable approaches to teaching science. This may not be true. In a study of student teachers' conceptions about the nature of science, about teaching and about learning, Aquirre, Haggerty and Linder (1990) found that even secondary, preservice teachers with a college major in

natural science were disposed to a transmissive approach to teaching science rather than a constructivist approach.

It is also not clear that science methods courses that emphasize conceptual change actually influence the way that preservice teachers teach science. Researchers have found that such courses result in awareness of conceptual change teaching, but do not result in a change in practice (Marion, Hewson, Tabachnick and Blomker, 1998).

On the positive side, Downing, Filer and Chamberlain (1997) found a correlation between preservice elementary teachers' competency in science process skill and their attitudes towards the field of science. They feel that teachers with low levels of confidence may avoid science experiments or may keep classroom questioning and discussions to a minimum, but that teachers who have been exposed to science process laboratory experiences themselves are more likely to use them in the classroom.

Teacher Gender

Although student gender has been the focus of considerable educational research, there is a paucity of information about the effects of teacher gender. Most studies of elementary teachers are, in essence, studies of female elementary teachers, since there are so few males in that sector of the profession. In recent years, a limited number of studies have considered the teacher gender issue, with some focusing solely on issues affecting male elementary teachers and some comparing male and female teachers.

Student Teachers and Gender

Notably, in the research studying only male elementary teachers, the teaching of science, as opposed to other subjects, seems to continually come to the fore. For example, Oyler, Jennings and Lozada (2001) explored the experiences of a former Marine Corps boot camp trainer as he sought to enter the field of elementary education. Lozada's road through student teaching was rocky. Conflicts arose from misunderstandings between him and his female evaluators. One of those misunderstandings occurred when Lozada, using information he gained from a science methods course, attempted to implement science experiments intended to encourage his female students to participate actively in a mealworm unit. When Lozada expressed his delight that the girls in the class were not squeamish with insects, his cooperating teacher was openly dismayed with his sexism. Issues of perceived sexism such as this led Oyler, Jennings and Lozada to conclude that gender is one of the axes upon which teachers construct identities and that discourse is the way to understand how gender permeates our teaching practices.

In a similar vein, Hebert (2000) studied six gifted males and their belief in self as they pursued careers in elementary education. These preservice teachers identified the major factors that influenced their strong belief in self and foremost among them was exposure to male teachers as appropriate career models. In several of the examples cited in the article, the participants particularly mentioned how their male role model taught science. “We studied dinosaurs in the “tar pits” behind the school building. . . We dissected frogs. We went on hikes. We had never seen this before in school.” or “He had aquariums with lizards and snakes in tanks.” This emphasis by these male participants supports the notion that male

teachers may emphasize active and hands-on learning. The importance of male role models to male teachers is also a significant theme in Hebert's work. It would be interesting to know if the participants in this study sought particularly to emulate the science teaching of their male role models.

Although Brookhart and Loadman (1996) did not allude to science in their study of 936 males and females entering elementary education, they did find that the males were less academically oriented, had more self confidence about teaching, and less favorable opinions about their education courses than the females.

Gender Issues in Elementary Education

Riggs (1991) has specifically addressed the gender differences in elementary teachers' views of self-efficacy. In a quantitative study using the Science Teaching Efficacy Belief Instrument, she found that male inservice and preservice elementary teachers scored significantly higher than females on self-efficacy for science teaching. Although she proposes that these data suggest a link to differential educational experiences for males and females, her research does not answer that question.

A study of Greek teachers addressed how their gender influences student-teacher relations (Hopf & Hatzichristou, 1999). Greek schools are ideally suited for such a study, since their teaching profession for both elementary and secondary school draws equal numbers of males and females. This quantitative study included a teacher-completed Pupil Behavior Rating Scale ($n = 60$ teachers) for each of their students ($n = 2003$ students), a teacher-completed student achievement scale for each of their students, a peer nomination assessment filled

out by each student and a self rating filled out by each student. Student grades from each teacher and grade points were factored into the data. Male teachers were more likely than female teachers to evaluate male students as having behavior problems. Students tended to perceive themselves more positively in female teachers' classes. The authors suggest that future studies should explore teacher-gender differences in behavior, teaching style and classroom treatment of students.

Sargent (2001) makes an important contribution to our knowledge of male elementary teachers in Real Men or Real Teachers: Contradictions in the Lives of Men Elementary School Teachers. This study examined thirty five male primary teachers ranging in age from early 20s to late 50s with a range of teaching experience from one to over thirty years. The study focused on the challenges of teaching in a female world and how these men negotiated these challenges. Most of the men in this study rejected the stereotype of men as more assertive, task-oriented, practical and authoritarian, although they believed that these qualities were sometimes projected onto them by others. In fact, the areas of greatest dissonance in their professional lives were often directly related to the stereotypical views of parents, fellow teachers, and principals. These men had to deal with how to nurture young children in acceptable ways and how to interact in lunch rooms and teachers' rooms with women who had their own, sometimes unfavorable, biases about men. These men found it disconcerting to be continually assigned tasks requiring physical strength, such as lifting, in the school. The assumption that all men are technology experts and skillful at repairing equipment was also distasteful. Some of these men felt that they were subjected to harassment by women teachers. In short, Sargent's study describes

men who, in an occupation dominated by women, express many of the typical hegemonic views commonly held by minorities. Sargent's findings are very pertinent to my research primarily due to the similarity of the participants, although Sargent's teachers are established teachers, not teacher interns. Also, Sargent's work does not focus on the teaching of a particular subject area. However, certain themes, such as the meaning of teacher nurturing, the lack of career prestige for male teachers, and the path to school administration for male teachers are particularly pertinent to both Sargent's work and mine.

In summary, this research shows that teacher beliefs are influential, but difficult to precisely delineate, even for a single teacher. Beliefs grow from roots deep in individual experience and may even result from gendered experience. The picture is complex, suggesting the necessity of further elucidation. This study of male preservice elementary teachers teaching science should add a piece to the puzzle.

Chapter 3 Methodology and Procedures

Introduction

In the first two chapters, I delineated the significance of this study as a logical outgrowth of the previous research in education generally and science education specifically. This chapter includes the underlying theoretical framework for this research, a description of the methods and procedures used to collect, organize and analyze the data, and an introduction to the participants.

Methodology

Underlying every study is a methodology, or theoretical perspective (Bogden & Biklen, 1998). To answer my proposed research questions, I needed to probe male preservice teachers' understanding of science and the teaching of science. That probing required a qualitative methodology, specifically ethnography. As described by Atkinson and Hammersley (1998), ethnography relies chiefly on participant observation and is characterized by the collection of largely unstructured empirical material. The data are analyzed to develop an interpretation of the meanings and functions of human actions. In this case, I am exploring the understandings that male preservice teachers hold about science and the teaching of science.

People are, by nature, complex. Understanding and meanings interconnect with the past and the present. The 5 men in this study are at the beginning of a journey into a career in teaching. Intrinsic to their stories are growth and change. As I talked with them and observed their teaching, I was aware of this evolution as people and as teachers. The emphasis that ethnography places on exploring the nature of particular social phenomena gave me a framework to examine the contexts of their thoughts and actions. Although researchers differ on the focus of ethnographic studies, most agree that ethnography is an effort to understand the view of the participants by seeking to be in the setting long enough to gain acceptance and understanding (Lareau & Schultz, 1996). Over the 10-month data collection aspect of this study, I gradually began to understand the world of my participant male preservice elementary teachers in a way that I could not have accomplished within a shorter time.

The goal of my research is to develop theory that is grounded in the data that I collect. Grounded theory, as defined by Strauss and Corbin (1998), is a methodology that assumes that human action is complex, but that “persons act on the basis of meaning” and that “meaning is defined and redefined through interaction” (p. 9). The researcher, through continuous comparative analysis, can develop theory that is a “set of well-developed concepts related through statements of relationship, which together constitute an integrated framework that can be used to explain or predict phenomena” (Strauss & Corbin, 1998, p. 15). It is my goal that the theory that I generate will offer insight into the decision-

making of male elementary teachers as they design and implement science curriculum in the classroom. Basic to this insight is an understanding of each of my participant's view of science as an academic discipline. A teacher's concept of the essence of science and the scientific endeavor is at the heart of their approach to science in the classroom. The actual teaching of science, however, encompasses not only an intellectual understanding of what science is, but also a pedagogy involving how children learn and how science should be taught.

Teachers differ widely in their notions of science and the pedagogy of science; their understandings are influenced by a wide variety of factors. The analysis of these factors is the second focus of this study. Finally, I want to examine the relationship among gender, concepts of science, and concepts of pedagogy in the lives of male preservice elementary teachers. My goal is that elucidating these relationships will lead to a better understanding of the male elementary school teacher.

The Education of an Education Major

All five participants for this study were seniors at the university and thus in their final year of the Elementary Education program preparing them to teach grades 1-8. At (pseudonymous) State University, Elementary Education students must meet 37 credits of Core Requirements, 50 credits of Pre-Professional Requirements and 48 credits of Professional Requirements. The Elementary Education major requires two four-hour courses in science. One course must be a physical science and may include astronomy, geology, chemistry, or physics from

the following choices: (1) Introduction to Astronomy with Observational Astronomy Lab, (2) General Astronomy, (3) General Chemistry, (4) Physical Geology, (5) Historical Geology, (6) Physics of Music, Light, Perception, Photography and Natural Phenomena , and (7) Inquiry into Physics (a laboratory oriented course designed for Elementary Education majors or Early Childhood majors only). The other science course must be a biology course and must include one of the following: (1) The World of Biology, (2) Principles of Biology, (3) Plant Biology for Non-Science Students and (4) General Microbiology. Two 3-hour math courses entitled Elements of Mathematics and Elements of Geometry are also required. Each Elementary Education major chooses an area of emphasis, which may include Communications, Literature, Mathematics, Foreign Language, Social Studies or Science. Each of these areas of emphasis requires 18 hours of coursework in the discipline, including some required courses and some choices from a selected list of courses in the discipline.

The Elementary Education program at State University sets aside both semesters of the senior year for practical experience in the elementary schools. During the fall semester, Elementary Education majors spend two days a week at the university taking methods courses in the areas of Language Arts, Mathematics, Reading, Science, and Social Studies. Students are assigned to blocks or groupings of students (approximately 25 in a cohort), who stay together for all of their methods courses. The other two days are spent in an elementary classroom with the elementary teacher who will mentor them throughout both

semesters. Each block of student teachers is assigned to a grouping of elementary schools in a local school district. State University sends student teachers to more than one school district. My participants were drawn from two different blocks of student teachers, but they all did their student teaching in the same school district. During the spring semester, Elementary Education majors spend five days a week in their assigned schools.

Settings

This research takes place in two main settings. The first site is the classroom of a Science Methods course at State University. This university is a large (35,000 student) mid Atlantic state flagship university. The second setting is the elementary classrooms in the participating district schools. Each of the schools will be described in the section focusing on each individual teacher.

Janet Zimmer's Science Methods Course

All of the participants for this study were drawn from two Science Methods courses taught by the same instructor, pseudonymous Janet Zimmer. My advisor arranged my initial contact with Janet Zimmer. Her two Science Methods blocks at the university at that time were the only two containing enough males for my study. Each of these blocks had approximately 25 students. The instructor readily agreed to my attendance in both her methods classes for the whole semester. Teacher interns in both Science Methods sections were given the same syllabus and had the same assignments. Data obtained for this study from these Science Methods classes took two forms: (1) my notes of classroom

observation in the Science Methods class and (2) students' reflective writings that were assigned by the instructor. Each section met once a week for two hours. One section met on Wednesday morning from 10:00 a.m. to 12:00 p.m. and the other on Thursday afternoon from 1:30 to 3:30 p.m. I attended these classes to observe the interactions of my participants with other students, the professor, and the materials presented in the course.

One of my goals for this phase of my project was to become acquainted with my participants in a fairly relaxed context. To avoid looking like an evaluator, I took few notes during the Science Methods class time and wrote down my impressions and specific memorable events after class. I took care not to align myself with faculty before, during, or after these classes. I tried to be an interested onlooker and interacted on a social level with all of the students in the class, not just the participants of my study. During class, I sat at the desk groupings with the students, rotating to different groupings every week. Most of the time, I avoided sitting at the front of the class, where I would be conspicuous. I never offered verbal input in any of the class discussions, such as group design of experiments or group participation in experiments or projects. The Science Methods classes met in the Science Teaching Center of the university, which has the furniture typical of a middle school science classroom. The center of the room was filled with groupings of low lab tables surrounded by glass-fronted laboratory cabinets, higher lab work areas and sinks. A demonstration table was

located at the front with a blackboard, screen, and various audio-visual equipment including an overhead projector, and television.

The classroom time for the Science Methods class was dominated by various laboratory activities appropriate for the elementary classroom. Some time was spent discussing science education topics such as 5E lesson plans, science process skills, and integrating science with other subjects in a lecture format. Class sessions were conducted several times at the university golf course, where ecological activities, such as water testing, were performed. One session on web-based science resources was conducted at the university computer lab. Various prepared lesson plans, as well as a journal, were part of the required assignments for this course. The journal was of particular interest to me, because four journals from each student were entered on the class Listserv and were reflective entries about science events occurring in each of the students' classrooms. These journal entries by my participants were used as a data source for this research study. The class culminated with a poster session of science inquiry projects prepared by the student interns working with a small group of students from their elementary class.

Participants Classrooms

All five participants were assigned to schools within the same school district. Two participants did their student teaching at the same school. Each school will be described in the section focusing on the individual participants.

Recruitment of Participants

Finding five male, preservice elementary teachers was not a simple task. In the two blocks I included, there were only eight males, two in one section and six in the other. Six men originally agreed to participate in my study, although one later dropped out due to complications in his elementary class. On the first day that I visited the class, Ms. Zimmer briefly introduced me to the students at the beginning of class. She told the class that I was a graduate student beginning my dissertation research. She dismissed class a few minutes early that first day and asked the men in the class to meet during that time with me so that I could describe my project. All of the young men in each section came to the meeting except two who had prior commitments. I explained my project to them as one that would study preservice elementary teachers' views of science teaching and their ways of actually teaching science. Since male elementary teachers have not been studied extensively, I was interested in what males bring to the table when teaching science, a knowledge that would be of benefit to understanding teachers in general and possibly help to attract more males into elementary teaching. I emphasized that my role was not evaluative and that I was not connected to university evaluations in any way. I also explained that they would retain anonymity throughout all phases of my research. The advantages to my participants would be the personal reflection that would be a part of the study, resulting in a greater understanding of their own teaching. After describing the extent of their involvement including interviews and observations, I asked them to

sign a sheet, if they would consider participating. Pseudonymous Glenn, Paul, and Donald, as well as one other young man who later dropped out of the study, readily agreed . Pseudonymous Josh maintained that he would not mind participating, but that his views of science were largely negative. We chatted for a while and I presented the possibility that it would be advantageous to my study to have the balance of a participant who did not even pretend to have an interest in science. Josh and I parted that day with a tentative commitment dependent on approval by my advisor. The next week, Josh signed on as part of this study. The final study member was pseudonymous Steve. Steve had not been able to meet with me the first week I attended the class, but after speaking with me, he enthusiastically consented to be the final member of my study group.

Initially, the participants in my study were guardedly friendly towards me. They would say hello if they saw me when they entered class, but did not pursue conversations with me. Although I had emphasized that I was not an evaluator, I believed that they felt “under the microscope.” This initial awkwardness dissipated quickly as I became more like a member of the class, behaving casually towards all the students. I valued this time as a chance to see my participants as part of a group. When there were classroom discussions, about either science topics or science education topics, all the males in my study participated unreservedly. This includes Josh, who claimed to have little knowledge of or interest in science.

Preservice teachers are close to their educational roots and are in a mode conducive to reflection, where in fact, reflection is demanded in the form of journals. This situation greatly facilitated the interview process. Since I worked with such a small number of participants, I was able to get to know each of them well. As described by Atkinson and Hammersley (1998), ethnography involves the “investigation of a small number of cases, perhaps just one, in detail” (p. 111). A case study is a “detailed examination of one setting, or one subject or one event (Bogdan & Biklen, 1998). When the study is expanded to include more cases, it becomes a comparative case study. The advantage of a comparative case study is that “the more cases included in a study, and the greater the variation across the cases included in a study, the more compelling an interpretation is likely to be” (Merriam, 1998, p. 40). The small number of participants in this study is characteristic of qualitative research, which exhibits the weight of richness and depth in data rather than the weight of numbers, which is characteristic of quantitative research. I found that having five participants yielded data rich enough for contrasts and comparisons (Huberman & Miles, 1998).

Data Sources

Information was collected from four sources: journals, interviews, classroom observations and classroom documents.

Journals

Journal entries were a requirement for the Science Methods class that the participants took in the fall semester. These structured journal entry topics related

to information about a preservice teacher's background in science, interest in science and theoretical positions regarding the teaching of elementary science. All students submitted these journal entries to the professor, but I examined only those written by my study participants.

Interviews

Individual interviews, both unstructured and semi-structured, were conducted with each of the five participants. Unstructured interviews occurred before and after class, on the playground, or when students left the room for other activities, such as music or physical education. Notes on these interviews were written as soon as possible after the interview. These unstructured interviews were aimed at "understanding the individual" (Fontana and Frey, 1998, p. 42).

Semi-structured interviews had a slightly more formal aspect. They were usually conducted in a classroom or teacher lounge with some forethought as to the line of questions, so that I could obtain some comparable data across subjects (Bogdan & Biklen, 1998). Between three and five interviews were conducted with each participant during the spring semester or Phase 2 of the internship. The time frame of the interviews was usually between 40 minutes and an hour. A few interviews lasted longer than an hour. Participants scheduled interviews at convenient free time during planning periods or after school. These interviews were audiotaped and transcribed.

Observations

Since observations enable the researcher to determine how people's words correlate to their actions (Macleod, 1996), I observed my participants throughout their experiences in the fall and spring semesters. During Phase II of the internship, which is spent entirely in their assigned elementary schools, participants were observed from four to six times teaching a science lesson. In addition, each participant was observed for an entire school day teaching a regular school schedule. Participants scheduled these observations, usually via email, although I did sometimes have to visit the school to schedule an observation. These observations were made in unmanipulated or uncontrived situations. I wrote extensive field notes during these observations. Memos were kept to maintain and focus awareness of the progress of the research.

Classroom Documents

I collected documents, such as lesson plans and handouts, from both the university classes in the fall and the observed science classes taught in the spring field experience. These were compared to the student and teacher versions of instructional booklets prepared by the district so that I could understand how each participant utilized the materials provided to him.

Using these four different data sources allows for triangulation i.e., the use of several sources to establish the accuracy of the data (Krathwohl, 1998). Triangulation is intended to provide support for a finding in several pieces of data. In this research, data from journals and interviews reveal the participants'

thinking, while observations, lesson plans and classroom documents show how that thought played out in action.

Data Analysis

Data analysis continued throughout the course of the study. Concepts were assigned by conducting a line-by line analysis of the data. (Strauss & Corbin, 1998). A concept is simply a labeled phenomenon. For example, an observation of a teacher intern showing his class a fossilized fern from his personal rock collection might be labeled with the concept “lesson illustration from intern’s personal collection.” As concepts emerged, they were then grouped under a more abstract higher order classification called a category. For example, in this study concepts concerning auxiliary resources brought into the classroom by interns were placed into the category of “implemented auxiliary resources.” As categories, or abstract explanatory terms, were identified, they were broken into subcategories that explain the when, where, why, who, and with what consequences of the category (Strauss & Corbin, 1998). For example, I analyzed the auxiliary resources, to discover who used them, when, where and for what purpose they were used and with what results. This latter process called axial coding reveals the various lines of symmetry of the category so that relationships within the category and between categories may emerge. Axial coding relates categories to subcategories at the level of properties and dimensions. A property is a general or specific characteristic of a category while a dimension shows where the property is located along a continuum. A property of auxiliary

resources might be “auxiliary resources used as illustrations” and a dimension would be “personally-held resources are readily available.” This entire process conceptualizes the data. Axial coding allows the researcher to clarify and link categories. I found that this category of auxiliary resources related to avocations, success of experiments, and enthusiasm for science. As major categories are connected in this manner, they can be integrated into an overall theoretical scheme in which one central category emerges. This central category unites all of the major categories by providing a logical and consistent explanation. The central category should even account for discrepant events or contradictory cases. Thus, the theory corresponds to the data and explains the data.

Building grounded theory is an inductive process that relies heavily on the collected data, and it is important that this data be reliable or trustworthy. As Bogden and Biklen (1998) point out, “Qualitative researchers tend to view reliability as fit between what they record as data and what actually occurs in the setting under study” (p. 36). To insure reliability or trustworthiness, my analysis was member checked by the participants after the data were collected and analyzed.

Unlike quantitative studies, qualitative studies are not concerned with generalizability, but are concerned with comparability and translatability. Comparability addresses the completeness of description with reference to participants, setting, analysis and concepts generated. Translatability refers to clear description of techniques and theoretical stance (Schofield, 1990).

Participants

I observed and interviewed the five participants of this study during the 2001-2002 school year. All of these men were seniors at the university at this time and graduated from the university with a degree in elementary education in May, 2002. At the surface, they share many characteristics. They are all white, middle class, and natives of the state where the university is located. Four of the five are interning in the same school district where they themselves were elementary students. All five attended a community college before completing their degrees at State University. Their individual stories, however, are different. This section will include a brief description of each of them, focusing on their backgrounds and interests. In the later chapters, I will concentrate more on their understandings of science and science teaching.

Glenn Adams

I remember vividly my initial encounter with Glenn. He came up to me during a break in the first science methods class I observed and announced in a friendly manner, “ You need me in your study because I am ‘the science guy’.” After some further conversation, we both agreed that his enthusiasm for science would make him a valuable participant for my research. Glenn could be classified as a somewhat unique elementary education major member because he began his college career intending to major in biology. He pursued that goal for two years. He also worked as a laboratory technician for several years while attending college. Glenn’s extensive background in science adds contrast and depth to my

group of male elementary teachers because he is the only one with an academic background in science.

Glenn grew up in a county in the close vicinity to the university and also close to the district in which he did his student teaching. He has one brother a few years younger than himself. He attended public schools and recalled his own elementary science education as weak. He remembered only a rock collection unit, some electricity and a study of properties involving identifying unknown substances. In middle school, he had a memorable teacher who exposed the class to many experiments in all areas of science. Mrs. Evans had her eighth grade class formulate a pH-balanced soap, which they carried through to production and marketing. Glenn also described balloon cars that students made in her class. He characterized this teacher as being "like me. She liked science and she liked children." (interview, 4/15/02). In high school, Glenn took courses in biology, chemistry, physics, and environmental science. After high school, he attended a branch of State University in another city with the intention of completing a major in biology. He completed several biology and chemistry courses, but one professor soured his interest in science. Primarily for financial reasons, he transferred from the four-year college to a community college where he completed an associate degree. From there, Glenn transferred to State University where he completed an education major. It took Glenn six years to complete college, primarily because he worked the whole time to generate enough funds for

his tuition. He mentioned proudly that he paid for his own education although it did mean that it took longer.

Glenn approached his career options analytically and often throughout his college life. His initial choice had been to be a research scientist. While employed in a laboratory, he met a researcher who had been working for seven or eight years on a project and then realized that the controls were wrong. This failure introduced to Glenn the possibility that work in science may not always be fruitful. It was conceivable that he might invest a great deal of time in science and end up with no results. Not only did this make failure a possibility, but Glenn also could not ignore the fact that science research sometimes has a boring, repetitive aspect. “I came in and I did the same tests every three days. You know, I cultured the bacteria and waited for them to grow. Day three, count and then do it again....It was very cool for the first couple of months and then it started to wear” (interview, 4/15/02). Glenn had also considered working with satellite systems, but he knew that sitting all day before a computer would bore him. He realized that he was a people person. He had enjoyed participating in an educational program for kids sponsored by the research center where he worked. That experience, coupled with his involvement with a county after-care program, caused him to consider education. Glenn stated that the pace of teaching suits his personality. “I don’t do anything for longer than 45 minutes and then I change up and do something else....By the time the kids are starting to get bored, I already am. My attention span matches theirs pretty well.” (interview 5/10/02)

Glenn's first preference is to teach middle school life science, but after that, he would choose upper elementary grades. Having accumulated many science credits made it easy for Glenn to fulfill the requirements for a science area of emphasis which would make him an attractive candidate for middle school positions in a district that does not require a science major for middle school science teachers. Teaching lower grades means a heavy responsibility for teaching reading, which he would prefer to avoid. He feels that he has more to offer as a math and science teacher and in his words, "I like to teach many things, but I love to teach science" (interview, 5/10/02)

It would be only half a story to relate Glenn's experience with school and work science and not include his incredible avocational interest in many science-related areas. Glenn recalled spending most of his childhood outside. He is now a self-proclaimed rock hound, astronomy buff, bow hunter and fisherman. These pursuits are more than casual and consume considerable amounts of his free time. Often during the course of interview sessions, Glenn related details about hikes, boating trips and biking trips. Some of these activities were solitary and some involved groups of male friends. Glenn not only loves to accrue information about the natural world, but he loves to share it. His conversation was peppered with enthusiastic stories about his experiences and specimens that he collected.

At the time of this research, Glenn was engaged to marry a fellow education major. He had also applied for a teaching position in one of the local school districts.

Glenn's student teaching assignment took him to an elementary school that attracted attention as having some of the lowest standardized test scores in the school district. The student population was over capacity and portable units had been added. Glenn's fourth grade class was held in one of those units. The ethnic mix of the school was 44% Hispanic, 21% African American, 19% White and 15% Asian. The school received Federal Title I funds.

Glenn always made sure that our interviews were conducted in places where we could not be overheard and were unlikely to be interrupted. The first interview took place in the teacher's lounge during the school day, and only one teacher came in to get coffee and then left. Our other interviews were in the computer lab when it was not in use, outside his portable classroom on a small porch, and in an unused workroom. Glenn seemed to enjoy sharing his thoughts about teaching and especially his thoughts about science. He never seemed to be in a hurry to finish, nor did he appear at all hesitant about what he said. Glenn scheduled most of my observations for times when his mentor teacher, a woman, was not present. On two occasions, his mentor teacher was absent for the day. The same substitute teacher was always in the classroom, but Glenn functioned as the teacher, using the substitute to help with smaller groupings of students, especially during mathematics or reading lessons. Throughout my research, Glenn impressed me as a mature and confident teacher.

Donald Green

Like all of the participants in this study, Donald grew up in the metropolitan area surrounding the university. He attended a public elementary school in the same district in which he is a student teacher intern. He has a brother who is three years younger. His father is a salesman. His memories of elementary school science were few, but he did recall an electricity unit that motivated him to build his own flashlight at home. He also remembered looking at cheek cells under a microscope in fifth grade.

Donald's high school science courses included laboratory science (physical science), biology and environmental science. He did not take either chemistry or physics.

Donald attended a community college for two years where he took environmental science and a geology course. He fondly remembered field experiences from the environmental science class, "Being in college, you don't expect to go on any little trips. We just jumped into a van and went. We went to a water treatment plant and a recycling center for trash...We thought it was cool because we all got to walk around with hard hats and goggles." (interview 4/17/02) After two years, Donald transferred to the university where he took a general biology, lecture oriented course with labs once a week. He specifically mentioned the *Drosophila* experiments and commented that he personally remembers information gained from hands-on experiences better than information gained from a book. As an education major, Donald took a concentration in

communications. He chose that because he thought it might be a possible major if education did not work. He particularly enjoyed a class in international communication and another in mass communications. In retrospect, he felt that a communications major was probably not as beneficial to his teaching as a major in science or reading. He had mistakenly expected that a study of communications would be of help in communicating with students, but that did not turn out to be the case. Donald took more than four years to graduate from college. He graduated at age 24.

Donald participated in several extracurricular activities during his academic career including Cub scouts, which he gave up when he was older so that he would have more time for his friends. He enjoyed being a part of an art club as well as stage crew and literary magazine staff in high school. His present avocations include maintaining a marine aquarium at home, reading popular fiction and some gardening. He maintained that he “loves science” and I believe that to mean that he is enthusiastic about it. He enjoys learning science and does not avoid encounters with science either personally or professionally.

Over the course of his life, Donald had considered a career as an artist but he concluded that he did not want to be a “starving artist”(interview, 4/18/02). The same conclusions made him abandon the idea of becoming a writer. During his sophomore year in college, he had a part time job at a day care center, and decided that teaching was something he could do, would enjoy doing, and at the same time make a respectable living.

Like all of my participants, Donald has a very friendly manner with people including fellow students, colleagues, and children in his class. To me, one of his most outstanding traits is a sense of humor that is exhibited in all kinds of situations even the inevitable spillage in laboratory experiments. Of all the participants in my study, Donald gave the most considered responses to inquiries and comments.. When asked a question, he responded with a precise and careful reply. He did not speculate much about the future. He was also the most prompt about responding to emails for setting up appointments.

Donald's student teaching took him to the same school as Steve, another participant in this study. This school had 560 students with 35% African American, 15% Asian, 22 % Hispanic and 26% White. The average classroom size for grades three through five is 23 students. Donald's classroom was down the hall from Steve's, and since they both taught fourth grade they often shared thoughts and ideas. When one of them did a science lesson, he would fill in the other on practical details such as how to distribute materials or control the flow of the lesson. I also observed their mentor teachers collaborating on a science/writing project. Interviews with Donald all took place in his fourth grade classroom. His mentor teacher did not usually stay, although once or twice, she met with some other teachers in the room at a table far removed from where Donald and I were talking. Our conversations were quiet, and I never thought that she was interested in their content. Don's mentor teacher did not interrupt our interviews in any way. Because Donald's classroom was in the basement of the

building and the school's rooms all seemed to be in use all day, it seemed to be most convenient to stay in Donald's classroom. Most of our interviews took place in a free period before or after an observation or during lunch.

Donald would prefer to teach 2nd to 4th grades, and especially enjoys fourth graders.

Josh Jones

In contrast to Glenn, who believed he would add to my study because he loves science, Josh believed he should not be a part of my study because he does not like science. After some conversation about my study benefiting from a variety of views, Josh agreed to participate. I found that although his original assessment was honest, science teaching brought some surprises to Josh and offered me some unique perspectives.

Josh has lived his whole life in the same district in which he is student teaching. He has one sister who is a few years younger and is attending college. After attending public elementary school and middle school, Josh went to a small, local, private high school. He does not remember a single elementary science experience and mused about how remarkable that was:

Josh: I remember every single teacher's name that I ever had. I remember units that we worked on since third grade, and I don't remember one science lesson in all six years that I went there. I don't say that there weren't, I just don't remember any. Not one! (interview, 3/18/02).

Josh did remember having a special interest in dinosaurs as a young child although this interest was nurtured primarily through family trips to museums and

personal reading. Josh speculated that had this interest been expanded upon in school, he might have developed more of an affinity for science at a young age.

Although Josh remembered nothing from middle school science, he did speak fondly of a chemistry teacher he had in high school. He remembers her as being able to explain chemistry so basically that everyone understood some part of it. This quality coupled with her good-natured personality, made her class memorable, although Josh still admitted that all the memorization of chemistry “went right over my head”(interview, 3/18/02). Besides chemistry, Josh studied biology and physics in high school.

After high school, Josh had an opportunity to study acting, but made a last minute decision to opt out of that program and attend community college. After two years there, he transferred to State University where he majored in Elementary Education. At the university, his work in science included a biology course and a meteorology course.

Josh arrived at a decision to become a teacher sometime during his sophomore or junior year in college. He had done some tutoring and found that he “had the gift to relay information” and that he “loved it” (interview, 3/18). Josh mentioned that his father is a teacher as are other family members and that familiarity with the profession influenced his choice of teaching as a career. While student teaching in elementary school, he enjoyed teaching reading and social studies. His goal is to teach middle school social studies, and he hopes to never teach in a self-contained elementary classroom. Teaching in a self-

contained elementary classroom would require Josh to teach science, a subject he dislikes so much that he wishes to avoid it entirely. Josh's area of emphasis for his Elementary Education degree was English Communications.

Josh started out his student teaching in a fifth grade classroom. The school where he was assigned received the academic support of Federal Title I funds. Breakfast was supplied daily to each of the individual classrooms for all the students. The ethnic composition of the school was over 50% Hispanic, 22 % African American, 15% white and 8% Asian. To accommodate the growing student population, portable units were added. When I first started observing Josh in a fifth grade class, his room was in a portable unit. He was assigned to this fifth grade class throughout the fall semester and through February of the spring semester. The university then moved Josh from the fifth grade class to a second grade class. The second grade class he was later assigned to was located in the main building of the school. The fifth grade class had about 23 students and the second grade class about 16. Academic subjects in the fifth grade where Josh began his student teaching internship were departmentalized so that Josh's mentor teacher, a woman, taught English and history and a male teacher taught science and mathematics. During the fall semester, while Josh was taking methods courses and spending only two weeks in the elementary classroom, he did not observe or teach any science classes except those that were required for projects for his science methods course. I did one all day observation of Josh while he was teaching fifth grade. No science whatever was taught on that day. All of my

observations of Josh's science teaching took place in the second grade class. Here again, his mentor teacher was a woman.

My interviews with Josh took place in varying places. The first interview, conducted while Josh was still interning in the fifth grade, was in the teachers' lounge during Josh's free period. We were totally uninterrupted. The other interviews, which all took place during his tenure in the second grade, were conducted at a table in the back of his classroom at the end of the school day. His mentor teacher was never present during these interviews.

Josh seemed very comfortable with the fifth graders in his first assignment, but he was less at ease in the second grade class. He answered interview questions thoughtfully and completely, but did not elaborate or give many examples.

Steve Smith

Like the other participants in this study, Steve is a life-long resident of a county in the close vicinity of the university. He has two sisters and three brothers. His father owns a business and his mother works as an administrative assistant. He attended a private elementary school, was homeschooled during middle school, and received his high school diploma from a public high school in the same district in which he is student teaching. After high school, he took a semester off, and then attended a community college for two years, followed by another 2 1/2 years at the university to complete his degree in elementary education.

Steve remembered little science from his elementary or middle school years, but was very positive about his high school science experiences. He specifically mentioned dissecting in biology which he described as “really cool” (interview, 4/17/02). He did not enjoy the lab science course in high school and did not take physics either in high school or college. Steve mentioned doing a lot of experiments in the physical science class in the community college and a professor who tried to make science enjoyable through the doing of science. He summed up his attitude toward science as a student by saying, “I liked science, but I didn’t ever love it. It was fun. It was enjoyable, and I could do it. I could understand it” (interview, 4/17/02).

When Steve graduated from high school, he was not sure what career he wanted to pursue. He had worked with kindergarten and preschool children in a child development course he took in high school and had a few responsibilities involving planning and teaching lessons. When he was at home for a semester after high school, he helped his mother with carpooling duties. These children were elementary age children, and Steve found that he enjoyed being around them. “I loved seeing kids every day and hanging out with the kids some days.” This led him to consider teaching and after some deliberation he decided that God had called him to be a teacher. This mention of God is congruent with Steve’s matter-of-fact approach to his religious faith although he talked of it only occasionally in our interviews.

Steve mentioned during our talks that he paid for his college education himself and was proud of the fact that he did not put a financial burden on his family. Nonetheless, this meant that finances were tight and even testing that was required for teacher certification had to be put off until he could afford the fees. Steve lived at home during the time that he attended college.

As part of his education major, Steve chose two areas of concentration—English and History. He admits to choosing English because it was easier to get into the classes, and he particularly enjoyed a World Literature class, and a Bible Poetry class. If he were to teach in middle school, he would want to teach history because “I love history. I wouldn’t be opposed to teaching science, but I would have to learn more.” (interview, 5/13/02)

Steve’s avocations include both watching and participating in sports. As a youth, he competed in swimming, baseball, football, soccer and basketball. His other hobbies include rock collecting, studying insects, reading and camping. After he took an astronomy course in college, his father bought him a telescope and they both enjoy going out to the country to observe the stars.

Steve hopes to teach third or fourth grade because he believes that older students are popularity oriented and are not as “nice to teach other” (interview, 4/29/02). He also stated that fourth graders are more interested in learning than older students while at the same time having the ability to do more without assistance. When asked about his long range plans, Steve thought that he might teach elementary school for four or five years and then pursue a degree and career

in communications—perhaps sports communications. He held open the possibility of pursuing a graduate degree and one day teaching at a university.

Steve was assigned to a fourth grade class with an African-American woman as his mentor teacher. Steve scheduled two of my observations when his mentor teacher was not present. The interviews held on those days were held in the classroom with little interruption. His mentor teacher was in and out of the room for one of the other interviews and worked at her desk for the fourth one while Steve and I talked quietly in another part of the room.

Steve is a sociable person who enjoyed interactions with both his peers in his science methods course and with his students in his fourth grade class.

Although his manner was more formal with his fourth grade students during class time, I often observed him joking with them during recess. From the start of this study, he displayed an easy and unreserved manner with me. I would describe him as a “happy-go lucky” man, but that does not do justice to his serious side. His serious side was evident when he was at the front of the class and also when he discussed issues such as his goals for his own life and his goals for his students.

Paul Costanzo

Paul has lived all of his life in the same school district where he did his student teaching internship. His father owns a business. He has one sister a few years his junior. Paul attended public schools in the same district from elementary through high school and then applied to the university. He was a student at the

State University for only a short time when a serious car accident put a hold on his plans. He then attended a local community college for two years and transferred back to the university.

The impression that Paul first made upon me, and one that persisted throughout my study, is that he is a very open and honest person with a positive outlook on life. He expressed joy in being able to take students outside for a science lesson and described a successful science experiment as “beautiful”. His answers to questions were thoughtfully phrased, but he seldom expressed any opinions in negative terms.

As far as scholastic experience with science, Paul did not remember many specifics from his own elementary school science experience, but mentioned two notable elementary school science events. One involved the construction of a simple machine, and one was a field trip to a local water recreation facility. In high school, he studied biology, anatomy, physiology and chemistry. Dissecting a cat was an experience that he vividly recalled. At the community college his science studies included environmental biology and astronomy. After he transferred to the university, he studied geology and meteorology. Of his later science courses, he remembers changing atmospheric pressure in a bottle and watching a liquid boil at the lower pressure. His summative comment about these science course was that “Such things (as watching the liquid boil at lower pressure) really stick with you” (interview, 3/20/02). Paul’s area of emphasis was science, but he did not study physics in either high school or college.

Paul decided upon elementary education as a career primarily through observing his mother who had done day care in her home and later worked in an elementary school. Paul had helped her with projects like talent shows and found that kind of work to be “a lot of fun.” (interview, 3/20/02). Later Paul, himself, taught a gymnastics class. This association with children, coupled with his degree of comfort with that experience, was a major factor in choosing education as a career.

When asked about memorable science teachers that Paul had as a student, he specifically recalled those teachers who “really seemed to care” (interview, 3/20). He mentioned one woman, a Mrs. Jones, who was “cool” and, when asked to elaborate, he specified that she was “social, and got down to a level with us.” (interview, 3/20/02) Paul also spoke fondly of a chemistry teacher who was always available for help, had a good rapport with students and did not become easily frustrated.

Our interviews were all held in Paul’s classroom. Most of the time, his mentor teacher left and one time she entered the room for very short periods while working. On one occasion, she answered one of the general questions that I was asking Paul. In this particular interview, Paul’s answers seemed more stilted, and I believe that the mentor teacher’s evident attention to our conversation made Paul uncomfortable. Paul’s elementary school was at the end of a long corridor and there did not seem to be any empty rooms along it. Some of our interviews were

conducted during a free period when the students were away at music and one was conducted after school.

When asked about his favorite subjects to teach, Paul specified both math and science with perhaps some greater leaning toward math. He expressed a special interest in science because science “tickles my fancy.” (interview 3/20/02). His plans include teaching in the district where he is interning because his family is located there.

Paul did his student teaching internship in a fourth grade class that started out as a 4th/5th grade combination class for the first four months of the school year. Paul’s projects for his Science Methods course were done with fifth graders. At about midyear the fifth graders were moved to another class, and Paul continued the major portion of his internship with the fourth grade class. The racial/ethnic composition of his school is 40% Hispanic, 28% white, 17% Asian, and 14% African American. The average class size for fourth grade is 24 students.

Comparison of Participants

The five participants of this study share many characteristics. They are all white, and come from middle class homes. They all grew up in the same metropolitan area as the university. They all attended, at some time in their lives, public schools near the university with four of the five being natives of the same school district where they were student teaching. Each of them attended a community college for two years before attending the university. Four of them

attended the same community college. They all took more than four years to complete their university education, making them older than the typical college graduates. Four of the five were student teaching in a fourth grade classroom. All of them had women mentor teachers. For a university with over 30,000 students, these are noteworthy coincidences.

However, to imply from these superficial statistics, that all of these men are somehow “cut from the same cloth” would be a gross oversimplification. They differ in their love of science, their beliefs about science, and their philosophy of teaching. Some of these differences are major and some are subtle. These similarities and differences provide the foundation for the next four chapters.

Table 1. Background information on participants

Name	Age	College Science Course Preparation	Subject Area of Emphasis	Grade Teaching
Glenn Adams	24	Biology, Ecology, Environmental Science, General Chemistry, Geology, Human Geography, Microbiology	science	4 th
Paul Costanzo	23	Astronomy, Environmental Biology, Geology, Meteorology	science	4/5 combination changed to 4 th
Donald Green	24	Environmental Science, General Biology, Geology	communications	4 th
Josh Jones	23	General Biology, Physical Science	communications	5 th moved to 2 nd
Steve Smith	23	Astronomy, General Biology, Physical Science	English & history	4 th

Chapter 4 Beliefs About Science and Science Learning

Introduction

Elementary teachers are not required to have an extensive background in science or a familiarity with the working world of scientists. For most children, however, elementary school offers the first, and perhaps the only, exposure to science in their early years. The nature of teacher beliefs about science and science learning can have several consequences including, the transmission of these beliefs to the students and the practical working out of these beliefs in science teaching.

As one would expect, not all of the participants of this study felt familiar enough with science as an academic discipline to discuss it in a theoretical fashion. Of all the participants in this study, Glenn was the most conversant about the nature of science. Given his extensive background in science and a fervent interest in all things scientific, it is logical that his opinions about the nature of science would be most clearly defined and most definitively articulated. What did come as a surprise, however, was that Josh, on the other end of the spectrum as far as enjoying science, was equally voluble about the nature of science. Josh's distaste for science did not prevent him from having well-defined notions about

the subject. Given the difference in their dedication to science, these two provide a fascinating comparison. The other three participants were less vocal about science as a discipline. They had made their peace with the subject and liked it to some degree but never waxed as eloquent about science as Glenn and Josh did.

I have included in this section not only a discussion of how these men view science, but their beliefs about who practices science and the qualities that they should possess. Teachers may play a role in their students' decisions that extend into the future. Just as Glenn could remember one middle school teacher who nourished his love of science and acted as his role model for science teaching, many students are directed down certain career paths by their teachers. The beliefs that elementary teachers have about the practitioners of science could have far-reaching effects.

Beliefs About Science

Glenn Adams

Glenn believes that science literally permeates all of life. Although to him, the rigorous study of science usually requires a laboratory and solitude, science as an avocation can be appreciated all the time, because science is everywhere. Science is a way of viewing the whole world. The following dialogue with Glenn clarifies his view:

BH: What would you tell a kid science is, if they came from another country or something and they didn't know and they said, "Hey, Mr. A., what is science?"

Glenn: My definition or the definition I would tell them?

BH: Both.

Glenn: My definition of science is the analytical study of everything.

BH: And what would you tell the kid?

Glenn: The kid? Science is a different way of thinking. It's not just guessing, it's actually.... Oh, general questions just hurt so much. It's really a way of thinking and looking at things with a certain eye. You look at things to find out why it works...why it works the way it does. What would happen if. It's a big "What if?" If you're looking at psychology, you're looking at human thought and human emotion. If you're looking at botany, you're looking at how plants grow. Astronomy, it has nothing to do with plants, but it's science. You could study leaves and not have it be scientific. You can just look and take observations but if they're not true observations, it's not science. *So it's not what you're looking at, but how you're looking at it* [emphasis mine] (interview, 5/10/02).

For Glenn, the essence of science is the experiment and the experiment is both constrained and set free by the scientific method. The scientific method is the modus operandi. Glenn describes it this way:

When you do anything, you have to do the scientific method. This is how we're using it. This is how we can use it. This is how we will use it in the future. The scientific method is like the Bible. (interview, 5/10/02)

This Biblical analogy is significant. As the Bible delineates actions for the believer, Glenn believes that the scientific method delineates actions for the scientist. A scientist must have a hypothesis, an experiment with the appropriate controls, the gathering of data and the careful conclusions. This, for Glenn, is nonnegotiable. Glenn's view of science is honed by his years of working in a research laboratory and conversing regularly with researchers. He understands the rigor required of laboratory work.

Glenn: Real science takes place in a notebook. You use the notebook for every single thing. Every thought that occurs to you, you write it down in your notebook. I had oodles of notebooks and they had carbon copies so that all your notes, everything was in there. (interview 4/23/02)

Glenn's view of science as knowledge is that science is a unique discipline in both its nature and method. Science can make claims that are true because of its reliance on the scientific method. He contrasts science with art:

BH: So if you are looking at it (the leaf) as an artist, you'd be seeing something different?

Glenn: You can't mix art and science. It just doesn't happen. To me, art and science are just bipolar. (interview, 5/10/02)

To place Glenn in Perry's continuum of epistemological views is difficult because Glenn speaks most about science almost to the exclusion of other disciplines. In Perry's scheme, Glenn falls between positions 2 and 3 because Glenn has a strong belief in absolute truth and thinks that science is the way to attain it. He points out "You can just look at a leaf and take observations, but if they are not *true* observations, it's not science" (interview 5/10/02). Glenn views science as philosophically apart from art. He views observations of a leaf as valid in other disciplines, but not leading to truth. Also, he perceives science as procedural and separate from the humanities. Other disciplines, in Glenn's mind, may not seek to attain truth.

Given Glenn's definition of science, who would be the scientists and what qualifications would they possess? When science is practiced, who are the practitioners? When asked about which of his fourth grade students might become scientists one day, Glenn chose only one student—a male. The reason for his choice was:

He thinks analytically. He looks at things and he breaks them down. He asks, ‘Why does that happen?’ He asked me this morning, “What is acid rain?” And I said, “What do you think it is?” And he said, “There’s like dirt or something in the air and it kind of turns into rain and it comes down.” And I said, “That’s really close. It’s not dirt.” And he’s the only one in the classroom that I kind of talked to about elements and the periodic chart. So I told him about sulfur dioxide and how it’s made from burning coal and fossil fuels like the gasoline from your car or like power plants. So when the coal burns, it goes up and mixes with clouds, and when it rains, it comes down to the earth and that smoke makes the water acidic. And that’s what melts the statues. We discussed that about marble and granite when we did the geology in the fall. So they would know that the granite doesn’t dissolve. So a little background knowledge....Yeh, there’s one or two that I could see in science, but not really becoming a scientist. I could see them taking a lot of science courses and really enjoying them, but not being scientist. (interview 4/24/02)

It is notable that Glenn believes that the characteristics of a scientist are innate. He refers to analytical thinking ability as something a fourth grader either does or does not possesses. Analytical reasoning is not taught, it is not developed through the learning process, and it does not accumulate with maturity. Only the very few who possess the ability to analyze, can be scientists. He maintained on several occasions that very few of his students “think scientifically.” Scientists are, in Glenn’s mind, a rather elite group to which only 1 out of 25 students in his class could conceivably aspire. One or two other students in the class might learn something about science, might even enjoy science, but do not have what it takes to be a scientist. When asked whether his students thought about science the way he expected, Glenn replied, “Some do and others don’t. Some are just amazed, but some of them really do understand. They really get into it, and they think ‘scientific’” (interview, 4/26/02).

Josh Jones

In contrast to Glenn, Josh does not enjoy science. He did not enjoy learning it, and he does not enjoy teaching it. Even though Josh does not like science, he has his own clear view of science as a subject:

BH: What's science like?

J: Science to me is like a bunch of random facts and stuff that's trying to explain things, and doesn't really happen to have necessarily a logical or rational flow, although that's what it's supposed to be. It doesn't have a logical or rational flow as to why things work the way they do. (interview, 3/18/02)

Here Josh maintains that he knows that science claims to be logical and rational, but that the rational flow is not readily apparent. He later stated that the rational flow of science was particularly difficult to establish at the elementary school level. Josh contrasts science as a subject with his favorite subject—social studies.

BH: Does social studies appeal to you because of your special interest in it or because you had better courses in it?

Josh: Oh, I definitely did not have better courses. I'm just more interested in it, and I know the content much better. And to me, it's a lot easier to teach. Social studies is very easy. You start at one end and it's very cause and effect relationship, and you just work on a time line. Very simple. Very linear.

BH: And science isn't linear?

Josh: Not at all. (interview, 3/18/02)

So Josh sees social studies as obeying simple rules of cause and effect, but science does not. Teaching social studies involves following that linear and

logical progression, but science is different. Josh admitted that he has no interest in teaching science and that he hopes to avoid teaching it by obtaining a position as a middle school social studies teacher. He had several reasons for this.

Josh: Science doesn't have a logical or rational flow as to why things work the way they do, as far as presenting the information. It's very easy for history or English, you know, you start talking about one area and that's kind of like this area. But as for science, it's just kind of general and out there, so that it's hard for me to get a finger on it. When I even look at science curriculums, even within units, it doesn't make sense as to how things go along from one thing to another. It just doesn't make sense. (interview, 3/18/02)

This disjointed and unrelated quality of science facts at the elementary level permeated Josh's discussions of science. He maintained that:

I haven't done much science and, to me--and that's what I was trying to say earlier--to me, it doesn't seem like it's a type of thing where you are building upon prior knowledge. Like there is just one thing and branching it out to a different topic. Although it very well may be and I just don't know it very well. It doesn't...it seems as though whatever topic or whatever direction you go in, it stays pretty isolated. And you just learn all the theory behind it and you learn how to do the experiments and then, you're done. And you go to the next topic, which is completely different from the others. And then you learn a bunch of theory, and then you learn how to do the experiments and then you're done. (interview, 3/18/02)

This comment by Josh reflects the way that science is commonly taught in elementary school. Theory is either not emphasized or it is not mentioned at all. For example, evolution which is the overarching theory of biology, is not mentioned in the second grade butterfly unit or the fourth grade ecosystems unit. It is then left to later science teaching in middle, high school or college to introduce that overarching theory. Josh's comment that "it may well be" shows

that he believes that perhaps his lack of exposure to science influences his view. Perhaps the discrete teaching of the various sciences leads to this disconnectedness. Perhaps Josh's teachers did not have a big picture view of science or did not articulate it to their students. Whatever the cause, Josh's statements about what science are related to his lack of interest in teaching it. I observed Josh teaching poetry to fifth graders. He told his students not to simply look for "right answers" because "Poetry is for your own interpretation"(field notes, 3/18/02). At a later date I called this quote to his attention and asked him if science had any room for interpretation, as poetry did. He answered, "Absolutely not. Science is just facts and that is all" (interview, 5/3/02). In a conversation later, Josh clarified that science has room for literal interpretation, but not subjective interpretation.

When I observed Josh teaching a second grade class about butterflies, his approach validated his verbalized views of science. He drew pictures of an insect on the board and asked the students to identify the head, thorax, and abdomen . The students added and labeled the antennae, eyes, wings etc. and reviewed facts concerning the function of each part. He had the students make a list of similarities and differences between moths and butterflies. Josh emphasized the facts of science to his students. While reading a book about monarch butterflies to his second graders, Josh asked them to think about what fiction is, as opposed to nonfiction.

Josh: Fiction is fake. Nonfiction is not fake. Name a fiction.
Student: Marmaduke.

Josh: Yes, something that's made up. How are they different?

Student: May be funny.

Josh: Yes, fiction may be funny. Can this be fiction? (Says the following in a monotone, boring voice with no inflection.) This butterfly is colored yellow and lives here. (Goes back to usual voice.) Very dry. Fiction sounds like somebody talking. Nonfiction doesn't sound that way. It sounds boring. It may be interesting, but there is not enough emotion. (field notes, 5/9/02)

Nonfiction is not as engaging to Josh because there is no emotion in it.

History and fiction are, to him, more closely tied to the human condition, while science is dry and unrelated to the more interesting aspects of human interactions.

Acting (Josh's original career choice) resounds with emotion and passion.

Science does not. In summary, Josh views science as cold and lacking subjectivity.

This information leads me to believe that Josh's view of some kinds of knowledge, such as poetry, is in position 4 in Perry's scheme. In this position, multiple views are equally valid, as Josh clearly pointed out to his students. However, like many of Perry's subjects, Josh puts science in its own particular place – a place of absolute facts. Josh does not view all knowledge through this same lens. Some subjects, like poetry, allow for subjective interpretation. They require thought and individual input. Since Josh values individual thought and input, he loves the humanities and dislikes science.

Steve Smith

Whenever Steve talked about science, he emphasized science's practical aspects. He did not discuss science as a unique field of knowledge nor say much

about it as a discipline. This, I believe, reflects his practical nature. Steve did, however, compare the scientific method to all kinds of problem solving:

It's developing a strategy to solve problems. And you do that in math; you do that in writing; you do that in every subject. If you can identify the main theme say, in reading, then you can start to tackle it using problem solving strategy. And you can do that the same way with science. It's mostly in science and math you see it, but it's important also in reading and social studies. (interview, 4/29/02)

Steve drew a distinction between the mere observation of phenomena that is emphasized in school science and the actual doing of science:

I think that process is very important. Like for them to know, all right, first you come up with the hypothesis. Although, I'll say that they haven't structured experiments like that in school, which is kind of weird, actually. (interview, 4/29/02)

Steve mentioned the importance of making circuits during the electricity unit to find out "how things work." It is this personal and independent aspect of science that fascinates him. Science is a subject in which "you discover yourself" (interview, 4/29/02). Then the important thing is "How do you implement that idea? How do you use that idea?"

As to the attributes of scientists, Steve singled out one girl in his class who he claimed was

so smart...She solves the idea and she gets it and she retains it and it's not just gone. During the electricity unit, she was my point person. If anyone was struggling, they could go to Mary and she could explain it to them. She has a really good knowledge of it, and she likes to do it. There's a smile on her face when she does it. Mary's pictures are amazing and her diagrams—very detailed. (interview, 4/29/02)

Although the elite aspect of scientists is certainly present in Steve's discussion, the practical is again emphasized. Mary can not only understand, but she can set her ideas down as diagrams and explain them to others. To Steve, Mary is an effective learner, and he does not characterize her as engaging in rote learning agreeing with the findings of Meece and Jones (1996). Also, reflecting Steve's pursuit of joy in life, Mary can be a scientist because she loves to do science. When discussing Mary's exceptional interest and ability in science, Steve did interject a caveat about girls in science.

Steve: But the girls, after like fifth grade, they don't like science anymore. Even if they're great at it. Once they get to middle school, it's all about being cool. So most girls don't pursue that science love that they had in elementary school. It's sad, because I think science is great. (interview, 4/29/02)

As claimed in the literature by Johnson (1987) and Kahle and Lakes (1983), Steve believes that the girls will not pursue their interest in science once they leave elementary school.

Steve did not discuss the theoretical aspects of science in any way. Science as an academic discipline was not as important to him as the applications that people could make with science. Steve does not view science uniquely in this sense, but applies this view to the other subjects that he teaches.

Paul Costanzo

Like Steve, Paul emphasized the problem solving aspects of science. He identifies the nature of scientific investigation as the problem solving of science that is "transferable to whatever science you are doing" (interview, 3/20/02).

Also, like Steve, Paul has a practical bent that causes him to emphasize the applications of science as opposed to simply the knowledge of science. Paul mentioned several times that it is important for the students to know “environmental issues, such as how the watershed is affected and how everything is affected by everything. I would like to redirect it to them and come up with some ways of, well, “What can we do? What do we do?” (interview, 5/1/02).

Paul did not discuss the theoretical underpinnings of science. Since he never studied physics, and the only chemistry he took was in high school, theory may not play a huge role in Paul’s understanding of science in general or the various scientific disciplines in particular.

When asked about which of his students might become scientists some day, Paul referred to one female student, Annie, and explained that her parents work at the Smithsonian. He expounded on this notion:

Paul: There are students here who definitely have the minds....It is those students whose parents are already involved with science or are working with science that I see going on.

BH: What do you see that they have?

Paul: They’ve been exposed to these concepts a little bit more. The math is there a little bit better. Maybe the interest is there a little bit more because maybe they see it in their home. But I do see mathematicians and scientists coming out of here.

BH: So you expect that one day that...

Paul: I would not be surprised. There are a few that I might target.

BH: So Annie and are there others?

Paul: Yes, Sally. During the science fair, we had three or four that entered the science fair, so...

BH: So, who were the ones that entered the science fair?

Paul: Yes, Annie and Sally and, I think, Joe and David. So we had four from one class. For them to enter the science fair, that’s not something that they have to do. So they are showing interest right there. (interview, 5/1/02)

In this excerpt above, Paul delineates his personal requirements for scientists: exceptional background (most likely from family members who are scientists), exceptional math skills, and enough interest to take on scientific challenges like a science fair project. It is notable that most of these qualifications are outside the influence of the classroom teacher. The family milieu and math aptitude come with the child into the classroom, and optional outside projects, like science fair projects, often take some adult guidance and commitment. Paul does not comment on the teacher as a force to guide students towards a career in science.

The mathematics/science connection is significant. This is a common correlation (Sells, 1980), and one that haunts both students and teachers. Since students are commonly tracked in mathematics, the “mathematically talented” students are already identified by fourth grade. As a result, some students who lack math skills are excluded from science careers in the minds of teachers. Paul believes that for his students to consider a career in science, they must also be successful in mathematics.

Donald Green

When asked about science as a discipline, Donald first enumerated science’s similarities to other academic disciplines. He mentioned that “there are lots of components to it (science) that are just reading and writing” (interview, 4/24/02). He also pointed out that the research of science bears similarities to all

other kinds of research e.g., in history where researchers do historic investigation from various original sources. This analysis was fascinating to me because it introduced the notion that the human activity of discovery involves the same kind of process no matter what kind of knowledge the researcher seeks. If one considers the scientific method of defining a problem, finding out what is known, hypothesizing, carrying out research and then forming conclusions, one could say that this process is used in many different academic disciplines. Donald started with similarities instead of differences and wound up with a universal notion of how discoveries are made.

When asked about the differences between science and other disciplines, Donald replied that "Science is unique in the sense that it is more often than not, hands-on. I guess that math is often involved in science" (interview, 4/24/02). Donald sees the manipulative aspect of science as important, that the experiments are designed and carried out by the scientist. One is reminded of controlled experiments, with carefully measured variables taking place in a laboratory setting. In fact, Donald mentioned the accoutrements of science as being part and parcel of the discipline. He recounted field trips where he visited a water treatment plant and "we thought it was cool because we all got to walk around with hard hats and goggles and looked like we were in our twenties"(interview, 4/17/02). So, for Donald, scientists, in many ways, perform the same kind of research work as other academics, but they have unique and identifiable aspects to their work that are primarily associated with the laboratory component of science.

When talking about his students becoming scientists, Donald shared his own ideas of the requirements of science.

Donald: Like I've got a couple in here, that love science to the point that they read nonfiction only and they come in with new facts that are new to me saying "That's what I read last night!" and one kid brought in this thick book about animals – all the different animals—onto the bus during our field trip and we all gathered round. It's like a biology book, basically, but geared towards kids. There are some that come in with that knowledge, but it's more based on what their interests are than based on what they've learned, I think.

BH: Do you think some of them will turn out to be scientists?

Donald: If I could pick out one, it would be that kid.

BH: And are there others?

Donald: (pauses) Some of them have the potential, whether or not they have the ah, the ah, determination. (interview 4/18/02)

Here, Donald reiterates what Steve, Paul, Glenn and Josh also pointed out, that those who seek a career in science exhibit a certain passion for the subject. But Donald goes further than interest and potential, and mentions determination as a requirement for a career in science. He brings to mind the picture of Marie Curie, sifting for grams of radium in tons of pitchblende or of Watson and Crick arranging and rearranging molecular models of DNA until they found one that made sense. Although, many academic disciplines require determination, Donald singles out this trait as a requirement for the pursuit of science.

Comparison of Beliefs About Science

The beliefs that I have described about science are what Kagan (1992) would refer to as content specific beliefs. Unlike the teachers that Cooney (1985) described, the men in this study were not reluctant to state their beliefs. As I compared the epistemologies of these men, I grouped them into two major

classifications. Both Glenn and Josh view science as relying on facts without significant interpretation, while other academic areas allow for subjectivity. Glenn, more than Josh, emphasized scientific truth and the path to truth. This is probably due to the high value that Glenn places on scientific truth. Josh values interpretation and emotion, but sees facts as dry. Glenn has more scientific facts at his command and a more extensive comprehension of the scientific theories that give a framework to these facts. He is also fascinated by the facts of science. Nonetheless, Glenn's view of science as knowledge is very similar to Josh's. The significant difference is that Glenn loves interacting with science facts enough to learn about them and spend his free time immersing himself in them, while Josh does not find science captivating.

Donald, Steve and Paul emphasize the application of science. The knowledge gained from science can be used to improve the environment or help mankind, while the problem solving techniques of science can be applicable to any kind of problem solving in our everyday lives. This emphasis on action would place them higher on Perry's continuum. In Perry's view, they have a higher view of the nature of knowledge than those who believe that they can find truth. It may seem remarkable that the participant with the most sophisticated understanding of science would score lower on Perry's scale than the others. I would make the case that most practicing scientists would not place high on Perry's continuum, because as Kuhn maintains, "Scientist have not generally needed or wanted to become philosophers" (Kuhn, 1996, p.88). It is probably

more valuable to note the varying views of science and observe their effects on teaching practice, than to classify one view as higher or lower than another.

It is notable that, when asked to pick students from their classes who might become scientists, the choices represented a cross section of students regarding gender and ethnicity. In fact, more girls were named by the participants as potential scientists than boys, and the reasons given for the choice were independent of gender or ethnicity. This observation is contrary to the research of Jarvis (1996) and Kelly (1985). Jarvis maintains that most people envision scientists as white males. Kelly believes that students perceive science to be masculine because of the large number of males practicing science. Clearly, the men in this study are not bound by traditional gender stereotypes about the practitioners of science. Although Willis (1996) found that boys often believe that girls only succeed because of hard work, conscientiousness and following rules, the male preservice teachers in this study attribute the success of some of their female students to intelligence and understanding. Steve, for example, found that one girl in his class can represent her understandings well in diagrams and explain science concepts clearly to other students. Neither Steve, nor any of the other participants, even hinted that boys, and not girls, used more meaningful learning modes as Ridley and Novak (1996) suggested. These men never mentioned that boys had more innate intellectual ability as some early educational research (Macoby & Jacklin, 1974, Fennema & Sherman, 1989, and Fennema & Peterson, 1985) maintained. However, gender stereotypes in our

society are continuously in flux. For example, there are presently approximately equal numbers of women and men in medical schools. Women comprise about 1/3 of all practicing physicians. These proportions of women physicians are higher than any time in history (American Medical Association, 2004). Women now also comprise over 45% of all of the workers in science and engineering occupations in the United States (National Science Foundation, 2004). These changes in the gender composition of the workforce result in changes in societal views. The fact that the male teachers in this study hold the view that women can easily participate in science is encouraging. The student teacher interns in this study also seemed to avoid stereotyping either their male or female students in their science classes. This was unlike the student teacher, Lozada, (Oyler, Jennings and Lozada 2001) who offended his mentor teacher by commending the girls in his class for not being squeamish about insects. It truly seemed to me that the men in this study treated all their students equally and without bias. Their own choice of a career in a field in which they are a minority may help to make them less likely to view either careers or academic subjects as gender-specific.

One of the most outstanding notions held by these men as they discussed their students' talent for a career in science was the elite aspect of science ability. Most of them chose only one student from the class, although the question did not specify numbers. A scientific career, in these men's minds, is not an option for most of their students. In general, they believe that their students lack either

the analytical thinking ability, the family background, or the determination and drive to become scientists. Although these men do not express a view of science as masculine as Sadker and Sadker (1994) suggest, all of them do view science as a subject best understood by a small elite. Also, contrary to the research described by Murphy (1996), these men do not favor boys in their assessment of which students could be scientists, but expressed that scientists were exceptionally analytical, exceptionally motivated and exceptionally hardworking.

Table 2. Summary of participants' views of science

Name	View of Science
Glenn Adams	<ul style="list-style-type: none"> • “The analytical study of everything” • “A different way of thinking” • The scientific method is the Bible.
Paul Costanzo	<ul style="list-style-type: none"> • The problem solving aspect is transferable to anything you are doing. • It comes down to “What can we do?”
Donald Green	<ul style="list-style-type: none"> • Science research is like other kinds of research. • The work of science is hands-on.
Josh Jones	<ul style="list-style-type: none"> • In elementary school, science is a bunch of random facts. • The connecting ideas of science are difficult. • Science does not allow for subjective interpretation.
Steve Smith	<ul style="list-style-type: none"> • Science involves developing a strategy to solve problems. • Applications of science are important.

Understandings of the Learning of Science

Ideas about teaching science flow out of notions of how science is learned.

An analysis of the participants' theories of learning science provides a foundation for interpreting their understandings of teaching science.

Paul Costanzo—Build On Background Knowledge

When asked about how children best learn science, Paul spoke of his notions of learning in general and said that he believed that all learning in any discipline followed certain basic principles.

Paul: I don't think that it has anything to do with just learning science. I think that it's just learning throughout all subjects. So, I would say for science, that I think you need to relate to what is going to be taught. Most likely in fourth grade, they will have some type of background knowledge. Something, whether it's right or wrong, they will have something. So I think that if you can get the kids to access that, then the new information that you present and whether it's, well obviously you want it to be in an exciting way, but obviously it doesn't always turn out to be as exciting as you would like it to be. But I think that if you pull that background information so that they can modify it or adjust it if it's wrong or add on to it, then they can make connections to it. You obviously need to bring it down to their level and maybe bring examples out that they are facing and that they would be able to connect to that information. So, if I'm connecting to an adult's background, that is not necessarily helpful to them that much. An example...like in solar energy...I don't think there were many hands-on things that we did. We worked with shadows outside and, well, kids notice their shadows. So I think that was in the kit, so I can't take credit for the idea, but they traced their shadows at different times of the day so they they got to see their own shadows moving and from the same point they saw both the motion and I think that they were able to adjust their own background knowledge. They gained something from that. (interview, 3/20/02)

There are several important views about science learning that Paul expressed in this quote. In Paul's opinion, learning science is like learning

anything because science is like all other subjects. To explain this basic view, Paul evoked Piaget and his definitions of assimilation and accommodation, although he does not mention Piaget specifically. Paul mentioned “adding on” to background knowledge, which involves incorporating our perceptions of new experiences into an existing framework, or assimilation. His “modifying information” also sounds like accommodation in the Piagetan sense.

It is also important to note Paul’s emphasis on engagement as a prerequisite to learning. Paul believes that, in order for one to really learn, the imagination must be captured. The imagination may be engaged by relating the learning to some exciting event in a child’s life. When I observed Paul teaching all day, his mathematics lesson involved planning a party and using grocery store newspaper ads to figure the cost of the refreshments. This lesson was also videotaped for a presentation at the university so one could infer that Paul put into the lesson the things that he considered important—some exciting components that had relevance to everyday life that related to the necessary mathematical operations. In a journal, Paul recounted an observation by a university professor of a classroom discussion of the components of a well-designed scientific investigation. Even though the students participated in the discussion and the university professor was positive about the lesson, Paul described the lesson as being “boring and not very engaging.” In science learning, Paul believed that imagination could be captured by experimentation or the “doing” of science. When Paul had to choose science lessons for me to observe, Paul most often

chose science experiment/observation lessons instead of simple reading activities or discussions. These choices show what kinds of science learning situations Paul believes are most effective. His choices probably also reflect his beliefs about the learning situations most highly regarded as effective by the education community at the university.

Steve Smith –Science Learning is Active

Like Paul, Steve believes that all people acquire knowledge in the same manner. Steve emphasized exercising the senses of seeing and hearing to learn, but he also added the practical aspect of learning—the application. To Steve, science has the distinct advantage of being a subject that is primarily learned by doing.

Steve: I learn by seeing, but I also learn by doing, and I know that they (students) like doing instead of hearing. That's one reason I love it (teaching science) because the kids can be active. They're involved and a lot of times it will just click in their minds. Like I saw something finally click in electricity. And it was like this with the student saying, 'Oh, you can do this and you can change that and you put this over here. O.K., I get it! I get it! Mr. Smith, oh yes, I can do this.' He was jumping around and just that—their excitement...(interview, 4/17/02)

Steve mentioned the children moving about in science class several times. The freedom of science and the movement of the students doing science are, to Steve, critical to the learning of science. Steve is very sensitive to the level of involvement displayed by his students; to him learning is directly correlated to involvement. Steve repeated Paul's sentiments that doing science is more engaging than simply reading about science.

Steve: So when I came, we started doing a unit on electricity and they loved it! They just ate up the electricity. We had so much fun with it! They worked on their table groups for that, too. Especially, they really got into discovering and learning and finding out how things work. Not just reading a paragraph that says ‘it works like this’ and then writing whatever it is they have to write about. So they really enjoyed the hands-on and ever since then, maybe a month and half ago, science is just zoom. (interview, 4/17/02)

To Steve, learning science is exciting and fun because students discover on their own, work cooperatively in groups and find out how the world works. This whole process of learning science makes the time fly by. For the students, science can be the timeless moment, when one is so thoroughly absorbed that time becomes meaningless.

Steve recognized that this kind of learning has some inherent disadvantages. One is that, given freedom, children do not always do or learn what is designated by the lesson. Even this disadvantage, however, was seen as an advantage by Steve.

Steve: ...even if they don't discover exactly what the assessment wants them to discover...if they work something out that is different than what we want, it is still them doing it on their own so it is going to stick with them. Compared to them acing an assessment but then forgetting it three months later. (interview, 4/29/02)

Ever the pragmatist, Steve will choose the practical result of having children learn something, even if it is outside the plan, to doing activities or lessons that, in the long run, do not result in real, lasting learning.

Glenn Adams—Science We Do

Like Steve, Glenn emphasized the unique characteristics of science learning that separate it from learning other disciplines.

Glenn: You can't learn science from a book. "Open your book to chapter 3. We're going to learn the first law of thermodynamics." Shove the kid down the hill – they'll learn about the first law of thermodynamics.... Social studies we read and analyze. Science we do. (interview 4/15/02)

Glenn made sure that his lessons on ecosystems involved all the hands-on activities prescribed by the curriculum. His students had considerable time to make their observations and to have conversations with each other and with Glenn about the meanings of those observations. Glenn is very comfortable with a slow progression of science learning. Hands-on learning has its own pace, often a slower pace than might be achieved by learning out of a textbook. Although he expressed doubts that all of his students would learn what he hoped, he believes that they will make progress. Glenn lamented that "They need more time than what we have to give them." And then he turned to the positive, "I think that most of them got it. There are a couple that are really going to need some individual help to get it and they will come around" (interview 4/24/02).

Glenn was committed to the belief that students will learn more science if they are exposed to more science. He threw his abundant energy into helping students with science projects for a school-wide science fair. He worked consistently with students during recess for weeks before the fair. During that time, he helped students plan sound scientific procedures, seeing it as part of his ongoing goal to acquaint students with the scientific method.

BH: It seems like a lot of them participated in the science fair.

Glenn: We filled the entire cafeteria. This school is very good on enthusiasm. The principal, Mr. Jackson, has enthusiasm to spare for everyone and it's a very, very good thing. He gets excited about everything and so everyone else gets excited about whatever it is that he is excited about. So it spreads. It's like a disease, but it's a good thing.

BH: So your kids came to you at recess to work on these projects? They picked a subject, or did you help them with that?

Glenn: Most of the time, they picked it. I had a hand in "Oh, that could be cool!" kind of thing, but most of them did their own thing, picked their own partner, and if they needed help, I offered it in my room during recess. For three-four weeks before the fair, it was ongoing. I did most of the help the last two weeks. Had kids lining up to come in to do projects. I had a bunch of them in there at points. Most of them are procrastinators and the last couple days it was "Whew!"

BH: They were probably glad that you had so much help to offer.

Glenn: But I let them do the work. I suggested things. One group, some girls, I saw regularly, they were taking an egg and putting it in vinegar. And I suggested that they put it in water so you know what happens if you don't have it in vinegar. So you have a control. So you know, water's not going to do anything to the egg, but you want to know what vinegar does. Make sure it's not the egg dissolving. So you're trying to explain controls. You need that. So they caught on eventually, but first, it was, "You need to have something besides just vinegar. Otherwise, it's not an experiment. (interview 4/15/02)

This involvement in the science fair shows that Glenn is willing to spend extra time on what he believes is important. It also shows Glenn drawing on his considerable experience as a scientific researcher to help the students do valid scientific work. He expressed considerable pride in what he and the students accomplished. Glenn is thoroughly committed to student independence. He did not take over any student's project by making major changes. To Glenn, students learn better if they have some input in that learning. So, he made suggestions about projects including ways to make them better, but he did not totally undo the concept of a student's project. I observed this patience and

respect for other people's learning in one of the science methods classes in which the students were doing experiments with water quality at a local pond. The students were working in teams. A girl on Glenn's team was having difficulty trying to use a hand-held spectrophotometer. Glenn, who had experience with this kind of instrument, talked her through the steps until she got a reading. I was impressed by his approach because the most common reaction of an experienced person is to take the instrument into their own hands and do the experiment. This relieves the confused person of the difficulty and solves the group's problem of getting the experiment done. However, it also means that the original experimenter never really learns how to use the instrument. Although this may not seem remarkable, to me it was a memorable event and told me volumes about Glenn's philosophy of how people learn and how they should be taught. Glenn's actions are totally unlike those described by Weinburgh (1995), in which teachers performed instrument manipulations for girls but not for boys. Glenn did not take over any student's work and do it for them. He believes that students learn best when they do their own work and he requires independent effort by both males and females. Glenn's actions show that teacher belief and teacher practice go hand in hand as Janesick (1982) maintained.

Glenn recognizes that students will learn science at different levels because the students have different interests in science. Although he is drawn to students who share his enthusiasm for science, he appreciates their other non-science talents. For Earth Day, he took his students outside to sit under a tree

while he read aloud Children of the Earth Remember by Shim Shimmel. He used the book as the inspiration for a discussion about ecosystems and had the students do a word splash about some of Shimmel's descriptive phrases. Each student then picked a phrase and wrote a poem incorporating it. Glenn described his students' poems with enthusiasm:

Glenn: Whatever popped into their heads, they wrote down and then just circled what they wanted to use and then they used those things in their poems. So it was just, pick one and write about it. Pick one and write about it. For 10 minutes or more – just beautiful poems. There was one that was just excellent. You'd think he was using a thesaurus, but he's not. He's just got these words in his head. "Deceitful darkness" and "how the light dispels the darkness." The line he used was "The black velvet of space ends up a new planet," and he wrote all about how the darkness was evil and the evil creeps into man's soul. But when man does good, and helps the planet, he creates a light that dispels the darkness.

BH: Wow, that's a far cry from terrariums. (Laughing.)

Glenn: Yeh, he did the whole soul and that's where he went with it. And that was what he was allowed to do. They had that starting point and then they just took it wherever they would. (interview, 4/24/02)

This melding of science with literature is Glenn's way of acknowledging that students learn when they are interested. He will use poetry to teach science and science to teach poetry and enjoy his students' skills in both.

Aquirre, Haggerty and Linder (1990) describe science teachers with a science background as being more committed to transmissive learning than experimental. However, Glenn is not at all like them. Glenn clearly espouses a more constructivist approach to science teaching. Glenn may have sat through his share of lecture-oriented science classes, but he is committed to the discovery orientation in his classroom.

Donald Green—Science Is Exciting

Whenever Donald discussed the learning of science, he mentioned the positive attitude that students, in general, bring to science and how that attitude is like a force carrying the learning along on a wave of positive energy. Donald describes himself as a person who “loves science” and he assumes that his students will also like science.

Donald: Yes, science I think is definitely one of their favorite subjects as opposed to social studies. When I taught that they say “awww” (*in a decrescendo voice*). Science, they’re like “YES!” (He pulls his fist down.) When I first started teaching science, it made me feel better about my own teaching because they weren’t sighing whenever we did it. (interview, 4/17/02)

Donald, like Steve, correlates a person’s interest in learning science with the amount of learning that occurs. In journal entries for his science methods course, Donald wrote his science vignettes in a most lively style, often using the terms “fun” and “enthusiasm.” One entry contained a detailed description of fieldwork done by his students at a nearby stream under the direction of scientists from a nonprofit ecology foundation. Donald mentions the children “having a great time, squealing with excitement when they found crawfish and minnows to put in their buckets” (journal 10/29/01). He summed up the day like this:

I could see the children having a terrific time all day. The hands-on learning was a wonderful way to break away from the everyday classroom atmosphere. They were all engaged the entire time, and when we talked about it on Monday, they were excited to share what they learned. (journal, 10/5/01)

On another occasion, he described making mock rocks.

The kids were very enthusiastic about getting into their groups and continuing their observations and experiments. It appears that interacting with partners and working with a hands-on activity really gets them excited (as opposed to sitting and listening to the teacher). Science consistently appears to create an atmosphere of fun-while-learning in Mrs. Allen's classroom. (journal, 10/29/01)

Donald's final journal entry described students individually making "fossils" as the "real fun part" of a lesson that also included demonstrations, reading and discussion. Donald's only journal entry that hints at any negative experience with science describes a student's disappointment when a rock identification activity was cut short because school was unexpectedly dismissed early. These journals show what Donald considers distinctive about learning science: science is fun to learn because science is fun to do. When discussing teaching math, Donald says, "It's just not the same 'wonder factor' because counting blocks just isn't the same as anything in science" (interview, 4/24/02).

Donald believes that children will respond to science with more enthusiasm and learn more science if they use the tools of science in the classroom. In keeping with his beliefs, Donald had his students keep a separate science notebook like a scientist does, and all the worksheets for science were bound into another booklet. Donald shares with Glenn the notion that a science notebook is an essential tool for scientists, but Donald actually implemented lab notebooks into the classroom while Glenn did not.

Josh Jones—Hands-on Is the Only Interesting Part of Science

When Josh talked about children learning science, he referred often to experiences outside of the formal school environment. When he was working on a constellations project for his science methods class with his students, he commented:

What was truly interesting to me was that only a few people knew about what constellations were, or had even heard of them. The students who had known about the topic had read books about them because somebody around them put that book in their hands. It made me think about how little actual science is being taught in elementary schools. It seems that most of the students who have any content knowledge about a specific subject in science have been taught them outside of the classroom. I just found that interesting. (journal, 9/29/01)

Although this lack of science learning correlated to the science teaching that does not occur in the classroom, Josh hinted that some of it may be a result of student maturation. While teaching second graders about butterflies, Josh commented:

I think it (science) is making sense to the students in the most literal, literal way. They work, and then they forget everything over the weekend. They are, you know, so concrete in their thinking that a lot of them will forget it over the weekend because they won't have reinforced it enough, or they weren't paying attention, or something wasn't driven home enough for them so it may not be as brought home enough in their own minds that they are physically able to maintain the information. (interview, 5/3/02)

So, as a second grade teacher, Josh voiced his frustrations about the students' learning of science. The first frustration, as the above quote illustrates, is that students are not mature enough to learn some things and retain them, and the second is the students' lack of exposure to science in the academic and home settings. These two factors contribute to an inadequate understanding of science

concepts at this level, and Josh believes that the students' view of science is vague.

In theory and practice, however, Josh believes that the only way that students can learn science at all is by hands-on experimentation.

Josh: Well, truthfully, the only thing that I ever found interesting and the only thing that I'd ever seen to be found interesting in science is the hands-on stuff. And so I'd like to try to do as much of the actual experimentation as possible. I'd do a lot of hands-on things with my students just because the theory, and all that stuff, is just so complex, and it's dry without any of the experiments or without any of the hands-on stuff. So I'd kind of plan to do a lot more of that stuff. (interview, 3/18/02)

Unlike Paul, Josh does not rely on the Piagetan theory that children learn science by assimilation and accommodation, which always begins with the child's present state of knowledge and always assumes some knowledge base.

BH: Do you think that you activate what the children already know when you teach science? Do you find the things they already know and you start there and move on? Or are you always talking about things that they probably don't have much background in?

Josh: I truthfully don't know. I haven't done much science and, to me, and that's what I was trying to say earlier, to me it doesn't seem like it's a type of thing where you are building upon prior knowledge. Like there is just one thing and branching it out to a different topic. Although it very well may be and I just don't know it very well. It doesn't... it seems as though whatever topic or whatever direction you go in, it stays pretty isolated. And you just learn all the theory behind it and you learn how to do the experiments and then, you're done. And you go to the next topic, which is completely different from the others. And then you learn a bunch of theory, and then you learn how to do the experiments and then you're done. (interview, 3/18/02)

For Josh, science has so few interconnections for the children in his second grade class that the teaching of it cannot be based on making connections to past knowledge.

When asked about his personal goals for student learning of the butterfly unit, Josh stated simply that he really wanted the students to “know about butterflies and have some kind of experience with them” (interview, 3/5/02). He emphasized both knowledge of some facts and the experience.

Josh made a fascinating comment about learning when he was discussing his own learning in a methods course. He said, “I did not learn anything new from the methods classes, but found them engaging and interesting” (journal, 11/28/01). Josh makes a fine distinction between being engaged and actually learning something. For Josh, learning involves an accumulation of information. He stated that he became a teacher because he “had a gift to relay information” (interview, 3/18/02). So, if no new information is relayed, the student may be engaged, but not learning. Josh introduces the concept that engagement may sometimes be nonproductive and may not result in learning. I do not mean to imply that Josh does not value engaging the minds and imaginations of students. The lessons I observed in science took advantage of the children’s engagement with the live butterflies, but Josh made sure that information was relayed in the lesson after the engagement event.

Summary of Beliefs and Understandings About Learning Science

The participants in this study do show, as Smith and Neale (1989) maintained, that beliefs about science teaching lead to certain teaching orientations. Glenn, Donald, Steve and Paul all favor a discovery orientation for classroom science that is exciting and hands-on. Josh tends toward a more didactic approach to science that concentrates on content although Josh believes that the spice of hands-on relieves the boredom of the typical science class.

Given the emphasis on hands-on learning in the science methods courses at the university and the fact that most of my participants recalled fondly only hands-on elementary science experiences, it is not surprising that they espouse hands-on science as the most effective type of science learning experience. However, their reasons for this adherence are different. For Paul, the learning of any subject requires engagement. Doing is one kind of engagement and experimentation is one kind of doing. It could be said that engagement is part of the learning process, but it is separate in that it is not the assimilation or accommodation *per se*. Donald seems to express a similar view when he pointed out how advantageous it is to science learning that the students regard science as fun. But Donald is referring to the atmosphere in which the learning takes place. Science feels more like “fun” to the students. For Donald, science has a “wonder factor” that other subjects do not have and part of the wonder is tied up in the amazing things that students can see when they do science. “Fun” in this instance

is part of the learning of science because doing science is fun and the results of doing science are amazing.

Steve, on the other hand, views experimentation as the working out of science. Hands-on experiences are the practical and immediate determinants of learning. For example, a student could show understanding of a series circuit by drawing one on paper with all components correctly connected and labeled. Gratification for this work would come when the paper is handed back with a grade, either the next day or the next week. Contrast that with a series circuit constructed in class of real bulbs and wire and batteries. Gratification occurs when the light bulb lights. This gratification is not delayed or remote or dependent on a teacher. This gratification causes students to jump up and down with glee, and time passes in this class on wings. Like Donald, Steve is thinking about science as fun, but he is expressing it in terms of accomplishment. The laboratory experience is, to Steve, the practical working out of science.

Although Josh admitted that the only part of science learning that was interesting to him or his students was the hands-on activity, he did not view the experiment as simply a motivator for science learning. Instead, the experiment is the only part of the field of science that Josh regards as interesting.

For Glenn, commitment to hands-on science learning in a classroom is a necessity because “science is doing.” Glenn knows how knowledge is accrued for the scientist in the laboratory, and he believes that it must be accrued in the same way for the student in the classroom. Glenn laments that children today do not

spend as much time outside as they once did. This means that they do not observe the natural world, manipulate it or draw conclusions from it as much as they could. Glenn does not see school experiments as the point of engagement for science learning, the inspiration for science learning, or the working out of science learning. The learning of science, to Glenn, is the experiment, both for the scientist and the student.

Besides a commitment to hands-on learning, I sensed in my conversations with these young men an almost unanimous personal enthusiasm for science learning. Except for Josh, they all recalled personal interesting experiences learning science-related subjects and had expectations that their students would also enjoy learning science at the elementary school level. Knowing that the focus of my study was science teaching could account for some of this enthusiasm. On the other hand, the specificity of their recollections and their ability to recount many classroom incidents as examples make a strong case for accepting their statements at face value.

Table 3. Participants' beliefs about science learning

Name	Beliefs About Learning Science
Glenn Adams	<ul style="list-style-type: none">• “Science we do.”• Students learn more science when it is interesting.• The more science connections are made in the classroom, the more science learning occurs.
Paul Costanzo	<ul style="list-style-type: none">• Science is like other subjects.• “Pull in that background knowledge so that they can modify, or adjust it, or add onto it.”• Engagement is critical.
Donald Green	<ul style="list-style-type: none">• “Science is fun.”• Science has a “wonder factor.”• Using the tools of science is important.
Josh Jones	<ul style="list-style-type: none">• Certain science learning requires a level of maturity.• Hands-on is the only interesting part of science.• Engagement is not synonymous with learning.
Steve Smith	<ul style="list-style-type: none">• Learning science is an active process.• Science learning is exciting.• Science learning applies to the real world.

Chapter 5 Understandings of Teaching Science

Introduction

In this chapter I will discuss my participants' understandings of science teaching. One of my goals in this study is to examine the connections between presuppositions about the nature of science teaching and the actual science teaching occurring in the classroom. Foundational to this examination are the participants' beliefs about the nature of science and science learning that were explored in the previous chapter. Only now the focus changes to the teacher and the practice of teaching.

Views of the Ideal Science Teacher

When discussing the teaching of science, most of my participants spent considerable time musing about the attributes of a good elementary science teacher. In some cases, these qualities were enumerated when discussing memorable teachers they had known, and, in some cases, when discussing the characteristics of good science teaching in relation to the contexts in which these men found themselves. Although these five men had different backgrounds and

interests, their discussions of the ideal science teacher had several notable similarities.

All of the participants in my study emphasized the relational abilities of teachers as being critical to the teaching of science.

BH: Were any of your teachers an inspiration to you?

Paul: I think so. Everybody has... There are a few teachers that stand out to them, that seem to really care. From my elementary days, I remember my teacher, Mrs. Ash, and I really liked her. She was, you know, cool, but um....

BH: What did she do that was cool?

Paul: Well, I think that she was just social and got down to a level with us, you know what I'm saying. It's hard to remember. (interview, 3/20/02)

And a little later, Paul said more about a high school teacher.

I can recall definitely, my chemistry teacher from high school, Mr. Apple. He was always kind of available to us – if you needed help. You know, umm, he wasn't a real rigid guy. I thought he was just a good teacher. If you needed help, he was there. He wouldn't get frustrated with you. He had a rapport with the students, which I thought was so important.
(interview, 3/20/02)

In Paul's evaluation of teachers, the ability to care is of prime importance.

In fact, personal characteristics are paramount. His evaluation of teachers does not seem to depend on their fund of subject knowledge nor on the quality of the educational experiences they provided. Paul remembers teachers he really liked, and the personal aspect of their teaching became an inspiration to him.

Even Josh, who claimed no great love for science, commented about the personality of one of his science teachers.

BH: So, did you have a science teacher in high school or college that you could consider a role model for your teaching when you get to do that?

Josh: Um... I will say that my sophomore year or my junior year, when I took chemistry, I had this teacher who really explained chemistry in a way that I never...she explained it so basically and made it so simple for us that everyone, even if they weren't getting good grades, everyone understood it or at least the stuff behind it. So umm, Mrs. Bond, I believe her name was.

BH: So, how did she do that?

Josh: I have no clue, but the way she made it...she made everything so simple. She was this big Australian lady, and she was just so nice and so sweet. She was a new teacher, straight from Australia, and this was the first class she had ever taught in America. She just made it very simple for me. Because I know that physical science and physics and biology, they all made sense to me. Chemistry, all the memorization, went right over my head. (interview, 3/18/02)

Josh emphasizes the teacher's ability to make the complex simple, but her personality is also a huge part of Josh's memories of her. So, for Paul and Josh, personal attributes such as being nice and caring are of critical importance. The caring teacher understands the student's situation in the class and makes the student's job as a student easier. This speaks to the atmosphere in the classroom and how it affects the students.

Donald also emphasized the teacher's approach to students, but, unlike Paul and Josh, Donald used some negative experiences that he had as a student as an inspiration to be different. Donald believes that teachers can make learning more fun by employing humor in their classroom approach to students.

BH: One thing I've noticed about your class is that you really use a lot of humor. You are very relaxed with the kids. Is that part of your personality?

Donald: Yes.

BH: How does it work for you, do you think?

Donald: I just tend to be (interrupted by other teachers asking questions. Then he continues,) I just tend to be a sarcastic person anyway. I use sarcasm.

BH: So it's part of your personality?

Donald: Yes. For example, the negatives-- if I worked with first grade, they're not going to pick up on it. (Uses high voice) "Why are you making fun of me?" you know. But fourth graders, they'll come right back at me, so it makes it fun instead of otherwise. I have unfortunate memories of some of my elementary teachers because they were very, you know, stone-faced. "Get your work done! Speak when you're spoken to!" And one of the things about my wanting to be a teacher originally is just because, well, knowing that that is the way I am is to make it that much more of a fun experience. Or if not fun, at least memorable for the kids as opposed to the opposite end of the spectrum.

BH: That is, more enjoyable?

Donald: Yes, I love to be playful with the kids – use a playful tone.

BH: And they respond to that and to you?

Donald: Yes. (interview, 4/18/02)

It is notable that I questioned Donald originally about his sense of humor and, in his response, he changed the word to sarcasm, which has a more negative connotation. However, as Donald continued his answer, it is clear that he is referring more to good-natured teasing than mean sarcasm. Playful conversation was much in evidence in Donald's class even when he was dispensing information to the whole class. One example of teacher-to-student humor is shown by this interchange:

Donald: Leave nothing blank, boys and girls. Even water can be described.

Donald (to one student): Describe the water.

Student: It is wet.

Donald (slaps his own head lightly): Who'd a thunk it? (field notes, 4/17/02)

Another time, when discussing one of the readings with the whole class, he mentioned a new word—isopod. This word is important to Donald because the

students would place isopods in the terrariums. He emphasized the word to them by asking, "What is an isopod? It sounds like an 'icy pop'" (field notes, 5/2/02).

The response of Donald's students to his humor was usually a smile, sometimes a laugh. They seemed to accept it as part of Mr. Green's personality.

Even in conversations with me, Donald showed a sense of humor and an fascinating way with words. When the students were making their aquariums, one student spilled some water that Donald cleaned up good-naturedly and without comment. After the class, he said to me, "Only one accident is better than taxes" (conversation, 4/17/02). I took his comment as showing that he understood that doing things can sometimes be messy and, although accidents may cause some inconvenience, they did not trouble him too much.

Like Donald, Glenn appreciates humor, but Glenn's analysis of good teaching stressed the teacher's ability to promote learning.

BH: And what about science courses in high school?

Glenn: Oh, history of ecology of the Chesapeake Bay. That was a cool course. We called the professor...oh, you know the captain guy from Gilligan's Island? He was "The Skipper." (Laughing.)

BH: (Laughing.) So was he a good role model for teaching science?

Glenn: No!

BH: Why not?

Glenn: He taught science through slide shows. It was very cool to see the things he did, but it was well, here you see a tree, here's my car next to the same tree, here's the front of my car next to the same tree. Oh, look! Here's a leaf on the windshield of my car from the same tree.

BH: So what about elementary school? Were you interested in science there?

Glenn: Oh, yes! I did all the science projects and all that kind of stuff. It was really in middle school, Mrs. Evans. She taught eighth grade science which was everything – a lot of physics, a lot of earth science, a lot of life science.

BH: Do you know her background?

Glenn: She was biology. But she liked science and she liked children. The two of us are very alike. I went back after I graduated from high school, or in college, I would go back and visit her class and help out. Now she's a science mentor in the county. It would be very cool to work for her. (interview, 4/15/02)

In contrasting two teachers that Glenn obviously enjoyed as people, Glenn's evaluation of a memorable science teacher was more complex than Paul's or Josh's evaluation. Glenn believes that a class can be fun, and a teacher can be cool and even do stimulating things, but may really not teach science in a manner that promotes learning. Glenn implies that "The Skipper", although amusing, may actually have wasted his students' time. But then, Glenn examines his memories of Mrs. Evans, and pronounces her two main qualifications as liking science and liking children. Mrs. Evans liked science enough to know science, and she did the extra work to provide a host of experiments for her middle school science students. However, that was not all that Mrs. Evans brought into the classroom. She truly liked her students. Glenn does not cite any evidence for this except that he responded by wanting to help out in her class even when he was in high school and college. In fact, Glenn would consider it highly desirable to work for her, since she had advanced to an administrative position in her district. Mrs. Evans is a role model for Glenn's teaching because she possessed all the qualities that he considers important in a teacher.

Like Glenn, Steve also considers a teacher's love of science as being a critical factor for good science teaching.

Steve: But then I went to County (a community college) and I had this teacher there who taught physical science, and he loved it. He was great. He was so excited about it. And this was college, so to make it exciting for college kids...well, college kids just don't care. But he made our class fun. We did live experiments. I had a biology teacher who was the same way. You know, he loved it and he wanted us to enjoy it. And I've tried to do the same thing – make it enjoyable and give them something to do. So that they're not just watching, but they are actually doing. (interview, 4/29)

Steve emphasized the teacher's passion for his subject and his desire for students to enjoy it. It is also notable that at the end of this explanation, Steve reiterates the importance of "doing" science.

Table 4. Participants' views of the ideal science teacher

Name	Qualities of the Ideal Science Teacher
Glenn Adams	<ul style="list-style-type: none">• "loves science and loves children"• uses science to teach other subjects• has many experiments and activities• goes the extra mile
Paul Costanzo	<ul style="list-style-type: none">• has good rapport with students• social• takes the time to explain
Donald Green	<ul style="list-style-type: none">• makes it a fun experience• has a sense of humor
Josh Jones	<ul style="list-style-type: none">• makes science simple• nice
Steve Smith	<ul style="list-style-type: none">• loves science• desires children to enjoy science• shares personal science experiences

My own personal evaluation, after observing these five men, is that they made an effort to live up to their notions of good teaching. Steve referred to many of his male students as "Buddy" in private conversations and would joke

with them, primarily at recess time. Unlike Donald, Steve did not feel comfortable using humor during class. He mentioned to me that his mentor maintained a certain atmosphere, but that he preferred to be more relaxed. I concluded from his comments that the humor I saw Steve display during relaxed times at recess would be brought into the classroom if he had the final decision in the matter. It is clear that Steve values humor and that it is part of his way of relating to people.

Paul, also, showed a fairly relaxed and friendly manner with his students. In the lessons that I observed, I saw him as a highly enthusiastic person who values his students as people and would never want to embarrass them in any way. One incident that caused Paul some anxiety occurred during an introductory lesson on solar energy very early in his internship. He was having the students generate a KWL chart (What do you **K**now and what do you **W**ant to **L**earn?) One girl equated solar energy with gravity and Paul did not know whether or how to add this to the chart. He said, “I want to take everybody’s ideas so that kids will take ownership of our discussion, but I am not sure what to do when answers are very wrong” (journal, 9/14/01). This sensitivity to students is very typical of Paul and is, I believe, a direct result of his commitment to being the type of teacher who truly cares about his students.

Glenn showed his students how much he liked them by spending extra time working with them on their science fair projects. Glenn also played soccer or some other game every Friday with his class during recess. This unstinted

giving of his time spoke volumes to his students concerning how much Glenn valued them as people. Glenn modeled his actions after his role model, Mrs. Evans, by bringing into class schist with garnets from his own personal collection as well as fern imprints in shale for the rocks unit. At another time, Glenn designed a computer session for his students so that the students could access a NASA website and watch a flyover of the space station with a space shuttle in tow. Glenn had observed the event at home and he described it to me.

Glenn: They went up right across the horizon. They tracked a perfect arc – I had my telescope out at night and I watched this perfect... at first it was really cloudy and there was a break in the clouds and I could see the space station and the shuttle go right by. It was so cool. (interview, 4/23/02)

Glenn went out of his way to share his enthusiasms with his students because that is the way that he understands good teaching. I observed Glenn teaching one lesson from the electricity unit and several from the ecosystems unit and was struck by how much student enthusiasm he generated. Glenn encouraged the enthusiasm by some casual language like calling the animals “critters” or saying that electricity is very “impatient.” Glenn repeatedly complimented his students’ good work and had a friendly manner with them. Alongside this friendliness, I sensed an ongoing analysis of the lesson taking place in Glenn’s mind. When he introduced the ecosystems unit, he kept clarifying definitions and asking for more details. This exchange is an example of this kind of clarification.

Glenn: I see a willow tree. What does it need?

S₁: Sun.

Glenn: What else?

S₁: Water.

S₂: And soil.

Glenn: And?

S₃: Air.

Glenn: Yes. Remember photosynthesis last year? Plants use air and water and give off oxygen. I am fond of breathing.

S₄: And the dragonfly eats flies.

Glenn: And what about nonliving things? How do they come into play?

S₅: Shelter.

Glenn: Yes. Places to live. They give space for the ecosystem. Suppose people build a city here?

S₆: Animal homes would be destroyed.

S₇: They'd all die.

Glenn: All?

S₇: Some.

Glenn: The trees would stay. The bees. The deer.

S₈: If the water goes, all the things there go.

Glenn: Or if the water is polluted, the plants might die. The ducks would move or die. The foxes that eat ducks would move or die.

S₉: Like blocks...One gone and all fall. (field notes, 4/23/02)

In this discussion, Glenn is guiding the conversation with a goal. In order for him to bring in photosynthesis, students need to mention the factors of sun, water and air. Glenn persists until he gets all the necessary factors and then proceeds. He also does not accept easy answers that are not, in fact, completely true. For example, if animal homes are destroyed, all animals will not die and Glenn draws this out. Glenn's carefulness persisted even when his mentor teacher tried to get him to move the lesson at a faster pace. I believe that this quality is part of Glenn's understandings of what is important about the science lesson: drawing out careful definitions and conclusions are an important part of good teaching. So Glenn mirrors both parts of his "ideal teacher" as someone who "likes kids and likes science."

Of all the participants, Josh was the least relaxed with his students. He had been moved from a fifth grade classroom where he had been through the first semester and part of the second semester to a second grade classroom. I had observed him in the fifth grade classroom teaching poetry and felt him to be comfortable with these students as he proceeded easily through the various elements of his lesson. The move to second grade meant that Josh had to shift gears and work with much younger children. He voiced the difficulties of this transition to me:

Josh: I don't really like second grade. They're very frustrating to me. A lot of the behavior stuff that isn't really bad behavior as much as it is that they are just little kids and they can't concentrate for so long on something. ...My style of teaching, the type of kids that I like interacting with, all of that, really lends itself to older kids...I don't know. It's definitely different, I will say that. It's definitely different. Umm, but I like the older kids much better. (interview, 5/3/02)

Josh's frustration is palpable. He wants to relate well with his students, but being thrown in with such young children on such short notice left him adrift. Perhaps, Josh, like Donald, feels that his sense of humor is not understood by students this young. Whatever the reason, he noticed how it affected his teaching.

The Prescribed Curriculum

In order to understand the context of science teaching for the participants in this study, it is necessary to have knowledge of the science curriculum that was provided by the school district. In this section, I will discuss the fourth grade and second grade curriculum as I observed it.

Fourth Grade Curriculum

Four of my study participants including Glenn, Donald, Steve, and Paul taught fourth grade and used the same science curriculum throughout the time of my observations. In fact, these four men proceeded through the same science curriculum in the same order throughout their entire student teaching internship. Josh began his internship in a fifth grade class in the first semester of the university school year and taught no science at all during that time. After moving to a second grade class during phase II of his internship, Josh taught a unit on butterflies.

The school district uses a prescribed curriculum for all elementary schools. At the time of this study, students in each grade studied three science topics over the course of the year, and the materials were delivered to and picked up from the teachers in a box on set dates. The boxes contained written materials and the supplies needed to perform the activities of the unit. The written materials were developed by the National Science Resources Center as part of the Science and Technology for Children program designed for students in grades one through six. This program centers on hands-on experiences using written materials as an impetus for reflection and application. In this school district, living organisms for the ecosystems unit and butterfly unit were delivered on a set schedule to each school. The use of this curriculum is an investment by the school district that reflects its commitment to a certain kind of science teaching. This school district emphasizes a hands-on approach to science that does not

ignore a conceptual foundation. The district stresses reading and writing as critical in science and all subject areas for analysis, interpretation, and communication of ideas. It is the teacher's role to engage students in higher-order thinking skills such as complex reasoning and problem solving.

All of the participants in my study teaching fourth grade began the year with a unit on Rocks and Minerals followed by a unit on Electricity. Ecosystems was the third and final unit. I will describe the materials provided for the unit about ecosystems because most of my participants were using it when I observed them. I also observed a videotape of Glenn teaching an electricity lesson. Also, journal entries from the fall semester's Science Methods class refer to the Rocks and Minerals unit. I observed only a small number of selected lessons on the Butterfly unit taught by Josh.

It is important to note that the classroom teachers assigned report card grades to the elementary students. The assessments for the ecology unit and the butterfly unit took place after the student teachers left the schools in the spring, and I was unable to include assessment measures in this study.

In the ecosystems unit, students construct a model ecosystem consisting of a terrarium and an aquarium made out of empty 2-liter soda bottles. Each part of this ecosystem contains nonliving components such as soil and water and living components including both plants and animals. The terrarium, which has a hole in the bottom, is placed over the aquarium to form an interactive ecotube, also called an ecocolumn. The design of these experiments assumes that the

ecocolumns are self-sustaining. There must be enough available food to sustain the life within the system. Plants produce food, some animals eat plants, and some animals eat both plants and other animals. Since this is a dynamic system, children can observe the changes occurring in it.

The lessons included in the Ecosystems book are:

Lesson one—An introduction of terms and a brief look at the interactions of organisms using a riverbank picture.

Lesson two—Setting up a terrarium as a system with soil, gravel and rocks and planting grass, mustard and alfalfa seeds.

Lessons 3 and 4--Setting up the aquarium and stocking it with algae, duckweed, elodea, snails and fish.

Lesson 5-8—Adding animals to the terrarium, connecting the terrarium and aquarium as one ecocolumn ,and observing changes, such as appearance of eggs or baby fish, or disappearance of animals and plants as they are eaten.

Lessons 9-14—Studying pollutants, designing an experiment using pollutants, and comparing polluted ecotubes to control ecotubes for effects on plants and animals.

Lessons 15-16—Linking lessons learned from the ecotubes to real-world problems by holding a mini-conference on managing the Chesapeake Bay.

There are 10 student readings included in the packet. Some of the readings describe components of the ecocolumn in detail. For example, one reading describes the plants in the aquarium section, and some give descriptive and anatomic details of the mosquito fish, crickets, isopods and snails. The readings stress the relationships of living things to other living things in the ecocolumn. About midway through the unit, the readings describe acid rain (including a

highly chemically-oriented description of pH, sources of pollution, and how an ecosystem like the Chesapeake Bay can be affected by pollutants).

The Teacher Guide accompanying these materials includes all the lessons and readings, a list of goals, a timeline, sample assessments and tips on maintaining the live materials. Extensions to Language Arts, Mathematics, Social Studies, and other areas of Science are included with many of the lessons. It is noteworthy that the stated goals for this unit included eight concepts, eight skills and four attitudes.

Second Grade Curriculum

The second grade science curriculum in this school district is provided by the same publisher as the fourth grade curriculum. Like the fourth grade curriculum, the boxes that arrive for the teacher contain the materials necessary and a teacher guide. The final science unit in the second grade, like the final unit in fourth grade, involves live specimens. In second grade, the students receive Painted Lady caterpillars. The caterpillars are observed both in the caterpillar stage and in the pupal stage. One netted cage, which must be constructed by the teacher, is supplied for the classroom. The teacher must pin each chrysalis to the net. Worksheets on the subject of the caterpillars' body parts, diet, and life cycle are provided in the kit. After several days, metamorphosis is complete, and the butterflies emerge. The butterflies are observed and fed for a short period and then released.

Four Ways of Teaching the Ecosystems Unit

One of the most fascinating things about watching four individuals teach the same unit from the same curriculum guide was observing the similarities and differences among them. All four teachers in this study had their students construct and observe ecotubes and all four used many of the readings provided. The actual logistics of the lessons, the number of lessons used and even the construction of the ecotubes themselves differed from teacher to teacher.

Glenn's Teaching of the Ecosystem Unit

Glenn began the ecosystems unit using the introductory lesson suggested by the teacher guide. He was the only one of the four participants in the study whom I observed teaching this lesson, and, by report, the only one who used it at all. In fact, when asked, each of the other participants admitted to using only the vocabulary of this lesson to frame his own shorter introduction. The first lesson plan in the teacher guide makes use of a transparency of a riverbank ecosystem to initiate a discussion of ecosystems. Glenn was careful to go into the root word meanings in ecosystem, terrarium and aquarium. Discussion was lively as the students were shown some of the plants that would go into the aquariums. Then, Glenn used the transparency that had nineteen different living things drawn on it. As Glenn sought to guide the students into stating relationships between these living things, I was impressed with his knowledge, attributing it to his experience in the outdoors, especially fishing. Glenn did not use notes or books at any time during this lesson. Later, as I further perused the teacher guide, I found that a key

identified all the species on the transparency. Even with a key at his disposal, Glenn had displayed a remarkable memory and a willingness to put in considerable preparation time.

Discussions of scientific material were lively in Glenn's class. Students contributed enthusiastically, but in a disciplined fashion. Glenn showed considerable patience in leading a discussion about ecosystems at the beginning of the unit.

Glenn: What do you know about ecosystems?

S₁ (tentatively): Suppose we don't know anything?

Glenn: Wait and see... Then he writes on the board – "How do living things depend on each other?"

S₂: I have a National Geographic World magazine about this. Can I bring it in?

Glenn: Yes!

S₂: Yea!!!

Glenn: So, no organism is completely independent. What do we humans depend on?

S₃: Food!

Glenn: What kinds?

S₃: Pizza!

Glenn: Well, let's consider the cheese on the pizza. That comes from cows. So we need cows. And cows need grass. And the grass needs...?

S₄: The sun.

Glenn: So everything depends on the sun. So for pizza, we also need flour and flour comes from a plant and the plant needs the sun. Let's do a quick food web. (field notes, 4/23/02)

Even though the first two students seem to be resisting the start of the lesson, Glenn dealt with them with great respect and then persisted with the lesson. Glenn wanted to include the role of consumers, producers and the sun in his introduction, but he did this using the student's example of pizza. At this point, all the children were involved and resistance dissolved. This interchange shows

Glenn's ease with children and his self-confidence in dealing with them. It also reflects his patience in getting the students to arrive at the place that he intends as far as the science material is concerned

When introducing new words like terrarium, Glenn was careful to point out the root word meanings and how they applied. Glenn was very meticulous with the vocabulary of science. In a lesson I observed on electricity in which students made a light bulb, Glenn went through all definitions that pertained to the laboratory experiment, including insulators, conductors, and filaments. His explanations were not lofty, but at a level that children understand and in a manner that grabs their attention.

Glenn: Most filaments are made out of tungsten, which is another type of metal. What happens is that the electricity doesn't go through the tungsten as fast as it goes through the copper wires. It's an energy traffic jam. The wire starts to heat up and gets very hot. And when things get very hot, they get all excited, which is what the light in the light bulb is. Most of the energy in the light bulb is heat and just a little bit of it is light. So today we're going to make a filament. The filament will become very, very hot. So you do not want to touch it. If you see something glowing red, you do not want to touch it. Even if it's not glowing anymore, give it a few minutes to cool. I don't want anybody to get burned. (videotape, January, 2002)

Glenn had two purposes in this exposition. The first was to explain why a filament lights and the second was to explain how the filament becomes hot and why caution is needed to handle it. This kind of explanation is typical of Glenn's teaching, and I observed that it was successful in keeping children involved and conveying the necessary information.

Although Glenn continually emphasized the “doing” of science, he did not ignore the readings included in the teacher guide. He employed a method of getting the most information to the most students in the least time that he described as doing a “jigsaw.” This involves dividing the students into groups and giving each group a reading or a part of a reading. Each group becomes “expert” on that reading and present the main points to the rest of the class. I observed that sometimes the students wrote the main points on newsprint and the newsprint sheets were hung like posters around the classroom. I saw hanging newsprint sheet that addressed various kinds of pollution. This “jigsaw” method helps to solve the problems of limited time and varying reading abilities among the students.

Glenn had some procedural difficulties with the ecocolumns. The seeds in the terrariums had a very low germination rate. Glenn attributed this problem to nonviable seeds although I believe that lack of water may have contributed to it. This lack of plant growth made the terrariums non-self-sustaining. The aquariums did not fare much better, because the fish consumed all the plants in the aquariums, and then the animals, especially fish, began to die.

Glenn did not do any of the extensions from the teacher guide during my observations, although he did take the students outside on Earth Day and read a poem about ecology and the interdependence of living things. He also had them write a relationship story about two living organisms, such as a flower and a bee.

Steve's and Donald's Teaching of the Ecosystem Unit

Since Steve and Donald worked at the same school and collaborated on their science lessons, I will treat their presentations together, pointing out individual differences where applicable. Although Steve and Donald taught the ecosystems unit in the spring, the school district had ecology experts from a local foundation come to the school in October to do a day-long, hands-on study of a stream near the school. This was considered an introduction to the ecosystems unit and so a brief review was all that preceded construction of the terrariums in both Steve's and Donald's classes in April. The terrariums were initially placed under grow-lights that had been borrowed from another classroom; the seeds germinated and grew thickly. Following the suggestions in the teacher guide, Steve and Donald put the crickets in the refrigerator about an hour before distribution slowing cricket activity down considerably. I observed Steve's class during the cricket distribution. Although student excitement was high, no crickets escaped and the whole procedure went smoothly. During an observation of the fish distribution in Donald's class, students were again very energized by events. The only mishap was some spilled water, which was easily cleaned.

Readings were handled differently in Donald's and Steve's classes. Donald's class read most of the science readings during reading time, and each student wrote summations of the readings individually. When time was limited Donald's divided his class into groups, like Glenn did, and had each group report major findings to the class. Science words were incorporated into spelling lists

and students were given the opportunity for input on weekly spelling lists. Students in Donald's class also recorded their observations in separate science notebooks. Although I did not observe Steve actually using the auxiliary readings, I did observe a lesson in which the vocabulary and principles of the food chain were presented in a guided class discussion with overhead materials, posters and handouts that had been generated by the mentor teacher. I also saw newsprint lists hung around the classroom that showed that the students had generated main thoughts about the readings. Steve said that only some of the readings were used because the class was falling behind, and time was at a premium.

When asked about the goals of the ecosystem lessons and unit, Steve had a well-defined vision:

BH: So what did you want them to get out of this lesson today?

Steve: The main thing I wanted them to get out of this besides making the aquariums, I wanted them to see that there are different parts of an ecosystem that they need to have. In order for plants to live and in order for fish to live, they have to all have an environment – a place to live, a habitat. We've been going over an ecosystem. An ecosystem is the living things and the place they live. So we created our place. I wanted them to see that the place that they had also had to have living things to help support itself. That was my main goal.

BH: So what are they going to do with this? I haven't seen this yet.

Steve: What they are going to do with this next is leave it a couple of days so everything gets accustomed to it. The water settles and the fish can be put in it. We have fish and we have snails that are going to be put in the different aquariums. And they are going to every day, daily monitor the effects of... Well, actually we have the soil environment, the terrarium, above this (aquarium) so it is a one capsule thing. The nutrients are going to fall down and help feed the fish and help feed the snails. And the fish are also going to eat up some of the plants in there. So they are going to see the effects of the cycle – the water and the soil and how they function together. So the plants will be giving oxygen to the plants above it. So it will be a cycle of the water and the air.

BH: Will the terrariums have the crickets in them?

Steve: Yes, we'll have crickets and little mealworms, pill bugs. And they already have ... here I'll show you one real quick. (In the terrarium), they have grasses, they have alfalfa, mustard seeds and some twig matter.

They planted these last Monday so they have time to grow. You can see that they already have some bugs in the soil.

BH: So what will the mealworms eat?

Steve: The mealworms eat the little grubs in here and they will also eat off of the grass and the twigs and leaf matter. Now the crickets will eat the mealworms... (Laughing)

BH: (laughing) Right!

Steve: And other crickets! The crickets will eat the grass, too. We're also going to introduce different parts of the whole ecosystem chain. And we're also going to introduce pollutants and see how it is affected by pollutants. How is it affected by disturbance – say like when we shake up the dirt and kind of mess up their whole ecosystem. We're basically going to look at the effects of us on the real world ecosystem. (interview, 4/17/02)

So, for Steve, all of the details will lead to an understanding of how all the components of an ecosystem relate and how this ecosystem can be upset by outside factors. His responses to questions about assessment reflected his goals for the unit.

BH: So what kind of assessment will you do?

Steve: I haven't looked at all the assessments for this, but for Science last time, I created my own. The assessment they have for this is good, but sometimes you deviate from exactly what they do. So, I think, basically, I will want them to know the effects that plants and animals have on each other in the ecosystem and how it's a cycle. How they use each other to survive and how they use each other to grow. And that some of them get used and are killed. And I want them to see the effects of pollution.

Seeing how humans cause problems. (interview, 4/17/02)

Donald expressed similar goals for the unit, i.e., wanting the students to see the big picture of how things in the ecosystem are interdependent.

Paul's Teaching of the Ecosystem Unit

By the time I started observing Paul's ecosystem unit, the terrariums had already been assembled. This class also had difficulty with seed germination and growth. Time constraints had required that the delivered crickets had to be maintained longer in their holding tanks and all of the crickets died, probably due to lack of food. Paul had to purchase more crickets at a pet store.

When questioned about his learning objectives for the unit, Paul had several goals.

Paul: Overall, I want them to see how everything is interconnected -how eliminating one thing has an effect on everything. But then, I'm into environmental science, so I want to show them that whatever goes into the dirt eventually goes into the water and then it's just a big cycle. So then the water evaporates and then it affects the water cycle as well.

BH: So what are they going to do after this? After today?

Paul: In the science unit, I think they eventually poison everything.

BH: Will they follow these until June? How many weeks more?

Paul: Until the kits are collected, which is probably the end of May.

BH: So that will be after you are gone. So what you want them to see is the relationship and the influence that people have. Those are the most important things.

Paul: Yes. There are so many lessons in there which are actually amazing to me. To have not so much run off, although I guess you can show run off, but there are so many environmental issues that you can actually see in the ecotube. How the watershed is affected and how everything is affected by everything. And I would like to redirect it to them and come up with some ways of, well, "What can we do? What do we do?" And we don't always know. We pour something in the dirt and then, to us, it is gone. Just that they see that it really does go down and it doesn't just disappear. (interview, 5/2/02)

Paul is committed to students personalizing the knowledge that they gain; he is especially committed to application when it relates to ecology.

Paul's approach to the readings involved a whole class reading and discussion of the provided articles. He asked students to highlight the headings in heavy black print. Sometimes a student would read aloud and sometimes Paul himself read the section aloud. When the reading mentioned things like photosynthesis, Paul would begin a discussion, refine the student responses and then write out the correct conclusions on the board. Paul often personalized his questions. For example, when they discussed consumers, he asked things like "What do we as consumers eat?" As a result, most of the children had enough knowledge to participate at some level. At the conclusion of the lesson, Paul summarized the reading with a Venn diagram on the board.

Comparison of the Interns Teaching of the Ecosystems Unit

All four men had their students set up the terrariums and the aquariums. They were committed to the idea that students should have the experience of setting up the ecosystems themselves. All of the students in these classes would be able to report that they did use the tools of science in contrast studied by Kahle and Lakes (1983) who reported less experience with the tools of science than boys. It is noteworthy that in each class, the terrariums and aquariums were constructed differently. Some used two soda bottles and some three for each ecocolumn. Some did not use the mesh at the bottoms of the terrariums and some used potting soil instead of the peat provided by the district. As mentioned, Steve and Donald used grow-lights. The time frame from start to finish was not the same for each class. This was largely controlled by vacations, field trips, and

other scheduling contingencies. Time was a factor of major importance in each of these classes. For example, time constraints forced the use of the “jigsaw” method. As a result, not all of the students read all of the readings. Although the students reported to other groups the content of the readings, or, at the least, posted a summary on the room wall, it is doubtful that this method had the same learning impact than if each child read all of the readings. The leisurely pace of learning that seemed to be espoused in the handbook was not realized in the classroom. Choices had to be made, and lessons had to be omitted. There were too many readings for many of the classes’ time allotment.

There were a number of other variations in the performance of the units. The unit was introduced differently and, more importantly, ended differently in each class. Paul’s mentor teacher opposed polluting the ecotubes with salt, fertilizer or vinegar because this practice would result in the deliberate killing of some of the organisms, especially the fish. Paul’s class simply did the observations of the ecocolumns, and then, at the end of the year, went on a boat trip to discuss an ecosystem in their locale and how to preserve it. Paul added a lesson of his own design. Since his mentor would not allow polluting the ecotubes, he set up an experiment measuring the pH of various household items. This provided the students with some experience using pH paper and exposure to the concept of pH. The provided pH paper (pH range 3-5), however, posed some unique problems since its working range was too narrow. Wide range pH paper that shows the entire spectrum of pH from 0-14 would have been more

appropriate to the experiments that the children were asked to perform. It is reasonable to conclude that the pH experiments had little real meaning for the students although no one seemed to be aware of this. The students did learn how to use pH test paper. When asked to predict the students' performance on an assessment, Donald commented, "They've made good predictions about things. But as far as once it gets into talking about pH and acid rain and the effects of pollutants...I'm not sure how well they will do on that" (interview, 5/13/02). Since teaching pH really requires a fairly good grasp of chemistry, and only Glenn reported taking any college chemistry courses at all, it is not surprising that Donald expressed some misgivings about its effectiveness.

Glenn's, Steve's and Donald's classes did the pollution experiments, although by the time that they got to them, most of the fish and other animals were already dead, so valid conclusions could not be drawn. None of the classes ever set up the classroom controls that were prescribed by the unit and were a crucial part of the pollution experiments. Steve did pair the student groups for the pollution experiment with one group's ecotube acting as the control. The purpose of the classroom control ecocolumns was to provide a comparison for each of the groups as they added one pollutant to their systems. Without controls, there was no scientifically valid way to conclude whether the animals died because of the pollution or whether animals died because all of the animals were dying. I did not observe any classes except Steve's where the purpose or need for controls was addressed.

In my mind, the most important omission in all the classes was that none went on to carry out the scientific mini-conference dealing with human influence on the environment as described in the teacher guide. This kind of activity would have focused the children on human interaction in the environment and the fragile relationship of living things in an ecosystem. Since each of the fourth grade participants in this study mentioned teaching the importance of human impact on the environment as a goal, the mini-conference would seem to be an important part of the unit.

Each of these men did with this unit what they and their mentor teachers considered important. They constructed and observed an ecosystem, introduced their students to some of the basic vocabulary of ecology, and showed the relationships of living things to each other. Since the living organisms were delivered to the classroom on a timetable established by the school district, it was difficult for the mentor teachers and the student teachers to avoid using these organisms. In other words, it was difficult to avoid constructing the ecotubes and impossible to postpone their construction because the survival of the living organisms literally required a home. This impetus meant that this science had to be accomplished in the class. This factor, plus the necessity of science observation opportunities by the university evaluators, established a compelling necessity for science teaching. Except for Glenn, my other fourth grade teacher interns remarked that the previous two science units were not as rigorously pursued. My presence as an observer of science teaching may also have had some

effect. In one class, the children clapped when I entered the room and cried, "Oh, good, we do science today!" This observation made me wonder about the regularity of science teaching in that class although I did not address it with the teacher intern.

There was one aspect of this whole unit that these men did not address with their students or with me until I asked them. These constructed ecosystems, for whatever reason, were not self-sustaining. The plants were eaten to such an extent that the elodea plants had no leaves. Although some of the guppies had babies, most of the guppies died. The simple truth was that after a few weeks, most of the organisms were dead. Paul's crickets died before he could house them, and he replaced them with crickets from the pet store. Steve had the same problem right after the construction of the terrariums. Donald expressed an interest in solving this problem for the future:

BH: Say that you got a fourth grade class next year, would you change anything? What have you learned from doing it once?

Donald: Oh (hesitates) well, I would certainly be more prepared a little bit, for setting things up. Try to figure out how I can keep the animals from dying before the experiments are done. I don't really know what the answer to that would be. (interview, 5/13/02)

Glenn mentioned that the animals were cannibalizing each other, especially the guppies. Glenn added more elodea to the aquariums, but that did not solve the problem. None of the men addressed the causes of the deaths of the animals with the students, although such a discussion would certain underscore the ecosystem-relationship theme. Without producers (plants) to act

as a food supply, the consumers would eventually die. I believe that there might be several reasons for this lack of discussion. The first possible reason is a reluctance to discuss death with children. I do not believe that this theory is explanatory because of the attitudes that both the male teachers and their students revealed in my presence. Before the experiments began, Donald expressed to me how he believed that students would respond to deaths in their ecosystem. "I don't think that any kids will cry over it. But, I think they will be disappointed" (interview, 4/17/02). This seemed to be the attitude evident in all of the classes. For example, in Paul's class, one group of students brought to Paul's attention that a fish in their aquarium was dead. Paul asked them to compare a dead fish to a living fish and the group observed that the dead fish was not moving and had a different color and a different appearance to its dorsal fin. They dispassionately speculated that the dorsal fin may have been eaten. They then removed the dead fish, disposed of it, and went on with their observations. The same attitude prevailed among students in Glenn's class, although the students did give the animals names. Dead animals were removed calmly. Some students voiced some concern about snails that appeared to be dead because they were not moving. Glenn treated the comment seriously and asked the student to come up with some ideas of how a snail's movement could be measured over time.

Steve told me in his statement of goals for the unit that he expected that some of the animals would be killed (i.e., eaten by the other animals). Steve's

students mirrored his matter-of-fact attitude when working with their ecosystems, although the students did manipulate the experiment to maximize survival chances of the animals. During the pollution experiments, the student groups were paired. To one group's ecocolumn a pollutant was added and the other group's ecocolumn was untouched as a control. As I circulated around the room, I heard several groups quietly discussing that the control should be the tube with a mother and baby guppy or the control should be the one with live snails. So, although the students were matter-of-fact about death, they really valued life and tried to preserve it.

Since all four of the participants dealt objectively with death in the classroom, I do not think that avoidance of the subject of death was the reason that these student teachers ignored the nonsustainability of the ecotubes in the classroom. It is possible that the student teachers regarded the deaths of the animals as some kind of failure on their part. These student teacher interns had many responsibilities and many things to think about. Since each ecotube had only a few animals at the start, the deaths of those few, seemed irremediable. Several of the teacher interns tried to make adjustments. Glenn tried adding food, without much success. When asked about the dead animals, most of the four student teachers pointed out how well the experiments had gone to that point and how amazing it was that any of the animals survived. In fact, in nature, the number of producers exceeds the number of consumers by far more than was maintained in these ecotubes. Although the deaths of the organisms was probably

not expected by the designers of the experiments, it could have been discussed in a scientific analysis with the children. Instead, the whole unit seemed to proceed a bit like a carousel ride that once begun would continue, until it finally, simply stopped. The mechanical performance of the experiment became the main accomplishment, although that was not the goal stated either in the curriculum guide or by the teacher interns in the study. If the students learned about the interrelationship of all organisms in an ecosystem, they learned it primarily from the readings. One could say that the dependency of consumers on producers was seen in the negative sense in that consumers died when the producers did not produce enough food, although this was never stated during my observations. I do not mean to imply that learning did not occur, but neither the mentor teachers nor the interns seemed prepared to take the time to deal with the experiment as it actually played out. The ecotubes had been part of the classroom activities for a long time. It is likely that students, interns and mentor teachers had tired of them. These four interns were also, by the time these problems occurred, near the end of the student teaching assignment. Their eyes were more fixed on graduation than on dead guppies.

The teacher guide provided a sheet on which a teacher could evaluate each student's performance on each of the eight stated conceptual goals and the seven skills that should be attained while studying these ecosystems. It is interesting that, when talking about goals for this unit the participants stressed the interconnectedness of the organisms and the role that humans play. However, the

goals stated by the authors of the unit were more extensive, involving definitions such as producers, consumers, decomposers and pollutants. One goal, to acknowledge what can be learned from model ecosystems, was not, I believe, addressed in any of the four classrooms. Some of the skill goals involved such as applying learned information to a new problem could only be addressed by completing the scientific miniconference.

Examining the parts of the provided curriculum which were included by each student teacher and which were excluded provides insights into teaching priorities of the interns. It is also true that the constraints of time, difficulties with executing the provided curriculum, and sensibilities of the teacher interns and their mentors all played a role in defining the implemented curriculum, making it different in each of the classes.

Integration of Science with Other Subjects

The integration of academic subjects has gained prominence in education in the past few years. Not only does it require higher order thinking skills, but, in elementary school, it puts time to dual use. For this reason, many elementary teachers are committed to academic subject integration in the classroom. The prescribed nature of the science curriculum in the school district did not hinder the creative integrating of the provided materials with other subjects.

The participants in this study all integrated science at some time with the other subjects. Josh designed a reading unit about butterflies that consisted of readings and answering questions. Steve's and Donald's mentor teachers

developed an extended research and paper project in which each student researched one animal and its relation to its habitat. Steve was very positive about this project.

Steve: So we've been able to spin off social studies and science with the reading, which I really like. But the kids do have to use what they've learned so far in science to help them with their reading. I think that's really cool. (interview, 4/29/02)

Steve, Donald, and Glenn all, at some time, used the readings provided by the science curricula during classroom reading time.

Glenn had his own interpretation of the value of integrating science with other academic subjects. Since Glenn is so passionate about science, he believes that integrating science into other subjects makes the other subjects more palatable.

I really like using book club to teach science and social studies. I get to cover more information and make a boring subject more interesting for everyone. I definitely plan to do this in my classroom. The county does not allow much time for science so I am going to make time. (journal, 12/7/01)

Glenn brought science into reading time (the book club mentioned above), and science into writing assignments such as writing a story about an ecosystem relationship. He also used a NASA website in a computer session and downloaded articles from the US Geological Survey page to help students learn more about birthstones. Glenn feels most comfortable teaching science, and so he finds many ways to bring science into the classroom. For Glenn, the goal of this

integration is not multitasking in the classroom, but bringing science into the classroom in as many ways as possible.

Paul was the only participant that consciously integrated science with mathematics or reported doing so. He used Venn diagrams, which had been part of one day's math lesson, to show the interrelatedness of organisms in the ecotubes on the same day. This discussion generated considerable feedback from the students and the students seemed to enjoy applying the knowledge from math to their ecotubes. Given the connections between science and mathematics, it is notable that Paul's was the only class in which I observed any integration of science with mathematics. This may be connected to the type of science units taught in fourth grade. Rock and mineral studies involve mostly observation and classification with little mathematics. The electricity unit did not include any of the mathematical relationships among volts, amperes, ohms and watts, so direct mathematical application was not necessary. The ecosystems teacher guide did have mathematical extensions, including calculating percent germination of the seeds, estimating how many cups would fill a 2-liter bottle, and calculating the chirping rate of crickets, but these were not done. Glenn seemed aware of the extension involving a snail's pace and suggested that a student calculate it, but time ran out and the activity was not done.

Paul often alluded to other subjects while teaching science and also brought science into the teaching of other subjects. For example, when discussing producers in a science lesson, he asked the students about the plants the Native

Americans ate, a topic that had been part of a recent social studies lesson. When asked about this kind of integration, Paul said, "I think it is desirable, although I don't know that I do it all the time" (interview, 5/1/02). His use of integration seemed to be the result of thinking "on his feet," as it were, while teaching. As previously stated, Paul has considerable interest in keeping students engaged. Sometimes he did this by asking outlandish questions such as, "Can a plant go to the Giant and shop?" Sometimes he recalled material from other subjects covered on the same day to keep the students actively involved.

Donald used the science readings provided to construct spelling lists with the students. It was his mentor's policy to incorporate words from actual readings in class into spelling lessons.

It is notable that so few of the extensions suggested in the science teacher guide were incorporated into lessons. Steve remarked that he left out anything in the teacher guide that did not seem "essential" (interview, 5/13/02). Glenn enjoyed adding his own "special twist" (interview, 5/10/02) and valued using his own activities over the suggestions in the teacher guide. Glenn commented that time was at a premium in the classroom and that some subjects such as reading were "sacrosanct" (interview, 5/10/02). However, the demands on teacher time are yet another restrictive factor. Most of the men in this study reported spending long hours at their respective elementary schools. Time before and after school was spent in preparation, grading papers, and meetings of various school teams. The participants also reported that their mentor teachers arrived at school at least

an hour and sometimes more before their students and stayed commonly until 5 or 6 p.m. To include in one's daily schedule the kind of extensions outlined in the teacher guide for the ecosystems unit would require extensive planning if the teacher did not have a strong background in science. Since most elementary teachers do not have this background, it is not surprising that so few of these extensions are used.

The Challenges of Teaching Science

One would expect that five teacher interns would experience many of the challenges of teaching. Indeed, although the five participants of this study were very positive about their student teaching experience, they did disclose some of the difficulties they faced. Since our conversations were mostly about teaching science, most of their comments are specific to that. However, in some cases, they discussed teaching in general and then focused on science particularly.

Personal Challenges

One of the biggest concerns about teaching anything was that one might lack some critical background knowledge necessary to make the subject plain to the students.

In a frank evaluation of his strengths and weaknesses, Glenn expressed how this evaluation influenced his career planning.

Glenn: If I don't get into middle school, then I'll come down into elementary school. See if I can get a position in a school where I just teach math and science. Because I'm comfortable and I feel that I can give more than that way. I mean I love to teach reading and I love bringing science stuff to my reading so I don't mind doing that, but I prefer the math and the science. I mean, my grammar isn't exactly the world's

greatest. I rely heavily on the grammar in "Spell Check." I can spell anything that ends in -ology, but for some reason I have a mental block against "tomorrow." Twenty-four years and I've been trying to learn how to spell tomorrow. Little words that I should know. I'll be on the overhead and I'm like... (Laughs). (interview, 5/10/02)

Recognizing his weaknesses, Glenn desires to teach from his strengths.

Yes, I don't think I could teach first grade. I'm not as routine-oriented as a first grade teacher needs to be. They have to take people who don't know what they're doing and get them into school. And the only thing that scares me in second grade is the huge emphasis on reading. I love to teach reading. I know how important it is, but I'm nervous that I'm going to screw it up. 'Cause I know I'll be messing with somebody's life and because of me, they can't read or read as well as they should. I want to get some years under my belt and experience truly learning and mastering how to teach kids to read before I attempt to be responsible on that level. Fourth grade, they already know how to read and have to refine how they read. It makes me feel a little better because they already have something to stand on. In first grade they don't have anything to stand on. They have to build up. I've been working with the reading recovery teachers to help me with this. I'm nervous about it. (interview, 5/10/04)

Glenn clearly has doubts about his ability to teach reading and spelling. He hopes to guarantee success by avoiding his weakest areas.

Josh, on the other hand, believes so strongly that science does not make sense at the elementary level, that he hopes never to teach it. He likes teaching social studies because social studies is "very easy" (interview, 3/18/02). Like Glenn, Josh desires to stay with his strengths, however for him that means teaching social studies. Even his projects for the Science Methods class involved an integration of science with social studies. For example, one project included a lesson about how Native Americans incorporated constellations into their cultural and religious lives. Josh worked out an arrangement with the Science Methods

instructor to do this project because, at the time, the fifth grade class he was assigned to was not doing any science. Even in projects for his Science Methods class, Josh was thoroughly invested in trying to teach his strongest area.

Paul did not express any general lacks in his knowledge base, but he was concerned about not knowing specific facts that are part of the curriculum.

BH: So you're really very comfortable with science?

Paul: Yes, I think a lot of it is, coming in and you kind of need to be familiar, like you need to know electricity and you need to have your facts straight, because if you give them wrong information then you're wrong and they're wrong. Oh my gosh!! But that is true for the whole teaching thing, it's not just science. But I think I have an interest in science more and that is what tickles my fancy, but I don't know that I feel more comfortable teaching science than I do math or...

BH: But you are not uncomfortable teaching science?

Paul: No, except for maybe if I don't know the material completely. Like rocks and minerals... Well, I don't know a whole lot about rocks and I don't think that the average person would, necessarily. That's when I am uncomfortable, when I'm not real familiar. And it's inexperience, too, like what other elements do I need to bring and what do they need to learn? (interview, 3/20/02)

Paul expressed a need for teachers to have a good factual knowledge base in whatever content area they teach, and he expressed the difficulty of trying to teach an area one does not know very well. He fears giving students the wrong information. In this discussion, Paul echoes Glenn's misgivings. Although Paul's area of emphasis was science, his coursework did not include chemistry or physics classes. Teaching these areas would require additional preparation, and even teaching more familiar science would require some review. Finally, Paul shows his lack of experience with the process of learning and what he needs to bring to the classroom to maximize learning. These two statements of Paul's,

which were both made in an interview early in the final stage of his internship before he had completely taken over the classroom teaching, probably give voice to some of his general apprehensions. However, given the personal planning time constraints that teachers experience in the elementary classroom, it is unclear when teachers who feel some lack of subject content knowledge are to find time to build that knowledge base.

Donald stated that he felt very comfortable teaching the ecosystems unit because of his extensive background in that area. He said, "The ecosystem thing is cool for me because I've always liked that kind of stuff. I have fish tanks at home so that's something I have a fair amount of experience with" (interview, 4/17/02). Donald, however, had never taken even a high school course in chemistry or physics. He claimed that "one of the reasons is that I didn't think that I would have gotten through it (chemistry or physics)" (interview, 4/17/02). When asked how that lack of background affected his teaching of the electricity unit, he commented that he only taught the end of that unit but that it required extra effort. "I had to teach myself series and parallel circuits because I didn't know that or hadn't learned about that in a long time" (interview, 4/17/02). At another point, he alluded to lack of content knowledge, even in the ecology area, as being one of the challenges he faced in teaching science.

One (of the challenges of teaching science) is that I need to re-teach myself or, teach for the first time to myself, the content. I remember mentioning to you, or you said to me something about the oxygen in the water. The problem is not being clear on certain things. Maybe the last time I learned it was fourth grade, so....(interview, 4/24/02)

Steve recognized still another intellectual challenge to the teaching of science – analyzing problems that occur during experiments and finding solutions for these problems.

BH: What do you think have been challenges that you find with teaching science that you don't find with teaching other things?

Steve: Umm... If something goes wrong. Like if the circuits don't connect. Then you have to troubleshoot, which is good, but you know...A noun is a noun is a noun. You know (changes voice) "Ohhh...it's not a noun anymore." (He laughs.) (interview, 4/29/02)

Steve was the only one to voice this concern that laboratory experiences are often in practice much less straightforward than they are presented in theory (or textbooks). Little problems occur that are not described in the instructions. Sometimes school experiments are somewhat akin to assembling a bicycle or some other toy. Things come up that are not expected. When that happens in the classroom, the teacher has to analyze and solve the problem on his feet with the students watching. It is this uncomfortable dilemma that Steve is describing.

Challenges of Hands-on Experiences

All of the participants in this study mentioned the teacher- exhausting intensity of teaching science that is inherent in the experiments. This intensity seems to stem from several major factors: (1) the excitement of the children when doing experiments, (2) challenges of maintaining classroom control, (3) the mess of allowing children to handle even the most basic components of experiments such as water, and (4) the extra work for the teacher in both preparation and clean-up.

Paul mentioned the noise of science hands-on experiences as something that surprised him when he began to teach.

BH: So now that you have been teaching this for a couple weeks, in what ways is teaching science like you expected? And in what ways not like you expected?

Paul: (pauses) I guess the activities and the hands-on part, I expected. Something that I didn't anticipate is that we go into science, they all go into a little chatter mood. I guess it's because they are excited. But I didn't anticipate that. (interview, 5/1/02)

Noise in the classroom can be very disconcerting to the teacher because it can be interpreted as a lack of teacher control. Noise can also interfere with the teacher's enjoyment of the lesson or his evaluation of the effectiveness of the lesson, as Steve so vividly describes:

Steve: But I try to have that attitude of enjoying it. On the other hand, it's hard to maintain order and have a smile on your face.

BH: Science lends itself to more...disorder sometimes than, say, reading.

Steve: Yes, I know. Like the last time I watched the video (of myself) and I heard myself tell them like a hundred times "Settle down!" (He uses a loud, screechy voice.) "Settle down. You're too loud! Settle down!"

BH: They get so excited.

Steve: Yes, they are excited and they are not used to it because they don't do it that much. (interview, 4/29/02)

Steve did not like to see himself berating the children during a science experiment. Being shrill with his students is not part of his notion of the ideal teacher and it disturbed him. It is intriguing that he voiced the opinion that more science experimentation would result in a calmer experience. Steve believes that the novelty of the experiments is an initiator of excitability in the children. By admitting that there is an element of novelty to the hands-on atmosphere, Steve is

admitting that hands-on science is not taught regularly. Although compared to other curricula, these kits do emphasize experimentation, there are only three kits in the total year's fourth grade curriculum. As a consequence, the students do not have regular exposure to experiments in the classroom. The teacher must then continuously remind students of procedures and protocol.

Donald's journal described one of his first lessons teaching science. As part of the rocks unit, Donald planned a lesson on fossils. The central activity of the lesson involved students making their own "fossils" from clay using their choice of rocks, seashells, sticks and leaves.

I modeled how to create a fossil impression in their clay, and they went ahead with it, displaying all levels of creativity. As fun as this was, this is also where my problems started. The clay was an absolute mess. When kids finished their fossil, they needed to wash their hands . . . one sink . . . 26 students . . . you can do the math." (journal, (12/7/01)

With good humor, Steve characterized the experience as a learning experience for him. It taught him to plan for clean-up and to plan for children completing science activities at different times.

Unlike Donald, Glenn expected the mess, but still found it a nuisance.

BH: So generally, in what ways has teaching this science been like you expected?

Glenn: Like expected?

BH: Yes.

G: Messy!

BH: And you expected that? (laughing)

Glenn: I most definitely expected a mess. When you are working with water and bugs and fish and whatever, there is always a huge amount of prep and a huge amount of clean-up. Why I can teach a math lesson, throw some problems on the board, and that's it. I don't think there is less planning, but there is less prep. (interview, 4/26/02)

There was added preparation for Glenn in the setting up of the ecotube aquariums. Due to overcrowding in his school, Glenn's classroom was in a portable unit. The portables are attractive and students reach them by well-designed covered walkways. However, in contrast to most elementary classrooms, the portables have no water hook-ups and no sinks within the classroom. Glenn and I worked about 15 minutes one day filling water containers and dragging them into his classroom. This activity added significantly to the preparation time for Glenn's lesson that day. The experiences of hands-on science are dependent on the teacher's energy resources for both preparation and clean-up. Students can help, but in the tight scheduling of the elementary classroom day, there may not be much time for that. I observed several science classes scheduled for the end of the day that were caught short on time. Children go home when the buses are called, but the teacher is then left to clean-up.

Besides the time spent in the classroom setting up experiments, science sometimes requires shopping time. Paul's crickets died before the terrariums could be set up, so he had to go to a pet store to purchase new crickets. Both Steve and Donald did not use the provided peat soil, but made a separate trip to purchase regular potting soil at the request of their mentor teachers.

Excited children talking and messy experiments may constitute the ideal for the designers of science curricula, but they do make the teacher wish for more adult help, as Donald pointed out.

BH: What do you think will be the challenges next year of teaching science in your new teaching job?

Donald: First thing that comes to mind is not having enough adults in the room. With Mrs. Allen in here, it's nice to have a second pair of hands to help...like when you've got 40 minutes to make sure that all the kids get their aquariums and get them all set up. That is a challenge in itself.

(interview, 5/13/02)

In spite of the drawbacks, all of the participants in this study remained committed to the practice of teaching science with hands-on experiences.

BH: So what are some of the challenges of teaching science besides going out and buying new crickets when the old ones die?

Paul: I would say classroom management and the challenge of it.

BH: Some teachers say that that's why they don't do science. They don't like the unstructured atmosphere and so they just don't do it.

Paul: No, not me. I would do science no matter what. (interview, 5/1/02)

Teaching a unit on butterflies to second graders led Josh to characterize some different challenges of teaching science. The second grade unit on butterflies involved caring for the caterpillars provided and observing their metamorphosis into butterflies. Extremely warm temperatures that year made the classrooms warmer than expected and considerably speeded up larval development into pupa and their metamorphosis into butterflies. This interfered with the planned science schedule. This disruption plus the perceived immaturity of second graders constituted challenges that were discussed in this conversation.

BH: So what have been the challenges of teaching science since you've done this whole unit?

Josh: I think time to do it. Really there's not a lot of time and there is no prep time to do anything. It's just you've got to get some stuff done. Eventually.

BH: What's the major focus do you think in second grade? Reading?

Josh: Yes. Science is just learning a little information about it. Just, I realize that most of these kids are just experiencing most of this stuff for the first time and I forget how little kids... half of their school day itself is like learning about life. Like a little girl brought in a conch shell and she didn't know what it was and I had to tell her what the name was and then I had to pass it around and let everyone listen to it – to hear the ocean. Some people hadn't even been to the ocean before, so that's a whole new story, but umm...I really feel like I want to show them, if I was to take a look at second grade, I want to show them little bits of the world. So to have them just have some, some experience with it. So that they can go into third grade and start really learning information without having the experience behind it. (interview, 5/3/02)

Like the others, Josh feels the lack of time, but his perceived challenges are quite different than the other four participants. Because Josh lost control of the timing of this unit, the whole process felt rushed.

Challenges of a Prescribed Curriculum

Although the provided curriculum, which includes all the necessary materials in a box saves the classroom teacher considerable time, it also places limitations on him. For example, it is difficult for the teacher to include any other science. Steve desired to add some astronomy to his lessons because it was an avocation of his, but he did not have time to pursue this goal. Although Glenn squeezed a computer look at the space shuttle flyby into a computer lesson, he did not have the time to spend either preparing or executing this plan as he would have liked. The provided curriculum did ensure that the district's standards for science learning were met (or at least made clear), but both Steve and Glenn felt that here was time for little else. Donald, on the other hand, did not feel the same time constraints.

Donald: If anything it was kind of a relief to me as a student teacher that I didn't have to suddenly be a master of science and generate my own lessons.

BH: So you see the kits as an advantage--as a good thing because they've given you all this ...?

Donald: Yes. If you can fit it into your schedule, then there is still time when the kits are finished to do other science things if you want to.
(interview, 4/18/02)

Donald did include some other science lessons outside the scope of the kits. For example, he did a lesson on the requirements of a "fair test" (i.e. controlled experiment) that involved throwing a kick ball outside. These different views of the limitations of the kits may have been affected by the mentor teacher.

Donald's mentor teacher did not object to Donald's "fair test" lesson, which took place between kits. However, Steve and Glenn mentioned how tight scheduling was in their class and how little room there was for improvisation.

Not only does a prescribed curriculum with kits not allow for teacher input in the major topics that are included during the year, but the teacher is also limited by the scope of the curriculum.

Glenn: At first I was really impressed (with the kits). They had granite and every rock contained in granite. Plus, they had samples of calcite, sample of this and that. I was impressed with the array, but I wasn't quite as impressed with what they did with it. You look at it, describe it. Is it black or white or shiny. They didn't go into luster, they didn't go into texture. They didn't explain Moh's hardness. It didn't explain why. Why is diamond the hardest? Why is talc the softest? (interview, 5/10/02)

Glenn has some knowledge of rocks and minerals and the vocabulary involved in their classification and study. He would have liked a more thorough study of rocks in the fourth grade, but was constrained by the curriculum.

Glenn also decried the lack of science textbooks, even though the kits included a considerable selection of auxiliary reading materials.

Glenn: The ecosystem is so complicated. A textbook would help just for terms. Like when you say “web” or “food chain” or something like that, I can tell you what it means, but I can’t tell you a definition that applies to everything. A textbook can generalize better than I can. These people who are paid to come up with definitions—they do a lot better job than I do a lot of times. (interview, 4/24/02)

It is remarkable that Glenn, of all participants, felt this need for a science textbook, even though he seemed to be highly conversant with the science terms. He seems to appreciate the support of an authoritative source. This source would take some of the burden off Glenn’s shoulders and would also save time. None of the classrooms I visited for this research had science textbooks, but Glenn was the only one who addressed this lack.

As previously mentioned, one of the drawbacks of the ecosystem unit was that the ecocolumn was not self-sustaining and, therefore, not a total success. This was not true with Josh’s butterfly unit. Although the timing was not as expected, the larvae metamorphosed into butterflies and the children were able to observe the process from the hungry, eating frenzy of the caterpillars, to the building of the chrysalises, to the appearance and growth of the butterflies. At the end, the butterflies were released in the school courtyard. It was a fit and touching conclusion. The children were sad, but one remarked, “They do not want to stay.” The children read a poem and Josh released the butterflies. Happily, the birds that had swarmed into the courtyard upon seeing the butterflies did not catch or

consume any of them and the children waved goodbye. One little boy spontaneously read his own poem, and they filed inside to write in their journals. I was totally surprised at the end of the day when I interviewed Josh and he spoke positively of the butterfly unit.

BH: So what have you enjoyed teaching with the second graders?

Josh: I would say the butterflies.

BH: That's interesting.

Josh: Only because it's just that they are very interested in it and it's very hands-on. It was a long project that ended up working out. So, you know, I feel like it was successful and they were definitely interested in it. And since it was such a long period thing and it was successful, it became easier to do and so more enjoyable. (interview, 5/9/02)

This pleasure with the science unit was so antithetical to all that Josh had previously said, that it affirms to me the power of successful lessons in framing teacher attitude. In the end, the one participant in my study who most disliked science claimed that he enjoyed teaching second graders about butterflies for the simple reason that it worked.

Another drawback of the kits in my participants' eyes was the limited types of experimentation that they provided. Although all of the participants in this study were committed to hands-on experiments, they did not view all hands-on activities as equal in value. The kits provided experiences that did not emphasize the processes of science or the scientific method. This was a notable limitation for some of these men.

Steve: I think that process is very important – like for them to know that all right, first you come up with your hypothesis. Although I'll say that they haven't structured them like that in this school, which is kind of weird actually.

BH: The kits aren't really like that, actually. I mean they don't think in terms of hypothesis etc.

Steve: No. I would kind of like to do that. A lot of these things (we're doing) they are not actually experimenting as much as you are just watching. With the lights and even with the fish, you are not experimenting, you are just putting it together and watching. So we're not saying, "Well, now I'm going to put in a live salamander and see if it eats a fish." It's kind of hard to do that here. But I think that kind of understanding that there are guidelines and rules, like gravity, that govern it. And within those rules, you can kind of test different things to find out what the dependent variable and what the independent variable is. You know, I didn't understand that when I was in school and to this day, it has given me problems. Because we didn't do much about it. We did it for like a month and then it was over. They need time. It's problem-solving and that's what it is. It's developing a strategy to solve problems.

(interview, 4/29/02)

Paul reiterated Steve's idea of the importance of students learning problem-solving strategies in science.

BH: So as an elementary school science teacher, what do you think you must accomplish? What do the kids have to know when they finish elementary school?

Paul: I would think, even though I may not have emphasized it, I would think, the scientific investigation. I think you need the problem-solving set up that is kind of transferable to whatever science that they are doing. They won't necessarily get, say, this is a stalactite, but that is not as important as the nature of scientific investigation. (interview, 3/20/02)

True to his philosophy of the unity of knowledge, Paul emphasizes that the problem solving strategies of science have universal scientific application.

Having said that, Paul admits that he has not emphasized this aspect of science in his fourth grade class. This emphasis is not one of the major goals of the ecosystem unit as Paul interpreted it.

Glenn expressed his dissatisfaction with the kits a little differently.

BH: So these kits are a timesaver in some ways, they tell you exactly what to do and set it up exactly the way the directions are?

Glenn: They are very explicit directions- extremely explicit directions. If you follow the directions, you cannot go wrong.

BH: So what does that teach them about science, do you think?

Glenn: It's a recipe science. It's a cup of this; a quarter of that; mix thoroughly; bake 350 for one hour and voila! Your cricket! It's learning how to do a recipe. It's like reading to be informed. Performing to do a task. It's not necessarily science. It has scientific terms and background knowledge, but I don't see them doing...experiencing investigations and using that thought process, I don't see.

BH: So you're saying it's not teaching them methodical, systematic science?

Glenn: Yes. They don't do enough observation. They don't do enough inquiry where they use an observation and what does this mean. They don't do enough of that. I think they could use some more background knowledge as far as basic, good science technique. At least, know what the scientific method is. Just looking at their science projects, some of them know what the scientific method is and "What is the scientific method?" And they...I think that if you're really going to do science you need the scientific method. You need a hypothesis, you need a procedure. You have to be able to repeat this procedure. As we do this, we don't have a hypothesis because we have an investigation. Instead of doing repeated trials of this, we're doing it seven times (seven student groups). So those are our trials, but we're doing it all at once. So we know if it happens once, it should happen in all the seven. Otherwise, it was probably a fluke. And controls? We don't necessarily have controls.
(interview, 5/10/02)

Both Glenn and Steve are describing a disconnect between the type of experiments provided in the kits and the types of experiments that they understand should be a part of the scientific method. In their view, these school experiments involve primarily observation and do not emphasize hypothesis, controls, or comparisons of data.

The Challenge of Limited Time

Time was mentioned as a limitation of a prescribed curriculum that did not allow for much innovation. However, merely finding time to do science was something that every participant considered problematic. Josh mentioned lack of time often, even in his journal entries for the Science Methods class. Steve also commented that time management was one of the skills he worked on throughout his student teaching internship.

Steve also considered standardized testing a classroom time consumer that stole time from science teaching.

BH: Do they love science too?

Steve: Ah, yes! They hadn't been doing much science until I came because they were really working on the TTBS tests.

BH: What are those?

Steve: Those are fourth grade comprehension/understanding tests. They have to read paragraphs and they have to bubble answers. So they were working on that a lot and so science they hadn't done a lot. (interview, 4/17/02)

Since science was often left to the end of the day, time might run out before everything was completed. Also, events such as bus drills, field trips, or chorus practices might interfere with science. These interruptions were not the norm and all of the participants' classes showed considerable planning and close time management. However, if a subject needed to be dropped from the schedule, it was science that was dropped. Not one of my participants ever cancelled a science class that they had scheduled for me to observe, although that may have been largely a courtesy to me. I do know that many of my

observations could only be scheduled with a lead time of one day because of the tentative nature of science class scheduling.

The Challenge of Student Questions

Glenn, alone among the participants, defined one challenge that seems more common to science teaching than teaching any other subject. This challenge involves the endless questions that children can introduce into a science lesson and the interference of those questions with the progress of the lesson. For example, a discussion about the components of an electrical circuit can lead children to question how fuses work in their homes, how a flashlight works, what causes blackouts and on and on.

Glenn: I need to brush them up on it (photosynthesis). If you want to stick to the topic... Well, they can do that to me. If they ask me a question, I try to answer. And then more questions come up and then, well, I'm over here when I need to be over here (motions to the far left and then to the far right).

BH: And then the whole period goes.

Glenn: And you make a left at Albuquerque and then it's all off and out of whack. (interview, 4/26/02)

Keeping the children focused is a special challenge for a teacher, like Glenn, who has a wide knowledge base in science. Although Glenn felt this temptation enough to introduce it to our conversation, it was never an issue in the classes I observed, where he usually had a strict timetable and defined goals that he had to reach.

The Challenge of Coping with Alternative Conceptions (Misconceptions)

One of the emphases in current science education literature is the identification of alternative conceptions (or misconceptions) that students bring into the science classroom (Hatano, & Inagaki, 1987). Alternative conceptions are attempts to incorporate new knowledge into existing conceptual frameworks that already contain information that contradict the scientific view (Vosniadou, 1994). For example, students may believe that one wears a hat in winter because the hat itself generates heat or may believe that the earth is really a flattened sphere or a disc. Alternative conceptions are not easy for the teacher to identify, but can act as a powerful deterrent to scientific reasoning. Although one would not expect that the participants of this study would be acquainted with the misconceptions literature extensively, several of them did mention the problematic aspect of student misconceptions in the classroom as a challenge in the classroom.

Very early in the fall of his student teaching internship, Paul encountered a student who expressed an untenable scientific notion during a science discussion about energy after the class had prepared sun tea. One girl equated solar energy with gravity leaving, creating a significant teaching dilemma for Paul. Since Paul emphasizes the relational aspect of teaching, he did not want to contradict her directly, but needed to address her misconception. At this early stage, in September, he had not formulated a way to handle this problem. This issue

continued to pose difficulties for him. When the same kind of incident occurred in the spring and Paul simply ignored an incorrect statement.

Paul: Right. What do we know about aquatic plants? Let's think about why we need them to survive?

Student₁: They need oxygen.

Paul: Need or give off?

Student₁: Need and give off.

Paul: And land plants need?

Student₂: Soil.

Paul: And water?

Student₃: It rains when God cries.

Paul: What else do we know about plants? (field notes, 4/25/02)

Paul helped student 1 clarify the scientific issue on the use and generation of oxygen by plants. However, he dealt with the nonscientific statement "It rains when God cries" by ignoring it. This statement, more than the first example of equating solar energy with gravity, has disturbing aspects for the classroom teacher because it has ties to religion and may create potential conflict with parents or other authority figures. His consternation was compounded by the irrelevant nature of the comment, and, perhaps, because there was an observer (me) in the classroom. It is not surprising that Paul did not pursue the student's statement. Paul had earlier stated to me, "I think that if you pull that background information so that they can modify it or adjust it if it's wrong or add onto it then they can make connections to it" (interview, 3/20/02). It seems to me that Paul viewed this misconception as going back so far into presuppositions about the world that he could not adjust it at the time.

Glenn, on the other hand, had an aggressive stance about misconceptions. He optimistically believed that, when the proper data are collected, students will revise their misconceptions. For his project in Science Methods class, Glenn asked a group of students to experiment with the mass of objects and their rate of fall. This exercise was meant to reprise Galileo's classic experiment at the Leaning Tower of Pisa. I had noticed from his presentation that the students had not repeated Galileo's perfect results, but had mixed results with objects of varying mass. In fact, their data seemed to prove that heavy objects fall faster. I asked him about the project in an interview.

BH: How did the project go that you did for Science Methods? Wasn't it how fast things dropped according to their mass? Did that work out?

Glenn: Yeh, I had a kid actually sit on top of the monkey bars and she held the weight at monkey bar level- at the same level every time - and we had a stop watch. And so a kid, start, stop, start, stop, every time. We had a kid recording. It could have been more accurate...

BH: This was kind of designed to deal with misconceptions...

Glenn: ...that heavier things fall faster.

BH: Did they come away with the right idea?

Glenn: Yes, we tried to present our results to the class. But it turned out that some of the things were off... just by...Usually, I would have, you know, drop and hit the timer at the same time or have a mechanism so that as you drop you trip the timer. But there were 2 separate people so it wasn't exactly synch'ed. So some things, well you know, the five second drop....we'll do that one over again.

BH: Do you think that many of them have misconceptions about a lot of science? Does the hands-on help to deal with that?

Glenn: Yeh, just little things. Like water and ice that it expands, it surprises them. Liquid solid stuff.

BH: How do experiments help?

Glenn: They get to see it. They read so much, all the other times, but when they actually get to see it and do it, then it's right there and it happens. (interview, 4/15/02)

Glenn's views of the value of experiments in revising misconceptions is consistent with his view of the importance of the scientific method to the scientist and the student alike. Actually doing the experiment in the correct way will lead students to see the answer for themselves and resolve all misconceptions. As Glenn found in the actual performance of the "Pisa" activity, experiments do not always work out as perfectly as we hope. When the students' data did not reflect Galileo's, Glenn had a dilemma. He proposed to me that he would redesign the experiment and have the students do it again. But, by this time, the Science Methods class was over, and he never brought up the subject to me again.

When asked about misconceptions, Josh said that he did not deal with misconceptions very often in the classroom.

BH: Are you acquainted at all with the education research that says that children have a lot of misconceptions about science. Do you think of science that way when you teach it?

Josh: I do, but, you see, the only problem is we don't have time. There's no time for science, A, and B there's no time to deal with science misconceptions,'cause even if you do have time for science you have to deal with all this other stuff. And so, I guess, I would add those (misconceptions) in as tidbits of information and try to tie it into whatever I'm teaching. I'll try to do that in social studies as well, but it's not necessarily misconceptions, but telling them the real story of what happened. Telling them a little more in detail of some of the behind-the-scenes type stuff, which kind of fits into the science thing as far as the misconceptions are concerned. Telling them how it really happens.
(interview, 3/18/02)

Josh brings up an important practicality about dealing with misconceptions in the classroom. That is, a teacher may identify a misconception held by one student, but the work of changing that misconception may consume too much time. A

teacher has a whole classroom full of students and the logistics of dealing with misconceptions may be prohibitive. Dealing with misconceptions may also demand a greater grasp of the science concepts than an elementary teacher typically has.

Advantages of Teaching Science

In spite of the drawbacks of teaching science, four of the men in this study embraced teaching science. One of the reasons, as I earlier discussed, is the positive attitude of the students for science. Another is the movement and freedom that hands-on experiences afford. The “doing” aspect of science that Glenn so insists on sets science apart. In many ways, science can be a form of respite for the students. This is not to imply that it is approached lightly, but that, like Physical Education, it gives a change of pace to a school day that can become long for elementary students. The burden of science for the students and the teacher is different than the burden of reading or the burden of mathematics. Elementary school is the place to learn to read and it is the place to lay a firm mathematics foundation. Science is almost viewed as the dessert of the elementary curriculum. Anything that is accomplished with science is viewed as a huge plus because the expectations placed on it are not as great as those for core subjects.

I think it is important to add at this juncture, that in all my classroom observations, I never observed these teacher interns doling out either behavior warning or praise differentially to boys or girls in the science class as Jones and

Wheatley (1990) described. In fact, I observed very few behavior warnings, and all of the interns were quite generous with praise.

Summary

In this chapter, I explored the understandings of the participants about the teaching of science in elementary school. In interviews, the participants expressed their ideas about science teaching. By observing their actual science teaching, I was able to observe how their ideas were actualized in the classroom. This chapter was divided into six sections: Views of the Ideal Science Teacher, The Prescribed Curriculum, Four Ways of Teaching the Ecosystem Unit, Integration of Science with Other Subjects, The Challenges of Teaching Science, and the Advantages of Teaching Science.

Each of the participants in this study entered his student teaching internship with certain beliefs about science teaching. In the Views of the Ideal Science Teacher section, these beliefs were examined. One of the strong influences on the student teacher interns' beliefs about science teaching was their own experiences with teachers when they were students, especially, but not exclusively, elementary students. Each participant emphasized the relational aspect of teaching as critical. To them, a good teacher must be a nice teacher who enjoys his students. They sought to exhibit this in the classroom in many ways. Donald felt that his sense of humor helped to make the classroom experience more fun for both his students and himself. Steve joked with his students and called them nicknames, especially during recess. Glenn drew a distinction

between science teaching that students might enjoy because a teacher is cool and science teaching that is both fun and productive. Glenn's most memorable teacher "liked science and she liked children" and Glenn believed that the ideal science teacher must combine those traits. Glenn tried to personally live up to this standard by using nicknames, spending extra time with the students, playing organized games with them at recess, going out of his way to share their enthusiasms with students, being positive towards their participation whenever possible and respecting them as persons.

In the second section of this chapter, The Prescribed Curriculum, I compared the ways that the four fourth grade interns taught a district-provided ecosystem curriculum. Each of these men constructed ecocolumns in their classes for the crickets, fish, isopods, snails and plants provided in the kits that were delivered to their schools. These ecocolumns were observed in the beginning as the teacher guide directed. However, each of the fourth grade interns chose to execute the rest of the ecosystems unit in different ways. Glenn used the introduction provided, but the other three did not. Each of them chose different readings from those provided and approached readings differently. Paul had students read aloud in class. Donald had students read silently. Glenn and Steve divided students up for the readings and had each group write large newsprint summaries. Donald used the readings to incorporate science words into spelling lists. Finally, each of the fourth grade classes ended the ecosystems unit differently. Paul's students did not pollute the ecocolumns because his mentor

teacher did not want to kill any organisms. Glenn, Donald and Steve had their students pollute the organisms but the ecocolumns had so few living organisms remaining that their results were inconclusive. None of the fourth grade classes performed or had plans to perform the culminating activity in the teacher guide, which involved holding a miniconference about the effects of humans on a local ecosystem. Also in this section, I examined how Josh, the only second grade intern, had his class raise caterpillars, observe their chrysalises, and finally release the butterflies. When the live specimens were delivered, Josh's class examined the caterpillars as they ate and built their chrysalises. The chrysalises were housed in a netting cage and the butterflies were observed as they emerged from the chrysalises. Josh used some readings from the teacher guide and had his students do auxiliary factual information sheets about butterflies in a booklet that he assembled. He also read to his students from a picture book about butterflies.

Each of the five participants emphasized broad goals for student learning of either the ecosystems or butterflies unit. The four fourth grade interns wanted students to understand the components of an ecosystem, how the components were related to each other and how this interrelationship could be upset by disturbances. Josh, the second grade intern, wanted his students to know "a little bit" about butterflies. These goals were not as detailed as the goals stated in the teacher guide. Since none of the mentor teachers in the fourth grade planned to implement the culminating miniconference activity, the students could not accomplish the curriculum stated skill goal of "applying previously learned

information to analyze a problem and suggest solutions" (National Sciences Resources Center, p. 17). Although Steve, Glenn and Paul emphasized teaching the scientific method or the processes of science as an important component of teaching science, they admitted that this was not emphasized in the provided curriculum. The failure of the fourth grade ecosystems to be self-sustaining was examined from a pedagogical standpoint. The unexpected deaths of the organisms was analyzed in terms of the goals for this unit. The impact of the animals' deaths was largely ignored by the interns when they analyzed the interrelationships of living things within the ecocolumns.

In the section, Integration of Science with Other Subjects, I discussed lessons that integrated science with other academic subjects. Students in Steve's and Donald's class did a major research paper on animals that partially used knowledge gained in the ecosystems unit. Josh brought in extra readings about butterflies for his students. Paul was the only intern I observed integrating science with mathematics. He used Venn diagrams in an illustration about ecosystems. Glenn used science-related readings in book club, assigned creative science writing for Earth Day, and had students examine a NASA website for computer lab. Glenn's interest in science motivated him to bring science into his lessons whenever possible.

As these five interns taught their science units, they encountered some major challenges that are examined in the section The Challenges of Teaching Science. One challenge mentioned by all the participants was the limitations of

their own personal knowledge about science. For Josh, his own lack of interest in science was a career definer, causing him to desire a job teaching middle school social studies. For Donald, his limited knowledge of circuits added to his preparation time. Steve, on the other hand, felt that troubleshooting during experiments, required challenging analysis. Other challenges mentioned by the participants are inherent in the hands-on experience. These challenges include student behavioral issues such as excess talking or movement, the messiness of experiments, the lack of adequate adult presence, the extra work involved in set-up and clean-up, and the requirement for continual involvement of the teacher to trouble-shoot breakdowns in experimental apparatus.

A prescribed curriculum is also challenging because it does not explicitly encourage pedagogical creativity by the teacher. Only Donald described adding extra science hands-on lessons of his own design with the blessing of his mentor teacher. Glenn believed that the provided units, especially the unit on rocks and minerals, had insufficient depth. Glenn also decried the lack of an accompanying science textbook. Paul and Steve believed that the prescribed curriculum lacked an emphasis on the processes of science.

The issue of time was evident in two major areas. The first was finding enough classroom time to incorporate science lessons. The second was finding enough teacher time to plan and set-up for science. These interns also expressed concerns about their lack of science background knowledge, dealing with student

alternative conceptions about science, and problems specific to the nature of science hands-on experiences.

Glenn also mentioned the challenge of keeping science lessons focused when students asked diffuse, but curriculum-related questions. Dealing with student alternative misconceptions was mentioned as a challenge that teachers need time to discover, analyze and confront. Most of the participants hoped that exposure to the “facts of science” would lead to students to abandon any alternative conceptions that they held.

In the last section of this chapter, The Advantages of Teaching Science, I examined the teacher interns’ perceptions of the advantages of teaching science. Primarily, the interns focused on the “doing” aspects of science that give the students a respite from the demands of other academic subjects. All five of the participants appreciated the unique qualities of science teaching that allowed for them to break with classroom routines and involve the students in a physical activity.

Chapter 6 Factors Influencing Understandings of Science Teaching

Introduction

As I begin this analysis of the factors that influence the views of science, science learning and science teaching held by the participants in this study, I am aware of the dangers of oversimplification. People are very complex, and these men have each lived over 23 years. They have had many experiences and encountered many people over those years. I know only what they have chosen to tell me and what I have observed. However, as I analyze the data, certain themes emerge that help me to discern why my participants understand science and the teaching of science as they do. I will divide these influences into groups: (1) personal factors, (2) academic influences, (3) experiences, and (4) interests.

Although these groupings flow naturally from my data, they have also been emphasized by other researchers. Hebert (2000) studied gifted male preservice teachers focusing on personal characteristics, academic background and sports interests. Brousseau, Book and Byers (1988) found that teachers' beliefs about teaching correlated to the number of years of classroom experience. Tosun (2000) connected academic science training and teachers' feelings of self-efficacy

when teaching science. In this chapter, I will explore these four types of influences as they relate specifically to my participants understanding of science teaching.

Personal Influences

Basic Personality

After observing these five men through their Science Methods class and their student teaching internship, I was impressed with the extraordinary impact that their basic view of life had on their views of teaching and learning. Four of the men in this study, including Glenn, Paul, Donald and Steve, shared a very positive view of life. Josh, on the other hand, did not exhibit the same general optimism. Glenn, Paul, Donald and Steve exhibited a certain *joie de vivre* that permeated their conversations, their relationships with students, and their teaching. This is not to say that they never expressed doubts or misgivings or that they never critically analyzed themselves and their work. There were days when some of these participants were sick and barely made it through the day. There were days after all-day field trips when they appeared exhausted. However, their enthusiasm for teaching and their positive outlook towards their students never seemed to diminish throughout the course of this study.

This attitude colored their view of science and teaching science. Glenn, with the most extensive science background, loves gathering more scientific information. He is curious about the natural world and carries nature guidebooks to answer his questions when hiking. He sets up his telescope to view celestial

phenomena. He cares about ecological problems at the reservoir where he fishes. He does not find science daunting, but an academic discipline to embrace. He is matter-of-fact when teaching, but his passion for science is evident in his level of preparation and his language. It is part of Glenn's personality to have deep interests and seems intrinsic to his nature to desire to share those interests as an expert. Glenn, of all the participants, has invested the preponderance of his personal resources in science as a field of study.

Although Paul does not share Glenn's dedication to science, his general enthusiasm about everything extends to his view of science. Paul claimed that science "tickles my fancy" (interview, 3/20/02), and he expressed his commitment to the environment and man's responsibility to preserve it. He declared that being outside with his students doing experiments is "always a joy" (journal, 9/14/01) and he described the ecological relationship lessons as "actually amazing to me" (interview, 5/1/02). The only negative statement Paul expressed was in a journal entry describing one of his own lessons as "boring and not very engaging" (journal, 10/31/02). However, he recognized the value of the lesson because it was about the nature of scientific investigation. Directly after his negative self-evaluation, he resolved to address the theme again with an experiment as the vehicle for the lesson. His comments show that although he can look at himself realistically, he does not wallow in negatives, but can make corrections and move on.

Donald did not state that science was his favorite subject to teach, but he did assert that he “loves science” (interview, 4/18/02). Donald described students’ enthusiasm for science and how that makes him want to teach it. He wants his job as a teacher to be fun, to have light moments and to be rewarding. He concentrates on maximizing those aspects of teaching and learning in the classroom. This seems part of his total personality.

Steve believes a teacher’s positive outlook influences the students. He maintained, “I try to make it exciting; I try to make it enjoyable and I try to have fun because I think it’s fun, and I want them to have fun” (interview, 4/17/02). Steve has a strong desire to share the astronomy that he loves with his class. Fun is a continuing theme in Steve’s discussions of education and schooling. Although he also emphasizes the value of hard work, he believes that science can be hard work and fun at the same time.

Throughout my interview notes and field notes, I find these four men using the words fun, joy, and love much more than I would have expected. They not only discuss the positive aspects of learning science abstractly in conversation, but they brought their positive attitude into the classroom. Their energy was contagious. I observed these men teaching other subjects such as mathematics, reading, or social studies with the same kind of enthusiasm. I saw it more in science, perhaps because I observed more science classes. However, all of them mentioned to me some special qualities about science that made it more fun to teach and made the time pass quickly.

One could, probably with some credibility, attribute their positive enthusiasm to their youth. However, enthusiasm is certainly not a personal quality universally found among college students. I view it as a part of their personalities and a part of their outlook on life. Hebert (2000) also observed this kind of optimism in the six gifted male preservice teachers in his study.

In contrast, Josh did not approach life with the same enthusiasm as the other four participants, nor was his conversation as exuberant. He executed the butterfly unit methodically, and added some extra activities to present all of the facts. Josh did refer to a week that would be “fun” particularly because the butterfly release ceremony would be held during that week. I would not place his outlook at an opposite extreme from the other four participants, but, in science, he did not project the same eagerness as the others. Josh did appear more energized when I observed him teaching a fifth grade poetry lesson. A student brought up Shakespeare and Josh launched into an impromptu discussion of Shakespeare’s poems, calling Shakespeare a “genius.” Also during that class, Josh led the students in clapping to the rhythm of a poem by Shel Silverstein. This occurred during my first observation of Josh, and I view it now as representing a level of involvement that I did not see when I observed science classes. Since Josh was quite frank with me at our first meeting about his dislike of science, he may have not really enjoyed the whole process of discussing teaching science or my observing his science classes. Also, Josh seemed more comfortable with the fifth grade students in his original teacher internship placement than he did with the

second grade students in his second placement. He admitted that the second graders in his final placement frustrated him. I noticed that he referred to the second graders as Mr. Jones or Miss Smith and he did not use those titles with the fifth graders. Clearly, I was observing Josh outside his comfort zone in both a second grade class and a science class, which may contribute to my perception of his lack of enthusiasm.

The enthusiasm for life and the experiences of life held by Glenn, Paul, Donald, and Steve positively impacted their teaching. From the point of view of this study, it greatly impacted their teaching of science. A review of the literature shows that many elementary teachers feel uncomfortable teaching science to the point of avoiding science in their curriculum (Tilgner, 1990; Downing, Filer & Chamberlain, 1997). However, these four men embrace science as an opportunity to actively interact with the world, to enrich reading and writing in the classroom, and to underline the importance of human interactions with the biosphere. Josh, who is the participant most uncomfortable with teaching science, illustrates Downing, Filer and Chamberlain's (1997) thesis that teachers with low levels of confidence teaching science have not been exposed to science process skills during their own academic experience. Glenn, Paul, Donald and Steve are not apathetic and indifferent to science as Rouchoudhury, Tippins and Nichols (1995) described their Science Methods students. Some of their positive attitude can be related to past positive science learning experiences and some is due to their attitude towards life. Apathy is really not a part of their personalities, although

Glenn did describe such apathy in some of the fellow education students who were in his block of methods courses:

Glenn: The methods class, it was wonderful. It was a nice class. I didn't learn much in the fall. I think it is mostly our class structure. Our class is exceptionally noisy and exceptionally uncaring. They didn't want to be there, and they let our teachers know it. So...not all of them...but...

BH: Why was that? Do you think they felt that things weren't practical enough for them?

Glenn: Yes. They're just...that chemistry was there. It wasn't everyone. Some wanted to learn their job and others would just sit and yak about their own little personal thing the entire class. Period. Would never shut their mouths. (interview, 5/10/02)

This indifference, which Glenn perceived as part of the milieu of the methods classes was so disturbing to Glenn that he commented on it more than once. Such apathy is alien to Glenn; it is simply not consistent with his approach to life.

Self-confidence

Being committed to hands-on activities in theory and in fact requires a certain level of self-confidence. Paper and pencil activities are, in most cases, predictable, but constructing circuits, building ecosystems, and collecting rocks are not predictable. The light bulbs in a circuit may not light, the organisms may die, or the rocks brought in may be difficult, if not impossible, to identify. In order to lead the class in hands-on activities, the teacher must first make sure that he actually knows how to do the procedure required. Procedures that seem simple and straightforward in textbooks are not always simple and straightforward in the actual performance. Donald mentioned that during the electricity unit, he "had to

teach myself series and parallel circuits because I didn't know that or hadn't learned about that in a long time" (interview, 4/17/02). Even though he had never had a course in physics, he had the confidence to work through it, and he never expressed to me any doubts about his ability to work through it. Once a teacher has worked through the experiment and set it up for the students, he must be able to rotate efficiently through the student groups, helping those students with questions or problems. Steve related how troubleshooting during experiments is a challenge but not an impossibility. Steve actually seemed to thrive on these interactions, but did comment that the mental activity alone and the tension of continuous problem solving made him tired. He never, however, expressed a doubt that he could solve the problems.

Teachers who are self-assured are more willing to try new things and to generate their own auxiliary classroom materials. Such innovations involve a certain kind of risk taking; self-confidence is a major component of risk-taking. A teacher's attitude toward his own risk-taking missteps is indicative of his self confidence. Glenn has enough self-confidence to laugh at his mistakes and learn from them.

Glenn: I've been really happy with a lot of them (lessons). I've done very few directly from the book and the ones I've done right from the book, I haven't liked. I almost always add my own special twist. Sometimes it works and sometimes it doesn't. I'll be the first to admit that I've screwed up a couple of really good lessons. (Laughs) They had really good promise and they went pfft.

BH: Any science?

Glenn: Most of them have been social studies, but I've had a couple of science ones go awry just because of little things I hadn't anticipated.

Some things I really should have thought about them, but they were so simple.... I really should have thought. (interview, 5/10/02)

Even though Glenn understood that some of his innovations were less than successful, this did not stop him from innovating. He was continually bringing in new ideas to try out in the classroom.

Steve exhibited self-confidence in his actual teaching. Teachers are not always willing to expose their own lack of knowledge to their students, but this was not true of Steve. During the addition of plants to their aquariums, one student asked if the plant elodea would still grow in the aquarium. Steve replied that he did not think so because they were cut off from the main stem. It is significant that Steve did not state his opinion as fact and even his tone of voice indicated his uncertainty. He then turned to the student and said, "That is a good question." Although Steve could have focused on himself, he focused on the student, showing the student that questions are valuable and welcomed even when the teacher is not sure of the answers.

The self-confidence that these examples show is probably related to their basic positive outlook on life. It is also associated with other factors. Self-confidence has also been linked to gender in several studies. Fennema and Peterson (1985) observed males exhibiting more "autonomous learning behaviors" and have emphasized males' abilities to persist and succeed at complex tasks. Emphasizing male ability to work independently, Pipher (1994) also links gender and issues of self-esteem, noting that boys tend to stick with

difficult math problems while girls are more likely to give up. Riggs (1991) tested male inservice and preservice teachers and found that males scored significantly higher than females on self-efficacy for science teaching. Although this research may describe “average” males, Thorne cautions that the researcher should view their data contextually rather than stereotypically. It is enlightening to examine the contexts of the three examples of self-confidence given above.

When Donald faced the dilemma of not knowing how to construct the series and parallel circuits, he had only a few choices. He could admit his lack of knowledge to his mentor teacher and use it as an excuse to bow out of doing the lesson. This could have the serious consequence that his mentor teacher would view him as inept and not resourceful. There are few student teachers, male or female, who would risk that consequence. His other options would have been to use the teacher guide and teach circuits to himself, as he did, or to appeal to a fellow student teacher for help, which he did not do. Although I observed Donald and Steve collaborate on science lessons, Donald chose to solve this problem on his own. I believe that he saw this as something that he could do and that the problem was not worth the trouble of consulting with another student teacher. He did not comment to me that the problem was too difficult for him, but only that it consumed time. This decision by Donald may, on the surface, seem to have simple and straightforward causes attributed to it. However, when examined closely, it is a complex decision with many alternative solutions. Self-confidence seems intertwined in the decision-making process, which seems to be validated by

the final outcome that Donald did succeed in the task he gave himself. It is not clear in what ways, if any, this self-confidence is tied to teacher gender although Hebert (2000) also characterized his six male preservice elementary teachers as possessing a strong “belief in self” (p.21). The fact that Donald chose to tell me about this incident, even in the context of the time-consuming aspects of teaching science, means that the event had some importance to him.

Glenn also had the self-confidence to learn from his mistakes in lesson planning and persist in developing his own lesson even when he failed. In the context of science teaching, Glenn also has a limited number of choices. He could abandon creativity altogether and use only lessons that are part of the prescribed curriculum. This approach has its own problems. Every teacher knows that the lessons in books do not always proceed as predicted. Science textbooks contain experiments that were never tested by the writers, and which, indeed, do not work as written. Glenn knows this as evidenced by this conversation:

BH: Just by chance, if you were to get a job teaching fourth grade science in a self-contained classroom... If this unit came up, you would get this box. What have you learned from this year that you would change?

Glenn: I was waiting for that one! The book is hideous! Oh, God. The way it describes things is so archaic.

BH: It's out of date?

Glenn: Way out of date. It was done by someone that had really good ideas and worked it well, but they weren't scientists. (Interview, 5/10)

So, Glenn is very aware that books and teacher guides do not always follow the best approaches. Glenn knows that relying on provided written materials solely

because one fears to make one's own mistakes is really not a path to guaranteed success in the classroom. For Glenn, driven by his own knowledge, love of science, and his desire to share that with his students, the only choice is to create lessons or "tweak" lessons and learn from his mistakes. As a former lab technician, Glenn believes that scientists learn from their failures and that most mistakes are not irremediable. Glenn's attitude could be evidence of self-confidence or it could be evidence of perseverance. I believe that the two are related; the research literature supports this view. Dweck (1980) connected persistence with the ability to connect success with stable internal causes rather than unstable external causes. Glenn clearly considers that he controls his destiny. He can learn from his mistakes, and he therefore treats mistakes as a factor in his continuing development as a teacher. Glenn's actions in this case are consistent with his history, the driving forces of his personality, and his view of science as an endeavor.

Steve's ability to admit his lack of knowledge when addressing a student's questions is a complex event to interpret. To admit one's lack of knowledge when teaching does require a certain amount of self-assuredness that is not dependent on other's opinions of oneself. It also requires some humility. Perhaps more than any other subject, science has a peculiar way of exposing teachers' lack of knowledge. Science deals with the natural world. Students are continually interacting with this world at some level and noticing things about the world that they cannot explain. The questions of students can require knowledge in areas

that the teacher cannot predict. The classroom teacher may avoid science because the student questions make him uncomfortable. Or he may, by his manner and tone, discourage questions. Of all the participants in this study, only Josh avoided teaching science, and even he could not avoid it throughout his whole student teaching internship. None of the participants discouraged students from asking questions in any way. In fact, all of them treated questions that they could not answer in the same way as Steve did. It is notable that Steve's response to the question included an affirmation of the student, "That is a good question." I do not believe that Steve meant by this statement that any question that Steve could not answer was a "good" question. In this case about the elodea, the student wanted to know if a piece of the plant would still grow. The elodea was a plant component of the ecosystem. The students had read that the elodea had a role to play as an oxygen producer and as a source of food for the plant-eating animals. The student is asking an important question, and Steve is, at that moment, not sure of the answer. Steve acknowledges the value of the question and, by his comment, encourages the student to ask more questions. He implies that such questions are very desirable. This affirmation is interesting in comparison to Paul's angst about not affirming students even when their answers are totally wrong. Rather than correct the student's facts, especially in an introductory lesson, Paul ignored the incorrect statement. In all the hours I spent observing my participants in the classroom, I never heard one of them tell a student that a response was wrong or incorrect. This is a significant finding in light of

Gilligan's (1982) work, which claimed that women define themselves in terms of relationships, but men "radiate the confidence of certain truth" (p. 160). The men in this study showed themselves to be protective of their students' egos in the classroom context. This affirms Thorne's (1993) contention that stereotypical gender statements can be a dangerous oversimplification. Relational caring may be a trait that researchers such as Gilligan (1982) and Belenkey, et.al. (1986) attribute to women. However, in the context of male teachers in the classroom, the men in this study can and do value their relationships with their students and act in ways to protect those relationships. They endeavor to establish a learning environment in the classroom that concentrates on the positive aspects of students' contributions. Hebert (2000) linked this same type of empathy to a strong belief in self. He stated that his participants' "belief in self appeared to involve a sincere and caring quality" (p. 28). These men are combining the stereotypical male characteristic of self-assurance with the stereotypically female characteristic of caring.

Sociability

All of the participants in this study expressed an admiration for teachers, especially science teachers, who like their students and care about them. This became a personal priority for their teaching. Steve made a point of joking with students especially during recess, calling them pet names like "Buddy" and asking if they would like a "Fear Factor" type game with the crickets in the ecotubes.

Glenn scheduled kickball games every Friday with his students during recess for the sheer fun involved. Donald summed it up:

BH: What do you really like about the classroom

Donald: Being with the kids. Teaching the kids. It's the interaction with the kids that I enjoy the most.

BH: You like the active aspect?

Donald: Yes. I couldn't sit at a desk for eight hours. I would get in trouble for talking to the next people or something. (Laughs.)(Interview 4/24/02)

Enjoying the interactions with children in the classroom was expressed not only by the participants in my study, but by those in Sargent's (2001) study of primary elementary male teachers. One of them maintained, "But I always say that my joy is here with the kids" (p. 100). It is a powerful statement to say that you enjoy your work and the people that you work with.

The teaching of science involves many typical teacher/student interactions, such as large group teacher-led discussion and one-on-one conversations. Hands-on science experiences, however, consist of small student groups working together to construct an objective entity with the purpose to observe and understand it. Teachers interact with these small groups, offering advice on the experimental construction and drawing out student knowledge so that they can draw conclusions. These interactions have a free-flowing aspect that defies strict control. The teacher who enjoys interacting with students as individuals has several advantages in hands-on experiences: (1) This teacher will seek out situations to interact with student because he enjoys them, (2) The teacher's attitude will encourage open discussion with students, and (3) As a part

of the small group discussion, the teacher will value interactions with students, even if there is a certain level of noise in the classroom. When students in the classrooms I observed worked in groups, I circulated around the room. I was amazed at how the students concentrated on their tasks and did not use the time to converse about other subjects. They were thoroughly engaged in their tasks. This total involvement of the students gave the interns the opportunity to concentrate on the students' understandings of their work. The teacher interns used this time to circulate and probe for understanding, as this example shows:

Steve (to one student group): What's in the aquarium now?

S₁: Duckweed.

Steve: What is it? Describe it.

S₁: It's green. It has no smell. It looks like a seed.

Steve: Good job! It is a plant. What else can you say about what's in the aquarium?

S₂: The elodea smell stinky and are dark green.

Steve: So elodea is a dark green plant. Why do we need these plants?

S₂: So fish can breathe.

Steve: Why else?

S₃: As food for the fish.

Steve: Yes, we won't feed the fish in the aquariums. (field notes 4/17/02)

Glenn also interacted with the students to propose some new experiments:

S₁: The snails don't seem to be moving.

Glenn: Now that would be interesting to study. How could we study that?

S₁: We could measure how much it moves.

Glenn: What else would we need to know?

S₂: We need to know the time.

Glenn: Yes. We could mark a line where it starts and stops and then measure how far. Maybe next week, we will do that and figure how fast the snails go. How much time do you think it would take for the snail to move one inch?

S₁: One minute.

S₂: Two minutes.

Glenn: We'll try 1 or 2 or maybe even 5 or 10 minutes and figure how far it goes in miles. How many feet in a mile?

S (several): 5280

Glenn: Yes, and we can figure the number of miles. (field notes, 4/26/02)

Glenn used the student question to teach a new concept – speed and its relationship to distance and time. He took the opportunity to enrich a small number of students. Glenn clearly enjoys both the social and the intellectual stimulus of student/teacher interaction.

The social milieu of an elementary classroom influences the learning that occurs. This is especially true of science. Lynch (2000) contends that “If the classroom seems unfriendly or ill-structured, then the knowing, doing, and talking science critical to students’ restructuring of knowledge seems less likely to occur” (p. 197). The men in this study enjoyed the social interactions in the classroom and this translated into an atmosphere in which more science learning happened.

Relaxed Attitude

In one lesson I observed, Donald had to rescue a fish that had been dropped and a cricket that escaped. These two incidents were a result of the children being so enthusiastic about the animals that they could hardly stand or sit still. Donald matter-of-factly helped the students and did not berate them. He did mention to the students that they should try to stay calm so that the animals would not be hurt. After these incidents, he commented to me, “I am glad to see how excited they are” (field notes, 4/18/02). This shows a certain relaxed attitude and an acceptance of children’s behavior that is simply a part of being children.

Glenn recognized this relaxed attitude in himself and implied that its expression was a conscious decision:

Glenn : I can be relaxed about just about anything, not just science. I'm a very take it as it comes, cross that bridge when we come to it, kind of guy. I try not to get uptight because it makes me nervous. And then I get edgy and nobody likes edgy teachers. (Interview 5/10/02)

I believe that there are several sources for this easy manner that I observed. One connection can be made to the age and maturity of the participants in this study. These men are not typical college seniors—they range in age from 23 to 26. They have a certain level of maturity that one would not expect of student teachers. Also, several of them, specifically Glenn, Donald and Paul, had considerable prior experience working with groups of children. Most of my observations of their classroom teaching took place after they had spent several months in the classroom. Whatever, the cause, not one of the five appeared anxious or nonplussed even when things spilled, children asked perplexing questions, or unexpected people entered the classroom. I observed one of Josh's classes when a university observer came to evaluate and Josh hardly appeared to notice her presence. On another occasion, I observed Steve when his mentor teacher changed his whole science lesson at the last minute. Like Josh, Steve acted calm and in control the whole time. This trait should serve them well teaching science, especially hands-on science, which is sure to have its unpredictable moments.

Academic Influences

Influence of College Science Courses

As I examined interviews and journals and field notes, it fascinated me how few times the participants in my study referred to their academic lives. Certainly, Steve mentioned two college professors who made science fun and who did “live experiments” (interview, 4/17/02), but he never mentioned anything he learned in the courses. Not once did he refer to any facts or concepts that helped him in the classroom teaching nor did I hear him refer to his students about anything he learned in any science class. Glenn, also, referred to his biology classes only in his history. He mentioned a chemistry course that was, “general, real watered down stuff” (interview, 5/10/02). When he talked about biology as a field of study or what he knew about it, it was most often in the context of his work in a laboratory. Donald said he was comfortable with the field of ecology because he maintained an aquarium, not because he studied it in any biology course, although he took a course in environmental science in both high school and at the community college. Likewise, Paul took a course in environmental biology in college, but when discussing ecology in his fourth grade class, referred to the effects of acid rain that he had observed on a trip to New York state. Josh believed that none of the science that he had ever studied made any sense to him. This is puzzling, since at least four of these men claim and exhibit a certain love for science. This may be related to the way that science is taught in the typical university class, as Steve pointed out.

BH: Do you think that your actual science teaching here was influenced by any courses that you took at either this university or the community college?

Steve: I think that at the community college, but not at the university, because the university classes are primarily lecture hall with about 500 people. (interview, 4/29/02)

Since all of them remember things that they actively did in some of these classes, this speaks to how science courses for teachers might be more effectively designed. Information that is acquired from the printed page or from the lecture format does not seem as accessible for ready use as information that is acquired in more notable circumstances. As Glenn emphatically stated, "You don't learn science from a book" (interview, 4/15/02).

Influence of the Science Methods Course

The response was similar when they discussed what they learned in the Science Methods class. However, since I was present in that class, I know that lessons from the class were applied. Donald designed a lesson about fair tests that was suggested by the Science Methods instructor, as did Paul. The Science Methods instructor stressed the value of hands-on experiences, which all of my participants enthusiastically hailed as the most effective way to teach science. Perhaps they had come to this conclusion earlier and independently, but they never mentioned the Science Methods class when they discussed the value of laboratory experiences in science. It is possible that they assimilated some of the information, but did not directly mention what they learned unless asked. I did question them about some of the types of lessons that were introduced in the

Science Methods course. One lesson, in particular, involved unstructured experimentation in which each group was given a box of equipment and allowed free discovery time. For example, one box contained chromatography paper, markers, various dyes and some glassware. There were no instructions given. The way that this played out in the Science Methods course was that someone in the group recognized equipment due to past experience and told the rest how to do the experiment. When I asked the participants in my study about this particular exercise, and they had differing opinions.

Glenn: I remember the boxes that Ms. Zimmer brought in. We did the chromatography. That was probably the only thing that I picked up from her course. I liked the way she structured her labs, and I'm going to steal that. I'm going to steal those boxes of just stuff and letting them play around with certain things. Nothing they could get in trouble with.

BH: Which is a very different mode than what you're doing now.

Glenn: I prefer discovery over telling them. But with certain things, say with these ecotubes, we have limited resources. We can't just let them play, because if it doesn't work, we can't do anything with it. And if you break it, it's gone. I let them do quite a bit of exploring when we had the batteries and the lights and the wire. We had tons of that stuff, so if they messed up a couple, it didn't matter.

BH: Did that work well with them?

Glenn: They know it better. (interview, 5/10/02)

Unlike Glenn, Paul believed that little from the Science Methods course was practically usable.

BH: Has your actual science teaching been influenced by anything that you learned at the university in science classes or science methods?

Paul: (Pauses a long time.) I guess I've picked up things from everywhere. I guess we did something about observation in methods. But I would say, right now, directly, no. We did do a science investigation and work with the kids on the process. We are doing observations in here. But anything directly, no.

BH: One thing I was thinking about was when she brought in these boxes and she didn't tell you anything about them- one had chromatography and one had rocks. And you had to figure out what to do with all the stuff.

When you're doing it with kids, would you prefer to do it they way these are-more directed- or would you prefer a box and the freedom of that?

Paul: I'd definitely set up lessons so that there is more investigation. I think that with this unit right now, I wouldn't just hand them these things, because you have live materials so if you mess it up.... And then there is time. It's too much time to have to replant and regrow things. The things that I want them to see are more important than them investigating that by themselves. I do, like in math, I'll give them say different shapes – We did a rectangle and square investigation and they had to write down things that we were observing from them and what we know about them. But for this unit, no, I have not. (interview, 5/1/02)

Like Paul, Donald had second thoughts about the value of really free type of discovery, especially for his age group:

BH: Do you remember Ms. Zimmer's boxes where you did whatever you wanted with what was in the box? What did you think of that idea as compared to these boxes where students are told more what to do. Which do you prefer?

Donald: It depends definitely on the age group and the objectives....For this age group, I think that giving them step-by step what you need to do is the most organized way to do it because, as you could see, I was getting flustered as it was, with some of them. (Laughs) Maybe more kid-friendly versions of what she had because what she had was more what I could see doing in middle school as opposed to fourth grade.

BH: They would have to have a little background because...

Donald: Right! When we did it that day, I was like "I don't know what to do with this." So I had to rely on some others that had some background.

BH: So you would have been more comfortable with some background knowledge.

Donald: Right. Then again, kids can be very creative.

These responses show that these men were processing the teaching options presented in the Science Methods class and evaluating whether to incorporate or reject these techniques. Some ideas were incorporated, but it seems that they were few. The science education literature supports this finding. Cronin-Jones

and Shaw (1992) found that preservice elementary teachers' beliefs about science teaching did not change after completion of a science teaching methods course. Furthermore, Marion, Hewson, Tabachnick and Blomker (1998) concluded that science methods courses may increase awareness of certain science teaching techniques, but may not result in a change of actual teaching practices. It is important to emphasize that the scope of my study extends only through the completion of the student teaching internship. The science that these men were required to teach in elementary school was provided in a box. This kind of experience did not afford much opportunity to incorporate ideas from their Science Methods course. When they have more control and independence in their own classrooms, these men may find occasion to use the resources suggested by their science methods instructor.

Personal Experiences

Experience with children

Experience with children in some kind of setting was a factor in most of these men's decisions to become a teacher and probably contributed to the relaxed attitude around children that I observed in most of them. Glenn had experience with children doing educational outreach for a science laboratory where he worked. He enjoyed it so much more than the laboratory work that he was motivated to try teaching as a career. Glenn spent several summers while he was in college working with grades K-8 programs in the county where he lives (interview, 4/15). Paul had taught gymnastics. He had also helped his mother

when she ran a daycare facility out of the home and when she was an assistant in an elementary class. Donald had worked in a daycare center for five years. He mentioned that he really enjoyed that experience and felt it was an influence on his decision to become a teacher. Josh decided to teach after being successful as a tutor of college students. It is a striking and fairly recent development that some public high schools in the participants' school district offer a course in child development that can be taken to fulfill a Practical Arts requirement. As part of this course, high school students could work in a day-care facility connected with the high school. Both Steve and Donald took this course and mentioned that it was fun. It also helped them meet student service hours required by the state for graduation. This kind of experience served to introduce the concept that working with children was something that they could do successfully. As Donald stated:

Donald: When I was a kid, I didn't know that men could be teachers. So I would never have guessed it back then, that I would become one. Never in a million years...

BH: You didn't think of it as an option until later?

Donald: Yes. Not until I graduated high school did I even think of it. I briefly thought of it as a senior because I took Child Development. Even, then, in my Child Development class, I was one of three guys in thirty students. (interview, 5/13/02)

After these men had some experience with teaching children in either a formal or informal setting, they entertained the notion of becoming teachers. I believe that this conclusion was based on their success in interacting with children in these settings.

Sargent (2001) also described his participants as coming to teaching after they discover that “children are not so bad after all” (p. 370). Perhaps one of the reasons that, historically, there have been few male elementary teachers is males’ lack of experiences with any kind of children’s scholastic or extracurricular programs. If this is true, then encouraging this type of experience through service requirements or courses in school could open up new horizons for young men as they consider possible careers.

Influence of Science-Related Jobs

Of all the participants in this study, only Glenn had held a science-related job. He had worked in a laboratory for several years to help pay his way through college. His emphasis on the scientific method, his familiarity with the tools of science such as a spectrophotometer, and his view of science as a discipline that uniquely seeks truth are all related to this practical experience and his exposure to working scientists. Glenn’s passion about his school’s science fair and his drive to help his students understand the meaning and method of science fair experiments is probably also closely related to his laboratory work. This experience gave Glenn an almost intuitive understanding of the world of science because he had lived and worked in that world.

Avocations

Each individual has his own history, the events of the past that influence the future; he has his own personality, a combination of nature and nurture; and he has his own intellect, the interactions of his mind with his world and his public

academic pursuits. A person's avocations represent an intersection of all of these factors because what a person chooses to do with time that is his own reveals what he truly values. Avocations are personal preferences, and avocations emerged from the data of my research as a persistent theme.

Glenn's avocations are hiking, biking, fishing, rock collecting, amateur astronomy, and bow hunting. Each hobby that Glenn related to me takes place outdoors and each is noncompetitive. Some, like fishing and bow hunting, involved groups of participants, usually male groups. Glenn told animated stories of fishing with his "brothers" [fraternity brothers] and bow hunting from a boat for carp. Glenn also spent large quantities of time pursuing his hobbies in solitude. Although Glenn characterizes himself as a "people person", he clearly enjoys being alone if he is pursuing his avocations. Glenn has an almost insatiable curiosity about the natural world. He mentioned collecting anthracite, schist, lignite, fossils and garnets. Like most people, Glenn enjoys sharing his enthusiasms. One way of doing this as a teacher is to show students personal collections.

Glenn: I passed around a fossil – a perfect fossil of a fern in a piece of coal. And I had anthracite and a piece of charcoal – bituminous. We compared the weights of them looking at the charcoal. And it's a huge piece of rock, but so light, and I tried to tell them that it's just plant matter. This was from a swamp millions of years ago. (interview, 4/15/02)

Glenn shared his coal specimens, and he shared the knowledge that he had acquired about them. He did the same and more with his schist.

Glenn: I have a massive collection of stuff I've found just around. My fiancee constantly complains every time I take a walk, I find a new rock. And when I ride my mountain bike, there are outcroppings of schist which you can find garnets in. You just chip away the schist, and there are garnets. They're too soft; they're not gem quality. So they're worthless, but they are cool for fourth graders. They all got a sample of that, they got to pick through it and find the garnets in it and take the garnets home.
(interview, 4/15/02)

Not only did Glenn allow the children to observe the garnets, but they handled and studied them, and ultimately got to keep them. This is not the stuff of ordinary science lessons—the everyday material that has to be mastered. This is something to be excited about. When Glenn brought his collections into the classroom, he shared his passions with them; this is very powerful teaching.

Glenn used his knowledge of rocks to introduce activities that the designed kits did not include.

Glenn: I really loved the rock unit. I love geology. I know a lot about it and have my own collection of rocks.

BH: Would that unit have been as good if you hadn't had those?

Glenn: In my opinion, no.

BH: What did you think of the box itself for that?

Glenn: At first I was really impressed. They had granite and every rock contained in granite. Plus they had samples of calcite, sample of this and that. I was impressed with the array, but I wasn't quite as impressed with what they did with it. You look at it, describe it. Is it black or white or shiny. They didn't go into luster, they didn't go into texture. They didn't explain Moh's hardness. It didn't explain why. Why is diamond the hardest? Why is talc the softest?

BH: You're saying it did NOT explain those?

Glenn: It didn't, but I did. (interview, 5/10/02)

Glenn also described taking his class to the computer lab to research a NASA flyover:

Glenn: We were in here researching a NASA website for fly-overs. The other night at 8:48 and 8:49, a national space station flew over our area with a space shuttle in tow. They went up right across the horizon. They tracked a perfect arc – I had my telescope out at night and I watched this perfect... at first it was really cloudy and there was a break in the clouds and I could see the space station and the shuttle go right by. It was so cool.

BH: Was it just your class that did that or did other classes do it too?

Glenn: It was just me. Just because I'm an astronomy buff. (interview, 4/23/02)

This experience of actually watching the space station fly over gave Glenn information to share with the class that he would otherwise not have possessed. Unlike the fossil imprints and the garnets in schist, Glenn could not include the fly-over in a science lesson because the science curriculum for the year included only rocks, electricity and ecosystems. However, he could and did include it as part of an internet resources activity. Glenn seized opportunities to expose the students to his avocations.

Glenn himself ties his hobbies to his past and to his personality.

BH: Do you think many of these kids spend time like that? Like you were talking about tromping through the woods, and seeing all these things and knowing all the plants. Do you think many of these kids have that opportunity.

Glenn: Some of them do and some of them don't know a stream from a river. They couldn't tell a creek if they were standing in it. Other ones are as bad or worse than I. I was one of those kids that if it was sunny, I was outside. If it was rainy, I was inside wishing I was outside. My mother would lock the door so I wouldn't go out and play in the mud. I would come back covered head to toe in mud. (interview, 4/23/02)

Glenn connects the man he is today with the child he was. Glenn's views of science are clearly colored by his hours spent outdoors both as a child and a man.

Not only do Glenn's avocations bring him experiences that are not ordinary, but they expose him to knowledge that is experiential and not typical school knowledge. It is one thing to memorize classifications that are required for a high school or college course, but knowledge one pursues of one's own accord because one values that knowledge is distinct—more highly esteemed and less easily discarded.

Glenn: ...I can do (identify) the various things around here--deciduous trees, coniferous trees, all that just from field guides. I take a pocket guide with me when I hike. I couldn't tell you a yellow-bellied warbler from a sparrow, but I can recognize arrowhead and mayflies - indicator species and stuff that I've studied I know. Otherwise, it's well, "Hey, that's a good climbing tree" and I can tell a sycamore. (interview, 4/23/02)

Glenn's avocations make him a richer person and they give him more to share with his students in the science classroom. His avocations help to shape his view of science as a certain way of looking at the world, a way that cannot be learned from a book. Glenn knows that his knowledge of science is not a finished package, but it is continuously evolving and continuously growing. Every time that Glenn hikes, bikes, fishes or looks at the stars, he adds to his scientific knowledge. This experience of knowledge building gives him confidence that his students can and will learn in the same way. Hands-on activities may be slower

and it may not always be evident that students are learning, but Glenn's personal experiences assure him that his students' science knowledge will also burgeon.

Glenn's avocations are consistent with his academic interests; so consistent that teasing avocation apart from vocation is difficult. However, several of the other participants in this study, also had science related hobbies even though their academic leanings were not scientific. Like Glenn, they used the opportunities thatthey had to share them with their students.

Steve also professed a great enthusiasm for being outdoors. When asked about his hobbies, he replied, "I love nature. I especially like rocks and insects. It's kind of corny but..." (interview, 5/13/02). He recalled bringing in some rocks to illustrate a lesson in the unit about rocks and minerals:

Steve: In the fall, I brought in five rocks that I got. I hiked on Mt. Rainier in Washington. I brought in four or five rocks that I collected on that trip with my grandparents.

BH: Were the kids interested in this stuff that you brought in?

Steve: Oh, yes! They liked it because it wasn't something that you could find around here. I had some great igneous rocks and you could tell they were igneous rocks. I had pieces that looked black like lava. So they really enjoyed that. (interview, 5/13/02)

Steve gives particular value to his personal collection of rocks because they originated outside the everyday geographic experience of the students.

Inspired by an enthusiastic teacher in the community college, Steve became intrigued with astronomy.

Steve: ...And I went out and got a huge telescope. Well, actually, my dad went out and got it. We would go out looking at stars. We would go out in the summer and drive to Pennsylvania and go star watching. (interview, 4/29/02)

Sharing astronomy was problematic for Steve. Like Glenn, his fourth grade class did not include astronomy in its science curriculum but, unlike Glenn, Steve could not find a way to include astronomy under some other guise. He voiced his frustration with this situation several times and vowed that when he had his own class, “I will definitely teach them astronomy” (interview, 4/29/02).

Steve’s involvement in outdoor activities began in his youth.

Steve: ...I went to Brigade – I’m not sure of the name—but it was at my church. Yes, I believe it was Brigade.

BH: You did badge type things? The car races?

Steve: Yes, we did that.

BH: Did they go camping?

Steve: Yes, all that. (interview, 5/13/02)

Steve played, and at one time in his life, competed in football, baseball and swimming.

Like, Steve and Glenn, Donald pursued a science-related avocation, one he shared with his younger brother—maintaining aquariums, especially salt water aquariums. Donald felt that this experience added to both his enjoyment of and background knowledge about the ecosystem unit:

Donald: The ecosystem thing is cool for me because I’ve always liked that kind of stuff. I have fish tanks at home, so that’s something I have a fair amount of experience with.

BH: Oh, my dad always had fish tanks. What do you have?

Donald: I have a salt water tank with two salt water fish. And my brother, which I help him take care of, has a 30-gallon tank with piranhas in it. (interview, 4/17/02)

Like Glenn and Steve, Donald used his avocational knowledge to advance his work in the classroom. He brought in dechlorination drops from his home aquariums to purify the water that his students used in their ecosystems. This knowledge gave him some insight in preserving the lives of the fish and other organisms in the student aquariums. Some participants, who used tap water in the aquariums without allowing the water to stand for at least 24 hours, lost guppies early on in the experiments probably due to chlorine poisoning. As mentioned before in a comment by Steve, science experiments can have complicating factors, even when the experiments seem straightforward. Teacher experience with related systems can be crucial to the success of the experiment.

Donald used experiences from his aquarium to illustrate concepts introduced in the readings. One science lesson that I observed involved a reading about crickets that was included in the kit. After some discussion about the exoskeletons on creatures like crickets and lobsters, the reading introduced molting as a shedding process that allows an isopod to grow larger.

Donald: What is molting?

Student₈: Sheds the exoskeleton.

Donald: I had a crab once in my aquarium. I thought it was dead so I threw it away. The next night I saw the crab in my tank. Why? It didn't climb back from the garbage.

Student₉: It shed its skeleton.

Donald: Right. (field notes, 5/2/02)

Still another time, Donald enhanced a reading lesson with some of his childhood play experiences:

S₁girl reads paragraph about baby isopods.

Donald: Who will tell me, how you know they were pregnant? How did they look?

S₂girl: Ours had babies. They were white.

Donald: White! Why?

S₂girl: They are babies.

Donald: Yes. They don't have an exoskeleton yet. Why haven't some of you seen your isopods curl up?

S₃boy: No enemy nearby.

Donald: Yes. When I was a kid we played with isopods and poked at them until they curled up. Now we will read the article about crickets.
(field notes, 5/2/02)

Donald is using his personal experience to help his students apply the knowledge from the reading to other areas. Students then understand that science knowledge can be applicable to everyday life, especially, in this case, to organisms that may occupy their world.

Donald also mentioned reading and gardening as hobbies.

Neither Paul nor Josh ever talked about any science-related avocations.

Paul mentioned that he had competed as a gymnast and also mentioned to me seeing forests in New York and Ohio polluted by acid rain. Although he did not allude to this directly in class, Paul did say that this pollution motivated him to impress man's responsibility for the environment on his students. Josh had been very involved with drama productions in high school. I have already mentioned Josh's lively poetry lessons and references to Shakespeare. His interests did give him something to share with the class, but it was not applicable to science class. I believe that Josh's experience teaching the butterfly unit did spark some interest in Josh about the science of insects. His lack of interest in science is consistent with his lack of avocational exposure to science.

It appears that knowledge gained from avocations has a particular value for the teacher. This knowledge is not something that is memorized and lost, but it is knowledge that is acquired because of interest and has tremendous longevity. When these men talk about their avocations, they do so with great enthusiasm. They seem to be literally sharing a part of themselves. Their avocational interests have a high value and sharing those interests with others is important. They are confident of the information that they have acquired from avocations.

Table 5. Participants' avocations

Name	Avocation(s)
Glenn Adams	<ul style="list-style-type: none">• hiking• biking• fishing• rock collecting• amateur astronomy• bow hunting
Paul Costanzo	<ul style="list-style-type: none">• gymnastics
Donald Green	<ul style="list-style-type: none">• aquariums• gardening• reading
Josh Jones	<ul style="list-style-type: none">• acting
Steve Smith	<ul style="list-style-type: none">• amateur astronomy• rock collecting• hiking• sports—football, baseball and swimming

Summary

In this chapter, I have analyzed the factors that influenced my participants' views of science, science learning, and science teaching. The emerging,

contributing factors to these understandings fell into four major groups including personal influences, academic influences, past experiences and avocational interests. Personal influences included their basic personality and attitude towards life. Four of the five participants have an exceptionally positive attitude about life in general and teaching in particular. These men want to enjoy teaching and they want their students to enjoy learning. They view science, in particular, as a vehicle for bringing fun into the classroom. Even Josh, who did not enjoy science in general, recognized that some aspects of science such as the butterfly releasing ceremony could be fun. Another personal characteristic that these men have in common is a level of self-confidence that allows them to attempt new things, to realize that they can learn from failure, and to admit to their students that teachers do not have all the answers. The final personal characteristic that these men share is that they are outgoing enough to enjoy the personal interactions with their students at some level and to encourage questions and small group discussions.

The second major influence on their understandings of science and the teaching of science relates to their academic careers. College science courses seemed to be relatively uninfluential except perhaps as a motivator for pursuing new avocations. The men in this study tended to attribute most knowledge acquisition to sources outside the university. Pedagogical knowledge from the Science Methods course was used to teach science during the internship, but these men seemed to pick and choose only a few practical ideas for classroom use. They rejected some lesson ideas as irrelevant either to the age, equipment or time

restraints of their real classroom situations. They all, however, acknowledged the value of hands-on science experiences, which was emphasized in their Science Methods class.

Personal experiences were another significant influence on the understandings that these men held about science teaching. Personal experiences with children were notable, as most of them had either taught children in some type of extracurricular program or daycare, or tutored, or worked in a Child Development program as part of their high school service requirement. Only Glenn had experience working in a science-related occupation; that experience deeply influenced his understandings of how science is practiced and therefore how it should be taught.

The final influence on understanding of science and the teaching of science that was discussed in this chapter was the participants' hobbies which reflect personal interests and passions. Glenn, Steve and Donald all had science-related avocations that influenced their teaching of science. Glenn spends considerable time in the outdoors and has many specimens and experiences to share with his students. Steve wants to share with his students his interest in astronomy and did bring rocks from his personal collection for the rocks unit. Donald credited his knowledge of aquatic ecosystems to his experience with marine aquariums as a hobby. Acquiring knowledge as part of an avocation seemed to give this knowledge a remarkable staying power. It increased the

teacher interns' enthusiasm for teaching science and served as a vehicle in the classroom to underscore certain science learning with personal experience.

Chapter 7 Relationship Among Gender, Scientific Understanding, and Pedagogy

Introduction

The focus of this research project is male preservice elementary teachers as they progress through their student teaching internship. The intent of the project is to gain insight into their understandings of science and the teaching of science.

At this point in history, gender studies are common in the sociology, psychology, education, and science education literature. Psychologists like Gilligan (1982) and Belenky, et al. (1986) have added to our knowledge about general characteristics and patterns of behavior that are prominent among males or females. Feminist research legitimizes the voices of women in our culture and validates women's priorities, such as relationships and caring. However, this research can result in stereotypes about both women and men that ignore behaviors in both sexes that are outside the statistical norm. The result can be a static view of gender that relies on a polarized view of males and females. Thorne (1993) cautions that all stereotypes have exceptions and that there is something to be learned from the exceptions to the stereotypes if the researcher carefully

considers the context of behavior. Thorne explains, “We need, instead, to develop concepts that will help us grasp the diversity, overlap, contradictions, and ambiguities in the larger cultural field in which gender relations and the dynamics of power are constructed” (p. 108). Connell (1995) characterized much of the feminist literature as normative and inadequate because it “gives no grip on masculinity at the level of personality” (p. 70). Connell extends our view of gender from the static to the dynamic when he states, “That gender is not fixed in advance of social interaction, but is constructed in interaction, is an important theme in the sociology of gender” (p. 35). As the men in this study progressed through their student teaching experience, I believe that all of their actions were consistent with their own views of themselves as male teachers. I see this whole process as dynamic and evolving, and I believe that their views of themselves as male teachers will continue to evolve.

The purpose of this chapter is to interrelate context, practice, and personality of male preservice elementary teachers with the goal of finding the interactions of the student teacher’s gender with his understandings of science and the teaching of science.

The crucial elements of this research from a gender perspective are the facts that the participants are male and that they are engaged in interning as elementary schoolteachers, a career most commonly chosen by women. Kuhn’s classic work on science paradigms and their changes informs my choice of participants and the conditions of this study. Kuhn (1996) defines a paradigm as

“like an accepted judicial decision in the common law, it is an object for further articulation and specification under new or more stringent conditions ”(p. 23). In science, the paradigm is the theory. For example, chemists work within the atomic theory, which is the main framework of their discipline. In addition to providing the model, the paradigm also defines certain areas of study for the researcher. Kuhn specifies three specific areas of research defined by paradigms. The first research area is the class of facts that the paradigm has shown to be important. The second research area is the examination of facts that compare directly with predictions from the paradigm, and the third research area involves resolving the ambiguities of the paradigm. Most research is commonly done in the first area. Knowledge builds slowly as new facts confirm the paradigm. The paradigm is strong at its center, where confirmatory knowledge is growing. However, it is the work in the third research area at the edges of the paradigm that shows the weaknesses of the paradigm. If those weaknesses cannot be resolved within the paradigm, a paradigm shift may be necessary. Kuhn’s insights about paradigms are not only applicable to the world of physical science, but also to the world of social science. Kuhn informs this particular study in some notable aspects. The research conducted for this study is not at the center of the gender research paradigm because it examines males working in a predominantly female occupation. Elementary teachers are only 15% male; in the early grades K-3, only 2% of teachers are male (U. S. Bureau of Labor Statistics, 1998). These proportions have not significantly changed in 30 years. The five men in my study

are willing to enter an occupation where they will be a noticeable minority. Their choice of an atypical career is an enticement to examine them as they practice that career. What can be learned about male teachers in the classroom? How does that knowledge inform our understandings of males in general? Addressing the second question places this research at the edges, and not the center, of the gender paradigm.

Understandings of Science

Kelly (1985) argues that in our society, science is viewed as masculine in the sense that the packaging of science and its participants is male. Kelly maintains that the scientific worldview is essentially a male worldview. This statement about worldview invites clarification. The prevailing worldview of science is predominantly the empirical worldview espoused in logical positivism. Logical positivism recognizes only sense perception and the analytical principle of logic as valid sources of knowledge (McGrath, 1999). The scientist, in that system, is “a dispassionate, wholly objective and rational explorer of a world that is knowable through observation and logic” (Lynch, 2000, p. 70). This scientist is also one who works primarily alone. In contrast to this solitary and objective stance is the relatedness and subjective stance assumed by the women in both Gilligan (1982) and Belenky, et al. (1986). It is undeniable that the milieu of science is changing and that the social aspects of the scientific enterprise are being emphasized today more than ever before. Kuhn (1996), in a postscript to his groundbreaking work, emphasized the importance of the scientific

community, which he describes as “men uniquely responsible for the pursuit of a set of shared goals, including the training of their successors” (p. 177). As Kuhn describes a change in the view of scientific truth, he also shows the beginnings of a shift from the emphasis on solitary science to scientific community. This shift continues in the American Association for the Advancement of Science document Science for All Americans (1989) which maintains that science is “a complex social activity” (p. 8). However, in spite of these changes, the traditional view of science as an objective, empirical, and impersonal discipline is still the prevalent view among both scientists in particular, and society in general.

A consideration of the intersection of the gender of the five men in this study with their beliefs and understandings of science would seem imperative at this juncture, helping to lay the foundation for their understandings of the teaching of science.

Of the five participants, both Glenn and Josh maintain most adamantly that science consists of cold, hard facts. Glenn, the man in this study who loves science, and Josh, the man who does not like science, share some common philosophical ground. Glenn emphatically stated, “Science is the analytical study of everything” (interview, 5/10/02) and “Science and art are just bipolar” (interview, 5/10/02). Guided by the scientific method, Glenn sees the scientist as working largely in solitude. This is one characteristic of scientific labor that caused Glenn to reevaluate his interest in a scientific career. “I used to want to work in a lab, have my own little hidey hole...” (interview, 4/15/02). The fact

that he was “a people person” drove Glenn from the laboratory to the classroom. Glenn is torn by his love of science, which is an intrinsic part of his personality and his belief that the work of a scientist is not work that he would enjoy. Of all the participants in this study, Glenn has the greatest experience with the working world of science. He pursued a biology major for several years of his college career, and he worked in a laboratory for several years during the summer and part-time during the school year. Glenn adheres to the masculine world-view of science that Kelly (1985) describes, and, although he embraces science as an avocation, he rejects it, at least at present, as a vocation.

Josh’s view of science is complicated by his dislike of science as a discipline, but his understandings of science in the classroom are clear. He describes his lessons on insects this way, “Yes, there’s cold, hard facts about stuff that you really can’t get away from....To tell you the truth, there’s not much subjectiveness really involved in it” (interview, 5/3/02). Josh’s experiences with science have been limited to the classroom, but he, too, has this objective, masculine worldview that both Kelly (1985) and Lynch (2000) describe. Josh dislikes the “lack of feeling” (field notes, 3/18/02) in nonfiction and personally finds it boring. He is not attracted to the subject matter of science like Glenn is. Josh never describes any exciting science class in the enthusiastic terms that Glenn did. Josh’s disenchantment with science has been inculcated through years of science classes that never touched his imagination. And yet, his view of the nature of science is very similar to Glenn’s.

The other three participants in this study approach science less from its intrinsic nature and more from its application. Paul, Steve and Donald all emphasized the practical aspects of science when talking about it as a discipline. Steve views the application of science, particularly the problem solving aspects, as important. All emphasized the importance of human impact on the environment as one of the main learning objectives of the unit on ecosystems.

This aspect of human responsibility resonates with the science-technology-society emphasis that has been prevalent in school science for several decades and has been a part of our culture since Rachel Carson. Teaching science from the science-technology-society perspective focuses students on issues necessary for good citizenship (Bybee, 1993). The National Science Education Standards (1996) incorporate the science-technology-society theme and state, “Central ideals related to health, populations, resources, and environments provide the foundation for students’ eventual understandings and actions as citizens” (p. 139). Clearly, Paul, Steve and Donald are not viewing science as an abstract collection of facts, but as a discipline with applications in many areas of life.

If science is defined by its applications for these three men, especially within society, Steve, Donald and Paul are not viewing science as abstract and impersonal. They are not describing science as objective and disconnected. Their perception of the worldview of science is not the objective, impersonal, masculine one described by Lynch (2000). Their worldview is more social and relational.

Although they are men, they are not viewing science as masculine in the senses that Kelly (1985) delineates. This is evidence that idea of science as impersonal is evolving to a new paradigm of personal involvement, not only among scientific philosophers like Kuhn, nor only among scientists, but at the level of nonscientist, male, elementary teachers. Although I believe that I have accurately represented the view of science that these three men described to me, I believe that I must be cautious about what I read into it as regards their general view of all science disciplines. All three of these men were teaching a unit on ecosystems that emphasized the role of humans in the environment. It would be natural for them to stress that aspect to me when they described their thoughts about science. That said, Glenn, who has a more traditional, objective view of science, also taught this ecosystems unit and stressed other aspects of the unit, such as the relationships of the organisms in the ecocolumn to each other. Glenn did not allow his students to overestimate the effects of human pollution. In a lesson in which one student maintained that if people built a city in the river environment where the animals lived, then all the animals would die, Glenn elicited the qualification that only some of the animals would die. Clearly, Glenn is not given to hyperbole, even if that hyperbole conveys a good application. Although Paul, Donald, and Steve presented the facts of science in much the same manner as Glenn did, their lessons showed their commitment to the theme of human response. Steve proudly described how his students were “insightful” about the human effects of pollution and related how they spent over 20 minutes in a discussion in which they “talked

about how man upsets the ecosystem" (interview, 5/9/02). The persistence of the traditional "male" view of science that Kelly describes is truly in flux today. The National Institutes of Health in its recently published a new document, "The NIH Roadmap: Building Interdisciplinary Research Teams" (2004), stresses the future advantages of this cooperation:

By engaging seemingly unrelated disciplines, traditional gaps in terminology, approach and methodology also are gradually eliminated. With roadblocks to potential collaboration removed, a true meeting of minds can take place...

The solitary male view of science is changing. It is logical that some of the men in this study have other views of science that emphasize what science has to offer society and human responsibility. It is also logical that, at a time when views are evolving, some men, such as Glenn and Josh, still adhere somewhat to the older views.

The men in this study also have positive outlooks on the value of group work in science, at least in the classroom. In all the fourth grade classes, students worked in small groups for laboratory experiments and often on readings. Glenn, Donald and Steve spoke of dividing up the readings in the teacher guide, allocating the readings to small groups, and assigning the groups to outline the major points and present them. Steve had some opinions about the drawbacks of group work that are probably universally applicable. He described an assessment that required students to solve a problem in groups.

Steve: They worked together to do an experiment and then they had to write up different parts of the experiment. And I liked that because it

wasn't just a written test, but the problem was that some of them didn't do the experiment correctly. They didn't include the series circuit and the parallel circuit. So then they didn't...when they explained their answer, their answer lost credit because they didn't do the experiment part right.

BH: Why wasn't that correct?

Steve: What they had to do was, each person had to design with wires, a battery and two light bulbs, they had to make a parallel circuit. So the lights run in parallel to each other so that they can both use the electricity and if one's gone, it doesn't matter. And the series is just like one big circle. So the idea was to change the series circuit into a parallel circuit. And some of their ideas didn't work, and so some of the questions were explain your answer and how you did it. So some of them could not find a parallel circuit that worked.

BH: Had they made a parallel circuit before?

Steve: They had. What happened was each had to come up with their own idea—their own hypothesis. And they had to test it. Every table had one kid who got it at least, but they wouldn't listen to that kid. So then they didn't get a good grade. Tables 4 and 1, they got it. Everyone got As and Bs and they got it because they listened to the person who knew what they were doing. This table (he points) they fought the whole time. You know, they just fought. Ann, the girl that we were just talking about eating crickets, she had the right idea, but they didn't listen to her when she explained her idea... she explained what they did, and she explained what her idea was. She didn't go with their idea for the answers. She said, "Well, I thought my idea would work." So it was correct and she got about an 85, a B, but she didn't listen to them. They got like a 75. They didn't get a good grade. So it depended on who you listened to in your group. (interview, 4/17/02)

Steve describes a very human situation and a human conflict. In groups, the accepted leader or the majority may not always be right. Steve saw this interaction in terms of the students' grades, and he was dismayed about the low grades. On the other hand, it is probably true that each student learned something about group negotiations and trusting their own good judgment. Experiences like this help to prepare students for the world in general and even the world of scientists as that world is evolving. In spite of the drawbacks of group problem

solving, student groups were commonly used in these science classes for both hands-on laboratory work and reading presentations. Teaching science in this way shows that, at least in schools, science is often a group effort. It is not unreasonable for the student to assume that the work of the scientist, too, may include group effort.

Gender and the Teaching of Science

In his study of male elementary primary teachers, Sargent (2001), describes the distaste that male teachers in his study had for being assigned duties simply because they are males. These male teachers described being asked to do lifting, repairing, and maintenance of technical equipment, whether they volunteered to do these tasks or not. They responded with the same kind of dismay that many women in offices express when asked to be responsible for making coffee. Furthermore, like many minorities, the men in Sargent's study described feeling powerless to respond lest they be accused of whining.

The participants in my study did not report any kind of perceived discrimination due to the fact that they are male. Interestingly, all, except Josh, were assigned a role in teaching science early in their internship, some from the time they first entered the classroom in the fall. When talking about this, they approached it from a positive viewpoint:

After hearing about some of my other classmates who cannot do science in their classrooms, I feel very fortunate. My teacher has already let me help lead a lesson in science, and the whole team is excited about my love of science. (Glenn, journal 9/19/01)

I had a wonderful experience today. One of the fourth grade teachers was absent and I got to teach his science lesson. (Glenn, journal 10/14/01)

When I came into this classroom with my being the observing person, there wasn't as much science early in the year then there has been later on where there was me to do the science. So it was a load off Mrs. Allen. (Donald, Interview, 4/1/02)

I would expect Glenn to view any occasion for teaching science in his classroom as a golden opportunity. The second quote, however, reflects his response when asked to go the extra mile and take over science for a sick colleague. Glenn could have viewed this incident as a form of coercion or an imposition, but he did not. He also could have put little effort into this class, which was given to him with little notice so early in his internship. However, Glenn enthusiastically seized the opportunity and in his journal commented, "I had the entire class on the edge of their seats the entire lesson...I nailed it!" (journal, 10/4/01). Glenn chose to view this whole episode in terms of opportunity. In the very beginning of his internship, when everyone expected him to simply observe, he had the good fortune to be asked to do what he really wanted to do. Instead of feeling inconvenienced, he enthusiastically brought his best effort to bear.

In Donald's quote above, he chose to see the advantages to his mentor teacher of giving the science to him to do. The advantage to him, as he mentioned many times, was that he had the opportunity to teach a class that the students truly loved. This gave his early teaching tremendous positive momentum. The

advantage to the mentor was that she could concentrate her efforts in other subject areas. Donald did not say that his mentor gave him science to do because she doubted his ability to handle the important subjects like reading and mathematics. He also did not say that she gave him science to do because it was a less desirable or more time intensive subject to do, and so she handed it off to him. Instead, he concluded that it was good for him and good for his mentor that she assigned science to him.

Steve, mentioned that science became his subject to do in class, and, like Glenn and Donald, he looked at it positively:

Steve: Like, they didn't do much science while I was gone and I was gone for like two months.

BH: December and January?

Steve: Yes. They didn't do any science then. I wouldn't do that. I would do science as much as I could. I'd try to integrate reading and science and social studies. And I would do both of those every day if I could.

(interview, 4/29/02)

In this comment, Steve proudly advanced the idea that not much science was accomplished in his class if he was not there to do it. Steve sees his presence as more critical to science in the classroom than any other subject. He could have complained about having science dumped on him. He could have complained that if he weren't a man, science would not be dumped on him, but he did not. He did, however, point out the exceptional amount of work it takes to prepare for science.

Steve: Yes. And the preparation for science is a lot of work. I did that all by myself for each kit – I've done both kits. It's been a lot of work.

BH: Even with the kits, it's a lot of work?

Steve: Yes, even with the kits. (interview, 4/29/02)

Like Steve, Glenn was convinced that his presence in the classroom was crucial to science teaching. He maintained, “We’ll only have science when I am here” (interview, 4/23/02).

These men could have looked at the assignment of teaching science as a way for their mentors to slough off less important tasks to them. But they chose to view it as an advantage for themselves, their students and their mentors. They did not mention that they might have been given the task of teaching science because they were males nor did they ever attribute any action by their mentors or principals to the fact that they are male. In contrast to the participants in my study, one male teacher in a school came up to me and said, “Can I help your study? I am the only male teacher in the school, and I have achieved celebrity status.” My participants, however, never mentioned their gender as a cause for any good circumstances or any bad ones. Sargent (2001) reported data that so conflicts with the data of this study that it bears investigation. The men in his study disliked being singled out as male. They complained, “All the heavy stuff is stored in my room” (p. 88); “This morning I was asked to climb a ladder because I was a male” (p. 88); and “A lot of the women say, ‘Oh, I can’t do the technology, I can’t do the VCR, I can’t do this. High tech, that’s your guys’ area’” (p. 90). The men in Sargent’s study showed an aspect of being male in an elementary school that my participants were silent about. Why? There are several differences between Sargent’s study and this study. First, his participants

were established teachers and mine were teacher interns. Sargent's participants may have felt more free to speak out than my participants, who are still looking for their first teaching position. Second, Sargent is a male researcher and I am female. Men may feel more free to share some thoughts with men than women. Third, Sargent employed one focus group of six participants. Although he had only two sessions with six men, the group milieu may have eased restraints and opened the way for more open discussion. Finally, Sargent's participants are older and may have more or different experiences to draw on. Whatever the reason, our results differ and probably reflect the different contexts of our studies. It is also possible that the reason that the men in this study did not voice any perceived differences in treatment because they are male may be that they honestly did not feel any differences in treatment.

Gender and Avocations

A case has already been made in chapter 5 that hobbies or avocations inform us not only about the interior lives of these participants, but also illuminate the number and kinds of resources that these teacher interns bring into the classroom to enhance their teaching. Glenn shared his love of the outdoors, astronomy, amateur geology, and sports with his students. Specimens from his collections found their way into his science classes, information he had gathered made him a valuable resource for science fairs, and sports gave him a recreation to share with his students during recess. Donald used the knowledge gleaned from his own aquarium maintenance to guarantee the success of his ecocolumns

and as examples for the ecosystem discussions. He also used sports knowledge to devise a kickball experiment utilizing the term “fair test” or what scientists call controls. Paul used his love of the outdoors and ecology to entice his students into a sense of personal responsibility for the environment. Steve incorporated rocks from a camping trip into his lesson and longed to share his love of astronomy and telescopes. Josh shared his love of acting and Shakespeare to enhance his poetry unit. Avocations are a rich resource for teachers, and the knowledge attained from them is strongly held. The sharing of personal interests helps the student to see the teacher as more than just a teacher who gives out information from a book or guide.

Kahle and Lakes (1983) found that girls reported seeing fewer phenomena such as fish eating, ants working, or seeds sprouting than boys reported. Girls also had fewer opportunities to use scientific instruments such as a compass, balance or meter stick. Across all ages, girls reported less experience with the objects of physical science such as magnets, mirrors and electrical circuits. Kahle’s research did not address the reasons for this lack of experience, but since, in general, girls attend the same school classrooms as boys, the boys must have experiences outside of school. These experiences could occur in organized groups such as Boy Scouts, in non-structured situations, such as play with other boys, or from hobbies. In our culture, it is more common for men to pursue avocations such as fishing, hiking, model building, aquarium keeping, and collecting various kinds of specimens such as rocks and insects.

Any avocation gives a teacher resources to use in classroom teaching. However, hobbies such as reading or crafts do not have much application in the science classroom. The hobbies that are typically male, the hobbies that most of the participants in this study participate in, give them more resources to enhance their science classes. It is important to clarify that not all males are interested in sports or outdoor activities. In this study, Josh did not mention an interest in either of these. On the other hand, there are many women who are interested in avocations other than crafts or reading. More women participate in sports in high school and college now than in the past. The significant observation is that teachers who have avocations and many interests have more resources to share with their students and more examples to enhance their teaching. There is some intersection of gender and types of avocations, and some stereotypically male avocations give male elementary teachers more resources to bring into their science classes.

Perspectives on Teaching

When asked specifically about their experiences as male teachers in an elementary classroom, my participants addressed several classroom areas that they considered important to the discussion of male elementary teachers: (1) nurturing, (2) male atmosphere in a classroom, and (3) considerations that might affect their future in teachings.

Nurturing

Sargent (2001) in his study of male primary elementary teachers maintains that men are less capable than women of nurturing children. Steve wanted to avoid younger grades because of the limitations of younger children.

BH: So when you apply for a teaching job in the district, are you going to ask for fourth grade?

Steve: I like fourth. I asked for between 3rd and 5th. If it were second, I wouldn't be upset. But I would like to choose 3rd, 4th or 5th.

BH: Why would you choose those?

Steve: I enjoy the kids and the interaction level. They're not babies. They have their own mind and they're beginning to show their independence without your having to do it for them. Like modeling is fine, but they can actually write their own paragraphs....

BH: A unit like this with the science would be more difficult with young kids?

Steve: Yes. I wouldn't trust them with the water. I don't know, this is kind of, the age that I enjoy. I've been in a fifth grade and a third grade and I like this the most. (interview, 5/13/02)

Both Paul and Glenn also alluded to nurturing when they talked about the grades they would prefer to teach.

BH: I have noticed that most of my participants are doing upper elementary grades. Do you think that that would be something I might expect, that guys would tend to lean towards upper grades as opposed to first or second?

Paul: I think, yes, simply because I think that lower elementary teaching – kindergarten, first and second, I think that that requires a more, kind of nurturing person. And I don't think that guys are completely comfortable with that. I know that I don't want to deal with, you know, bathroom accidents and zipping pants and I don't want to deal with snotty noses.

BH: The kind of mothering aspects?

Paul: Yes (laughs) it kind of is. (interview, 5/8/02)

Paul sees the level of nurturing that younger children need as problematic.

Sargent (2001) described this same attitude in his study.

Men are inferior to their women peers in terms of their ability to openly nurture the children. This is not a trivial matter in the primary grades, where nurturing is a major component of teaching. Early education is strongly associated with motherhood. (p. 72)

Paul hopes by his choice of grade assignment to avoid mothering as much as possible. He does not view himself as a nurturing person by nature. He was the only one of the participants who ever mentioned a limitation in teaching that might be tied directly to his gender. Paul wants to avoid any kind of bathroom-related activity or any situation that requires zipping or fastening clothing. I am not sure that Paul believes that these activities are more risky because he is male, since he also mentions wanting to avoid “snotty noses” in the same sentence. They could be simply the merely unpleasant aspects of “mothering”.

Glenn, on the other hand, believes that he is totally capable of nurturing:

Glenn: ...I don't take snively stuff.

BH: Do you think that's typical of guys—they can't be...

Glenn: Oh, I can be very caring and sensitive.

BH: But not conned? I'm envisioning a kid coming up and crying “Mr. A. I couldn't...”

Glenn: Tears and stuff I understand. These guys are still kids. I completely understand and I can deal with that. (interview, 5/10/02)

Glenn, however, separates caring and sensitivity from mothering. As a male, he believes that he can be an understanding person, but that is different from his conception of mothering:

Glenn: ...I've always heard parents say that they are happy when their kid gets a male teacher in the elementary school, just because it's different. It exposes them to what the rest of life is going to be like. I am not his mother and I'm not mothering. You can ask any one of them. I am the scourge of the fourth grade. I can be mean. I have very high expectations and they have to perform. (interview 5/3/02)

Although Glenn believes that he is a caring male, he maintains that he can be strict and have high expectations. I think that Glenn is explaining exactly how far he is willing to go in taking on a sensitive role. He will understand that children are children, he will understand that they may have disappointments and cry, but he can be tough. In his mind, parents know that the world outside is not always an understanding world; it can be a demanding world. Both the parents and Glenn believe that a male teacher can uniquely help prepare children for that demanding world. Glenn has not said that women teachers cannot be demanding, but this demanding aspect is, for Glenn, the flip side of his understanding aspect. He maintains that both aspects have a necessary place in the classroom. He may be implying that male elementary teachers actually have an advantage in that they are more comfortable with making demands.

Josh, who was assigned to a second grade class for part of his internship, found it difficult to handle the nurturing needs of second graders. Josh did not explain it in terms of personally aiding the children with hygiene, but in terms of nurturing the personal needs of such young children.

BH: So are you getting used to these second graders?

Josh: Well, kind of. I don't really like second grade. They're very frustrating to me. A lot of the behavior stuff that isn't really bad behavior as much as it is that they are just little kids and they can't concentrate for so long on something. They can't get two directions at one time so I have to say everything to Johnny individually. I can't give directions and expect that he will do it. I will say just get in his face and just yell to him. I have to say, "Johnny have you taken this out?" and "Johnny, have you finished it? Have you finished all of it?" He isn't trying to be sneaky, he just...Well, it just doesn't occur to him.

BH: So if they put you in an elementary class, which grade would you prefer?

Josh: I would have to be in an upper grade. Fourth is the absolute lowest. (interview, 5/3/02)

Josh recognizes that second graders require a certain kind of patience and attention from a teacher that he cannot achieve. Josh believes that this is a function of the child's age, so he hopes to avoid these issues by teaching older children, particularly middle school aged students. Josh simply does not believe that he has the attributes necessary to deal with young children.

All of the participants in this study mentioned the positive relational qualities of teachers in their descriptions of a memorable science teacher. The ability to relate to students on their level, to like students as people, to be patient with students' needs for further explanations, and to enjoy interactions with students all figured strongly into their equation of good teaching. This contradicts the dualistic system of feminine and masculine traits set forth by Gilligan in which women value relationships and men do not. These men's constructions of masculinity and their role as male teachers clearly set a high value on good relationships with their students. Indeed, Glenn, Donald and Steve emphasized often that the students and their relationships with the students made teaching a viable career option. This is consistent with Connell's (1995) assertion that masculinity is interpreted at the personal level and that normative definitions of masculinity ignore personality.

Constructing a Classroom

Several of the participants in my study stressed that the classroom they hope to establish when they are on their own would look a little different from the classroom in which they did their student teaching.

BH: When you talk about having your own system, how would you start on your own?

Steve: For me, I'd be a little bit more friendly sometimes. A little less serious at certain times.

(Interruption by students.)

BH: So the atmosphere in a science class would be....

Steve: Hard work. I want my kids to work very hard. But I also want them to be able to enjoy it, too. I like the fact that we're so well-behaved in this class. It's great, but sometimes there's room for personality and what kids can do themselves being kids. Maybe just lighten the reins a little bit. (interview, 5/13/02)

This conversation bears a striking resemblance to the conversation with Glenn in the prior section. It speaks to opposing forces in the classroom. Glenn contrasted understanding and toughness, and Steve contrasted hard, serious work with fun. Both Glenn and Steve believe that these two antithetical qualities can coexist and that education will be better for it.

Glenn goes further than Steve to maintain that the male atmosphere in a classroom is a different kind of atmosphere. According to Glenn, male teachers can provide a uniquely male classroom.

BH: I thought it was interesting that you said that this one guy who wants to do first grade is really relaxed.

Glenn: Yeh. He has a six-foot cardboard cutout of a basketball player in his room and he will just stop and talk to the basketball player. It's like a ghost in the classroom and he'll just sit there and talk to the guy. He'll think aloud talking to the basketball player. It's not Shaq, it's Kareem Abdul Jabar. He'll say, "Kareem, what do you think about this? I

think..." And he's goes into it. You don't see that with...the sports and the male atmosphere. It makes the boys not be mothered, but be fathered. It's a different type of feeling. It's still the same care and respect and fulfilling needs and everything, but it's a different way of doing it. I think we need to have more guys in elementary school. (interview, 5/10/02)

In Glenn's ideal classroom, children can be nurtured in a fatherly way.

There is humor and a sense of play. Like the men in Hebert's (2000) study, Glenn supports the premise that male teachers are more comfortable with certain kinds of teaching atmospheres. The total feeling is different because the male teacher is not a female teacher. He is different. Glenn's believes that he brings two uncommon, but important things to the classroom. One is that he loves science and one is that he is a man.

The subject of male teachers as role models came up in some of our conversations about teaching. A male teacher can be a role model in two ways. He can model how a man should be and act and he can model that males can be teachers. Only Glenn discussed male teachers as role models in the first sense.

Glenn: Another way is just the whole role model idea. A lot of kids don't have role models and they really need them at the lower levels. And that's why I am elementary and not secondary. I could be happy in high school, just teaching my high school class doing chemistry or biology. But these guys in fourth grade need a real male role model. (interview, 5/10/02)

Glenn is optimistic enough to believe that he can truly influence the lives of the students in his classroom. As a man, he thinks that he can make a difference in the lives of the boys in his class, but here he does not state exactly how. Sargent (2001) described the men in his study as also being very ambiguous

about the exact nature of role models. Several of his participants said that being a male teacher meant that one is a role model. Sargent commented, “Statements such as this include little explanation or description. They simply say that being an adult male in contact with boys is what is needed and asked for” (p. 119).

When asked about being a male teacher role model, Glenn had more to say.

BH: So you’re thinking of it from your student’s point of view. You want to be a role model for them? Not that the males need a teacher role model to go into elementary teaching?

Glenn: Well, if you’re going to get males in the schools, you have to have males in the schools to attract them. You want my fourth grade boys to be teachers, you have to have males in the elementary school. Otherwise, it’s, no offense, but it’s woman’s work. What they see is that women do elementary and all the guys do upper level. (interview, 5/10/02)

Glenn is expressing the same importance of male teachers as teaching role models as the six men in Hebert’s (2000) study. Without males teaching in the elementary classroom, the male students will never view elementary teaching as a legitimate career choice for males. Donald also voiced the effects of a totally female elementary school experience on boys.

Donald: I think that a little boy might be more likely to look at their male teacher and say, “I want to be like that guy when I grow up” as opposed to a little boy saying, “I want to be like that woman” when you’re looking at it through the eyes of a kid. (interview, 5/13/02)

Both Glenn and Donald are putting forth the notion that men will not seek to do “women’s work.” They believe that boys need to see other men do the work

before they accept it as an option as an occupation. Donald mentioned his own reluctance to be a teacher:

Donald: ...I never had a male teacher until middle school. When I was a kid, I didn't know that men could be teachers. So I would never have guessed back then, that I would become one. Never in a million years.
(interview, 5/13/02)

It took working with children themselves and enjoying the work to convince both Glenn and Donald to become teachers.

Salary, Advancement, and Motivation to Remain

When asked what it would take to attract more men into teaching, all five of the participants mentioned money first. However, several of them immediately qualified that answer to say that there is more to life than money.

BH: We talked about getting more guys into teaching and you mentioned salary. Besides that, why do you think that we have only six guys in a class of 30 for el. ed.?

Steve: I'm not sure. I think that part of it must be money because men, you know life's expensive, and they want to be providers. I don't think there are a lot of people who care enough to sacrifice money and time to help other people by being a teacher. And then for men, people say, "You don't want to be a teacher." It's not prestigious. For me, money is not an issue. I couldn't care less about money. For me, one thing is people. That's one of the most important reasons why I want to be a teacher.
(interview, 5/13/02)

Steve speaks of his personal reasons to teach being more related to people than to money, but he does introduce the concept that, in his mind, men should provide for their families. Money, then, will always be part of the decision-making process for a man with a family because he has more people to consider

than himself. Glenn also mentioned his way of life. Since he planned to marry that year, resources and lifestyle were a part of his decision making.

Glenn: ...Basically, teaching is a volunteering position anyway. Hasn't kept me from it. As long as I can feed my family and live in a decent place. Well, compared to what I could be doing if I had gone into computers, but I can't sit and deal with that. (interview, 5/13/02)

In this statement, Glenn casts a look backwards at what he could earn if he had gone into computer work and has a moment of doubt. Then he focuses back on the present and recognizes that he cannot undo the choices he has made.

Paul also compared teacher wages to other occupations.

BH: My last question is that since only ten percent of elementary teachers are male, can you give me some ideas about what might encourage more guys to go into elementary teaching?

Paul: (Pauses) Honestly, I think as the salary goes up, more males would go into it if it were something they were interested in. Now, you can do something else and make so much more and you have to get down to that. You need to make a living....(interview, 5/8/02)

Money in terms of hourly wages was an issue for Donald.

BH: What do you think are the advantages of being a teacher?

Donald: Depending on how you look at it, the effects you can have on that many kids is a notion that is very rewarding. If you look at it that way. But I imagine you do. The disadvantages are also the hourly wage when I consider the time I am spending here. (interview, 5/13)

There is a tentativeness in all of these statements concerning the advantages of teaching in real terms. As Donald points out "It depends on how you look at it." Teaching may be rewarding in many ways that are not monetary. However, being a teacher is not a prestigious career for a man (or a woman), and it does not pay as well as other occupations. In conversations about teaching, all

of these men could enumerate things that they enjoyed about the profession including the children, the variety of tasks and the potential for creativity. However, here they acknowledge that it is not a career to brag to your friends about and it is not a career that is financially lucrative. Steve, Glenn and Paul all mention the necessity of making a living or providing for your family. The occupation of teaching will not add as much to the family coffer as other positions. For these men, at least for a time, the die is cast and, in Glenn's words, "I can't sit and deal with that." All of these statements were from interviews made during the last week of the student teaching internship. These comments could reflect the facts as they see them, or second thoughts, or they could reflect exhaustion. Both Donald and Steve mentioned putting in 12-hour days for weeks.

Administration

When the possibility of becoming an administrator was mentioned, all but Glenn recognized that money considerations might make them consider administration.

Josh: There has got to be more money in education for it to attract men.
BH: Is that factor what would drive you to administration?
Josh: Yes. (interview, 5/9/02)

Glenn believed that administration was not the place for him. In an interview, he told me about a teaching job that he interviewed for and hoped to get.

BH: So you don't have a goal to become an administrator?

Glenn: The way that I feel is that if you are going to make a difference, you have to make it from the teacher's chair. You have to be in the front of the classroom to make a difference. Principals make a difference in a school, but if you are going to make a difference in an individual child's life, it has to be done in the classroom. And I think that that's my main goal. (Interview 5/10/02)

Glenn had mentioned before how much he hated desk-work, so this comment is very consistent with all that he said.

Steve said he would consider administration, but that he also entertained other possibilities.

BH: Do you have a plan? Like to teach so many years and then do something else? Or teach so many years and then go into administration? Or teach so many years and then get a master's degree?

Steve : I'd like to teach four or five years and then get my master's - probably in communication. I don't want to abandon teaching, but I'd like to maybe do sports communication. I'd like to see what would happen. I do love teaching. I don't think I'm going to be a teacher my whole life. I'd like to maybe be a professor at the university. Get my doctorate. (interview, 5/13/02)

Steve had mentioned his love of sports several times and it is clearly something that he would like to pursue as a career. He does not consider himself inextricably bound to a teaching career.

Summary

Throughout my analysis of these data, one theme seemed to frequently reappear. Like a persistent motif in a symphony that keeps repeating itself in the various movements, it is recognizable in both the lighthearted moments of the music and the more poignant, serious ones. The resources teachers bring into the classroom and the origin of those resources are recurring elements in this

research. Teachers carry into the classroom the sum total of their personality and their experiences. The manner in which they have interacted with these experiences, the lessons that they have extracted from them, and their interaction with the opportunities presented to them help them to build skills that become the tools that they use. The resources may be their own personalities, their experiences with children, their academic learning, their job experiences and their hobbies. Each of these men has his own identity and he has constructed it from all of these resources. Each of them is also male and that is part of their constructed identities. As males, they plan to enter elementary classrooms and build their own learning environment. This environment will draw on all their resources, and the fact that they are males is a part of it.

People live and make decisions within their culture. Ann Swidler (1986) postulates that there are two models for looking at how culture influences individuals. One model assumes that culture shapes individual actions by supplying values, and one model postulates that culture supplies a “tool kit” of resources that people may use in various ways to solve many types of problems. Culture, then, controls not the ends of action, but the strategies of action. It is this second view that Swidler finds most compelling in stable environments.

If applied to education research, Swidler’s work would imply a change of emphasis from consideration of teacher beliefs to inspecting the contents of the teacher’s “cultural toolbox.” For example, one of the primary beliefs that the participants in this study hold about science teaching is that it should be hands-on.

They included this belief in their expressions of how children learn science, and they included it in their expressions of how good teachers should teach science. All of the participants used hands-on learning in the classroom. Although the provided curriculum had a hands-on orientation, these men chose hands-on activities for science that they designed for the classroom outside the curriculum as well. Also, when given a choice of which activities to omit from the provided curriculum, they never chose to omit the hands-on activities. Steve and Glenn acknowledged that they themselves appreciated the active aspect of hands-on lessons. Donald, Glenn, and Steve were very comfortable with the construction of circuits and other tool-requiring activities. Donald had maintained aquariums enough to enjoy the care and maintenance of aquatic plants and animals. Steve, Donald, Paul, and Glenn were all relaxed enough to easily handle spillage and accidents. So did they do hands-on because they had a belief that it was valuable or did they do hands-on because their experiences in their culture had provided them with the tools to do hands-on, making it easy for them? Swidler would say that their culturally-shaped skills, habits, and styles explain their behavior better than their stated beliefs. The satisfying aspect of the cultural toolbox theory is that it accounts for actions that do not correspond to stated beliefs. In order to perform a task, one must have the tools necessary to implement that strategy of action. In this analysis, I have implied that there may be a whole set of tools that are necessary for implementing hands-on learning. A curriculum in a box provides the equipment and the written resources. The teacher may need other

tools, such as some first-hand, practical knowledge of that particular system (e.g. electrical circuits or ecosystems), the skill to use the tools necessary to construct the experimental apparatus, and the ability to tolerate the more chaotic aspects of hands-on learning.

As I have documented, the men in this study had certain resources at their disposal on the first day that they walked into their student teaching internship. Several of them, especially Paul, Steve, Donald, and Glenn, had some experience instructing children. This gave them assurance that they could handle almost any type of student/teacher interaction. They were not apprehensive about the movement and freedom that hands-on activities generate in the classroom. Josh, who had not worked with children before his student teaching, had more habits to establish in the area of student/teacher interactions. Glenn had his exceptional science academic background that served as a store of knowledge and experience to share. All of these participants drew either on stored background knowledge or knowledge they acquired from the teacher guide. There were a few awkward moments when their stored knowledge failed them and the background knowledge in the teacher guide was inadequate. In the analogy of the “cultural toolbox” they needed a hammer and it was not there.

Glenn, Steve, and Donald particularly possessed an air of confidence when constructing scientific apparatuses. It is also true that when I observed them teaching the last science unit of the year, these three had been actively involved, if not solely involved, with the other two science units. Josh and Paul had not been

given as much responsibility for science early on in the year. In this case, the student teaching experience itself may have added skills that they needed.

The consciously relaxed attitude and the reliance on humor seem to be traits that the men in this study value highly. Glenn states outright that it is related to gender. There are all kinds of personalities among both men and women, so I must make clear that I am not implying that no women work at acquiring a relaxed attitude or that no women develop a sense of humor. However, if we go back to the image Glenn evoked of the teacher talking to the life size cutout of Kareem Abdul Jabar during his lessons, would this not seem more typical of a male teacher than a female? Glenn thought so.

I believe that the participants in this study maintain that men are different from women and that male teachers are different from female teachers. Both Steve and Glenn acknowledged the male role as breadwinners. All of them tried to avoid the more mothering aspects of teaching by teaching older children. They did try, through the more accepted male methods such as joking, teasing and other forms of humor, to foster a friendly environment—in my view, a version of a friendly environment consistent with their conception of themselves as male teachers. One quality that they did particularly strive to achieve and which was not alien to their own construction of being male teachers was a sensitivity to the needs of children. I believe that, in a sense, they married the more accepted male form of interaction i.e., teasing, with the more accepted female form of

interaction, i.e. sensitivity. Perhaps this is one way they viewed the role of male, elementary teachers.

Finally, I believe that hobbies or avocations played a vital role in defining the resources that were brought into the classroom. As I have previously stated, all of these men were greatly enriched by their hobbies.

At the beginning of this research, I was drawn to the findings of Manning, Esler and Baird (1982) who stated that 25% of elementary teachers teach no science and that 75% taught science two hours or less per week. Except for Josh, the men in my research study taught science more than that and had every intention of incorporating significant science into their own classrooms once they became full-fledged teachers. Given the small percentage of men in elementary education, Manning, Esler, and Baird probably included very few men in their study. Their findings may have been different if they had included more male elementary teachers. To the extent that my participants are representative of male, preservice, elementary teacher at all universities, my research implies that there would be more interest in science teaching among male, elementary teachers. The typical male cultural toolbox may have more tools that solve science teaching problems than the typical female cultural toolbox. Finding ways to enhance the cultural toolbox of both male and female preservice and inservice elementary teachers so that the teaching of science in schools is improved is an area for future research. The connection between avocations and personal teacher resources would also be a little explored aspect of teaching and teacher

recruitment that should be studied. Finally, an examination of male role modeling and the cultural knowledge that males bring to teaching would be a compelling follow-up to this study.

Epilogue

Every story has an end. This one ends in May, 2002, when I observed the last class and interviewed the last participant. The stories of my participants continue, and knowing something about their pursuit of an elementary teaching career seemed compelling. I contacted each of them to discover what they are doing nearly two years after their graduation. Three of the participants in this study are currently teaching in the same school district where they grew up and where they did their student teaching. Donald is teaching 3rd grade and writes, “I love it (usually)☺”. Donald had stated to me and to the school district that he was willing to teach from third grade to fifth. Paul has taught a second grade class for the past two years. Although he had stated a preference for fourth grade to me, the school district offered him this position which he accepted. Steve worked as a permanent substitute in an elementary school for a year, and then transferred to another school where he is teaching second grade. He was very positive and excited about his work and claims to enjoy second graders.

Josh is working in a nearby school district as a sixth grade Social Studies and English teacher.

Glenn, my most scientifically enthusiastic participant, is teaching in an adjacent county at the same middle school he attended as a student. He did teach

seventh grade Life Science for one year, and then moved to sixth grade thinking that he would enjoy the more general science topics including chemistry and earth science taught in that grade. He has started an astronomy club and helped with the school science fair. He plans to enter graduate school and work towards a master's degree in earth science with the goal of enhancing his science teaching.

One of the most satisfying aspects of my data collection was discovering that all of these men are presently teaching. After journeying with them through the final stages of their preparation to be teachers, it is a pleasure to see their efforts rewarded.

Appendices

Appendix A Initial Interview Protocol

Name and place of birth

Family background

Elementary, middle and high school experiences, especially in science classes

Significant life events

Program of study at the university

Describe your motivations for becoming an elementary teacher, including influential individuals.

Describe any previous experiences you have had working with children.

Did you ever have a teacher in elementary school that particularly motivated you to learn science? What did that teacher do?

Describe the science classes that you had in high school.

Describe the science classes that you had in college.

What aspects of learning science did you really enjoy in any of your educational experience?

What grades in elementary school would you prefer to teach? Why?

Do you expect science to be a significant part of your teaching day? Why?

What do you think you must accomplish as an elementary school science teacher?

How do you think children best learn science? Can you give some examples?

What do you think will be some challenges to teaching science in the elementary school?

Describe the kind of teacher that you hope to be.

Describe the lesson plans that you have prepared for your science methods class. Why did you choose these lessons? Describe the teaching of the lessons.

Appendix B Ongoing Interview Protocol

Describe the experiences you have had so far in your student teaching assignment.

Describe the science lessons you have taught so far.

How do your students respond to science class?

In what ways has teaching science been like you expected? In what ways has teaching science been different than expected?

Describe some interactions you had with children while teaching science. How were the children understanding the science lessons?

What have been the challenges of teaching science? Do you think these challenges will be the same in your first teaching job?

Describe any ways that your actual science teaching has been influenced by courses that you have taken at the university.

Do the children think about science the way you expected them to think? Give examples.

Do you think that any of your students might be a scientist one day? What characteristics or behavior give you that impression?

What encouraging experiences have you had in the past week? Did any of them relate to science?

Which subject(s) seem to be the easiest for you to teach? Why?

Describe your most successful teaching experience so far.

Describe your professional aspirations.

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