WHAT INFLUENCES SCIENCE TEACHING?
A STUDY OF THREE NOVICE RURAL
SCIENCE TEACHERS

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CHAPTER ONE

BACKGROUND OF PROBLEM

The mid 1980s were filled with reports calling for reform in education. Some of the reform reports, such as *A Nation at Risk* (National Commission on Excellence in Education, 1983), *Action for Excellence* (Task Force on Education for Economic Growth, 1983), *A Place Called School* (Goodlad, 1984), *The Paideia Proposal* (Adler, 1982), *High School* (Boyer, 1983), and *Horace's Compromise* (Sizer, 1984), "consistently identified science and technology as a vital area with a pressing need for reform" (Trowbridge & Bybee, 1990, p. 136). These conclusions led the science community to initiate a project that has had major effects on the development of science teachers and the learning and teaching of science—American Association for the Advancement of Science's [AAAS] *Science for All Americans* (1989). "*Science for All Americans* (1989) consists of a set of recommendations on what understandings and ways of thinking are essential for all citizens in a world shaped by science and technology" (p. xiii). This project, led by the National Council of Science and Technology Education, was written by college professors, scientists, and others in professional occupations. At this time, classroom teachers or science teacher educators were not on the council.

Science education reform has been in transition since the introduction of *Project 2061* (AAAS, 1989) which led to *Benchmarks for Science Literacy* (AAAS, 1993). Classroom teachers were included as authors of this applicable document. Next, the National Academy of Sciences National Research Council established standards for science education which led to the *National Science Education Standards* (1996). All of these documents outlined the need for change in science education and suggested ways to accomplish this change.

The primary problem with the reform efforts, according to Klopfer and Champagne (1990), two science educators, is the limited research on secondary science teacher development during the preservice education. Furthermore, no one at that time knew for sure what effects the preservice education has on beginning science teachers. Klopfer and Champagne (1990) suggest that without an understanding of the influence of the preservice program to build upon, the effort to reform will probably fail as many reforms have failed in the past.

Science education reforms continued and in 1993 Brunkhorst, Brunkhorst, Yager, Andrews, and Apple stated "Science teacher preparation is now recognized as the pivotal point in the reform of science education. . . . No longer can we view science teacher preparation as discrete and separate from science teacher enhancement." (p. 51) Anderson and Mitchener (1994) note the small amount of research on preservice education. Past research on secondary science preservice education is mainly limited to subject matter preparation, professional education coursework, and secondary science preservice programs. The influence of preservice education on secondary science teachers' classroom practices have not been included in past studies.

Subject matter preparation is crucial in helping teachers make curriculum decisions (Powell, 1994). Research has shown that teachers' beliefs about science affect their teaching (Grossman, Wilson & Shulman, 1989). These beliefs must be changed in order to bring about educational reform (Anderson et al, 1992).

Another aspect of preservice education is professional education coursework. Professional education coursework is designed to prepare teachers for the classroom. Anderson and Mitchener (1994) indicate that the major criticism of research in this area is whether professional education gives a realistic view of what the teachers will face in the classroom. As a result, there appears to be a need for research identifying the aspects of the secondary science teacher's professional courses that are relevant to the beginning teacher's classroom practices.

Anderson and Mitchener (1994) note that preservice secondary science programs research is "limited in scope" (p.28). What little research that is available has a narrow view and is "limited in . . . usefulness" (p. 28).

Prior to the mid-1980s almost all of this research was focused on evaluating the results of various programs and techniques with little attention to the dynamics of the learning that occurred or critical examination of the content of the instruction (Anderson & Mitchner, 1994, p. 28)

Frequently, education courses are seen as a waste of time by the preservice science teachers (Anderson & Mitchener, 1994). Studies are needed in order to find out what courses beginning teachers perceive to be valuable so that the universities will have adequate information for the development of courses.

STATEMENT OF PROBLEM

This study investigated the influence teacher preparation education has on a science teacher's classroom practices as well as how secondary science teachers' behaviors in the classroom portray the teaching guidelines in the *National Science Education Standards* (NRC, 1996). Both of these problems are important for the following reasons. First, Lederman, Gess-Newsome, and Zeidler (1993) noted, after studying the science education research for 1991, that there is a lack of empirical research on science teacher education and called for more research so that science education reform can occur. Second, Finley, Lawrenz, and Heller (1992) noted that much of the research on secondary science teacher preparation will be of little value unless we learn ". . .which of the teaching practices provided in methods courses are actually employed by students, and determine the types of experiences that are important for the preservice teacher when they enter the profession" (p. 302). There is limited research on the links between the secondary science preservice program and the beginning years of teaching.

PURPOSE OF STUDY

Undergraduate preservice science teachers encounter science teaching primarily in two types of courses at the university—the science education methods course and science courses such as biology, chemistry, and physics. In addition, students bring memories of past experiences with them into the university setting. Britzman (1986) believes that preservice teachers:

> bring to their teacher education more than their desire to teach. They bring their implicit institutional biographies—the cumulative experience of school lives—which in turn, inform their knowledge of the student's world, of school structure, and of curriculum. All of these contributes to well-worn and commonsensical images of the teacher's work. (p. 443)

The purpose of this study was to look at how three beginning secondary science teachers perceive the influence of science methods courses and science courses on their classroom practice. After collecting the data, I looked at how their classroom practices compare to the teaching standards established in the National Research Council's document, National *Science Education Standards* (1996).

DESIGN OF STUDY

The design of the study was qualitative in nature. Classroom observations, lesson plans, and personal interviews with three novice rural science teachers provided the information. The results are presented in three parts: the beginning science teacher's view of teaching, my examination of the teacher's classroom practices, and my evaluation of lesson plans for different types of classroom practices. Classroom practices were placed in two categories, expository and inquiry. These two categories were considered influences from science courses and methods courses respectively.

The data was used to answer the following research questions:

1. How do these science teachers approach teaching science?

2. In what ways do these teachers perceive their science methods courses as affecting the way they teach science?

3. In what ways do these teachers perceive the way they were taught science as affecting the way they teach science?

4. In what ways are the *National Science Education Standards* for teaching science (NRC, 1996) reflected by the teacher's classroom practices?

DEFINITION OF TERMS

Academy- An academy was a private boarding high school that had a modern curriculum combining the classical subject matter with a practical education. Coursework consisted of "English grammar, composition, literature and rhetoric, mathematics, the social studies, the modern languages, the sciences, the arts and music, and the practical career-oriented studies" (Butts & Cremin, 1953, 127).

Block scheduling- A school day is divided into four blocks of instruction of approximately one and one half hours instead of six or more class periods of approximately fifty minutes.

Common school- An ungraded school with one teacher. It is comparable to an elementary school that includes grades first to eighth (Pinar, Reynolds, Slattery, & Taubman, 1995).

High school- Public educational institution that had a similar structure and coursework as the academies (Tanner & Tanner, 1995).

Non-traditional student- A college student who has either waited a few years after high school graduation to start college or has interrupted the college years for personal reasons and returned to college at a later date.

Normal school- "An American teacher training school or college. Nineteenth-century normal schools were often two-year institutions on about the same level as high schools" (Pulliam, 1987, p. 292).

Resident year or entry year- A formal program of mentoring and assessment required by this region for the first year of a teacher's career in which the new teacher is peer coached by a mentor teacher from the local school, an administrator and a university supervisor. At the end of this year, the teacher can apply for teacher certification.

Rural- For this study, rural was considered as a town outside of the major cities that has a single attendance center serving middle school and junior high students and one high school for the entire community. Population of the community is less than 20,000.

Secondary science education- Science classes for grades seventh through twelfth.

Science literacy- A person is scientifically literate is able to use science concepts, process skills, and problem solving to make decisions about life (Bybee & DeBoer, 1994).

Traditional student- A college student who continued in school, in this case at the university, directly after graduating from high school.

LIMITATIONS

1. The beginning teacher populations are limited to a restricted geographic area and the findings may not apply to all teachers.

2. This was a convenience sample rather than a random sample; therefore, the results may not be generalizable to a broad population.

ORGANIZATION OF THE REPORT

This study will have five chapters. Chapter Two reviews the relevant literature, studies, and texts concerning the historical background of science teacher education, particularly of beginning secondary science teachers. Chapter Three describes the research process of this qualitative study of three rural, beginning secondary science teacher classroom practices. Chapter Four provides a brief biographical background of the education of each novice teacher, the narrative text describing each teacher's classroom practices, and the researcher's analysis. Chapter Five contains a summary of the conclusions and suggestions for further research in this area.

CHAPTER TWO

REVIEW OF LITERATURE

Many things affect how a science teacher practices the craft of teaching. These practices are developed over a period of time. Historical documentation gives the teacher an idea of what was the accepted ways of teaching and what was not accepted at certain periods in history. It also shows how teaching has evolved and what has influenced this evolution. The influences don't stop there.

Preservice teachers gain experiences in their science courses as well as their education courses but to what effect these courses have on the science teacher's classroom practices is unknown. It seems as if a teacher is aware of recent research on teacher practice, the studies could have a major significance on how a teacher teaches.

TEACHER EDUCATION

1820-1860

Today, as educators acquire more experience, their knowledge of what is needed for the classroom develops. It takes time to understand the needs of the students. The same pattern is observed in teacher education during the mid 1800s.

Colonial teachers prior to the 1820s received little formal training (Pulliam, 1987). The first private school that had teacher education training was founded in 1823 in Concord, Vermont (Lemlech & Marks, 1976). Massachusetts established the first state school for preparing teachers in 1839 (Cottrell, 1956; Herbst, 1989; Lemlech & Marks, 1976; Pulliam, 1987; Urban, 1990). These institutions began the development of normal schools in the United States (Herbst, 1989; Lemlech & Marks, 1976; Pulliam, 1987).

Originally, normal schools had four basic components of curriculum. These consisted of the art of teaching, school government, a review of basic knowledge, and a model or practice school. Even with the professional education component, the normal school's training of teachers was weak on pedagogical theory and lacked academic cohesion (Goodlad, Soder & Sirotrik, 1990, Herbst, 1989). Preparing educators to teach the common school subjects was the goal of a normal school (Herbst, 1989; Lemlech & Marks, 1976; Urban, 1990). In general, a common school was an ungraded institution with children of various ages. One teacher presided over the lessons for all subjects and all grade levels—first through eighth (Pinar, Reynolds, Slattery, & Taubman, 1995).

By 1860, there were only twelve state teacher normal schools, located predominantly in Massachusetts and surrounding states (Lemlech & Marks, 1976; Pulliam, 1987), preparing 1/3 of 1% of the nations teachers (Cottrell, 1956). Most of the teachers of this time were graduates of only a common school education which would be comparable to today's eighth grade education. Few teachers were alumni of academies or high schools (Pulliam, 1987; Lemlech & Marks, 1976).

1860-1920

In the 1870s and continuing into the 1890s, the normal schools expanded the curriculum in order to prepare teachers to make them eligible to become high school and academy faculty members (Herbst, 1989). At that time, the professional education program had three main areas of concentration—theoretical, practical, and student teaching. History of education, science of education, philosophy of education, and element of pedagogy were the courses that constituted the theoretical component. The practical section consisted of courses in school economy, school organization, and school management (Stiles, Barr, Douglass, & Mills, 1960).

Pressure for better trained teachers from national scholarly and professional organizations as well as accrediting institutions initiated many changes in education during the last quarter of the nineteenth century. During the late 1800s, liberal arts colleges and universities started introducing courses in pedagogy and aptitudes needed for teaching (Pulliam, 1987; Stiles et al, 1960). In the same time and continuing into the early part of the twentieth century, normal schools began evolving into teacher colleges. Prior to this change, the teachers were required to complete a two year training program. This led to a diploma and teacher certification. When the process of changing the normal schools into liberal arts colleges and universities was complete, educational students were exposed to three years and eventually four years of higher education. Because of these new developments, a bachelor of science degree in education was inaugurated (Goodlad et al, 1990).

1920-Present

Most states did not require teachers to be college educated individuals prior to 1920 (Lemlech & Marks, 1976). Once states upgraded their academic qualifications and expectations for teachers, general education courses were included in the curriculum plan of study for educators. General education components were mathematics, physical and biological sciences, history and social sciences, humanities and fine arts. Proponents of education supported the idea that studying these subjects in addition to pedagogy prepared a teacher to be a better citizen, thus a better teacher (Herbst, 1989: Stiles et al, 1960).

The trend for secondary teachers has been based on the subject matter specialization model. This model varies from state to state for science teachers but generally it falls between 36-40 semester credit hours for natural science students (Beisenherz & Dantanio, 1991; Blank & Espenshade, 1987; Newton & Watson, 1968; Stedman & Dowling, 1982; Stiles et al, 1960). According to a 1985 survey of 1,040 colleges with teacher education programs, professional education courses for secondary teachers was found to be any average of thirty semester credit college hours. Generally, an average of ten of these hours were spent in the student teaching experience (Pulliam, 1987).

Little has changed in the curriculum for pre-service educators in the last fifty years. The main difference appearing in the 1970s was an emphasis being placed on educational psychology and other specialized education courses. Competency tests were also implemented during this same time and have dominated from the 1970s to present. According to Tanner and Tanner (1995), the focus appears to be on training teachers as technicians. Teacher education encourages its students to have specific behaviors when presenting a lesson. Certification testing is taken in whatever subject areas a teacher has concentrated his or her studies and wishes to become authorized to teach.

EDUCATION FOR SCIENCE TEACHERS

Theory

Like other beginning secondary teachers, a secondary science teacher has spent many hours in subject matter classes and only a few hours in education courses. This is the usual pathway of a liberal arts model for secondary science education majors. No matter what type of education science teachers participate in, the major portion of the pre-service education consists of courses outside the college of education.

Course work comes from all of the major departments at the college with the majority coming from the college of arts and sciences (Anderson & Mitchener, 1994). In a study by Feiman-Nemser (1990), it was found that there were five common educational patterns for science education majors: academic, practical, technological, personal and critical/social. Each educational pattern will be discussed separately.

Academic

Transmitting knowledge and developing comprehension are the main focuses of the academic class of education. This type has a close association with a liberal arts plan of study. In this format, the teacher must have a subject matter specialization in classes that are led by a professor who has studied in that particular field of study. Strong subject training and little pedagogical skills are a common aspect of this form (Feiman-Nemser, 1990).

Practical

The art of teaching is the predominant aspect of the practical orientation. This orientation tends to focus on the classroom experience as the source of learning. Apprenticeships are associated with this type of teacher education. The new teacher works with a master teacher to gain the skills needed to teach in the real world (Feiman-Nemser, 1990).

Technological

Competency and proficiency are the predominant goals of the technological classification. Teaching is presented as a science in which certain behaviors being required. Competency based testing is the culmination of this orientation (Feiman-Nemser, 1990).

Personal

Personal concentrates on the teacher as a learner. Past history and personal development of the individual is the core of teacher preparation. "Advocates of the personal orientation favor classrooms in which learning derives from students' interests and takes the form of active, self-directed exploration" (Feiman-Nemser, 1990, p. 225).

Critical/social

Removing social inequalities and promoting democratic values are two of the major goals of the critical/social category of education. The third objective of this group is problem-solving. A new social order is to be the product of these three initiatives (Feiman-Nemser, 1990).

Application

The traditional model of undergraduate teacher education has three strands: (a) general education, (b) subject matter educational requirements and (c) professional. The first two strands are course work taken outside of the college of education. General education requirements are met in the areas of the social sciences, the natural sciences, and the humanities (Anderson & Mitchener, 1994). "Subject matter preparation of preservice science teachers has been unquestionably the responsibility of the liberal arts and science faculty" (Anderson & Mitchener, 1994, p. 74).

The third strand science teacher education involves the professional education phase. Educational foundations usually start this part of the teachers' training. Psychology and methods courses follow the basic courses. Methods courses either show the teacher to be a subject matter expert who is trying to improve classroom practices or the educator is shown as a facilitator of learning (Anderson & Mitchener, 1994).

Following the completion of the college class work, a time of student teaching usually completes the degree plan for secondary science teachers. Student teaching lasts an average of 10-12 weeks. The first few weeks, the student teacher observes the cooperating teacher teaching lessons and maintaining student participation and motivation. Gradually, the novice takes over the classroom under the auspices of the regular classroom teacher. During this time, the student teacher practices his/her teaching practices and classroom management (Anderson & Mitchener, 1994).

Science teachers' educational programs involve more that student teaching. Studies of science teacher education programs across the United States were conducted in the early 1980s. "These studies indicated that there are few differences among the programs in terms of structure . . . most are headed by single faculty member. The faculty is committed to teacher education—but there is little time for research, reflection, or program development". (Yager, 1993, p. 144)

The single faculty mentioned above is generally a science teacher educator. Many science teacher educators teach as they were taught. Few of them question the effects of their preservice education or their present classroom practices. According to Yager and Penick (1987), the main efforts of these science teacher educators is the methods course and supervision of student teachers.

SCIENCE EDUCATION

During the mid-nineteenth century, many European educators, such as John Amos Comenius, John Locke, Johann Heinrich Pestalozzi, Freidrich Frobel, Johann Fredrich Herbart, Thomas Huxley, and Herbert Spencer influenced American science education. Comenius is known for being the first person to bring science to the classroom. He believed that children should learn about material from their natural environment. Locke supported this idea with his philosophy that concrete examples should be used to help us develop our ideas (Bybee & DeBoer, 1994; Pulliam, 1987).

Pestalozzi proposed that the goal of education was to develop self-motivation and learning. This would be accomplished by allowing the students to conduct experiments instead of learning by rote (Bybee &

DeBoer, 1994; DeBoer, 1991; Downing, 1925; Pulliam, 1987). Froebel agreed with Pestalozzi but went a step further. "He believed that education's purpose was to link the spirit of the child with the divine through a study of the natural world" (Bybee and DeBoer, 1994, p. 361).

The development of one's mind was Herbart's main goal of education. He believed that education serves to help a person live a well-rounded and moral life. Herbart also believed in the "importance of the connectedness of ideas and the value of having learners discover the relationships between ideas instead of having those relationships presented to them directly" (Bybee & DeBoer, 1994, p. 361).

Thomas Huxley suggested that education should prepare individuals for a modern society. He thought that the study of science would increase a person's ability to make accurate observations of the natural world and interactions with the physical world would help to build inductive reasoning in a person (Bybee & DeBoer, 1994; DeBoer, 1991; Pulliam, 1987).

Spencer thought that education should have an impact on all areas of a person's life (Bybee & DeBoer, 1994; Tanner & Tanner, 1995). Bybee and DeBoer (1994) stated that Spencer believed:

> Knowledge of the functions of the human body and their relation to good health was important for self-preservation. Earning a living, an indirect form of self-preservation, was dependent on a

> knowledge of the products and processes that formed a major part of the new industrial and agricultural economy. Knowledge of machines (the lever, wheel, and axle), the steam engine, melting furnaces, gunpowder manufacturing, sugar refining, and agricultural production through courses in physics, chemistry, and biology would be useful in most people's lives because so many people were involved directly or indirectly in the production, preparation, and distribution of commodities (p. 362).

Spencer went so far as to state that raising children and aesthetic appreciation could be enhanced by science education. A person's mental ability would also increase with the study of science (Bybee & DeBoer, 1994).

The late 1800s brought forth two Americans, J. M. Rice and Charles W. Eliot, who had influence on American science education. Rice said that traditional lessons from textbooks gave the students an opportunity to be passive about their education. The approach he proposed, which involved active participation, led a child to reason as well as to develop physically and morally (Bybee & DeBoer, 1994, DeBoer, 1991).

Eliot believed that laboratory activities were the appropriate way to present science lessons. This style of teaching was thought to develop the abilities of observation and reasoning within a person (Bybee &

DeBoer, 1994; DeBoer, 1991). The educators of the nineteenth century were proponents of science education as a way to achieve personal development.

By the late nineteenth century, the Committee of Ten (1893) suggested that science in the curriculum would help to develop intellect. The Committee of Ten, led by Charles Eliot, was organized in order to determine what courses should be taught in the high schools. Results of this council started with the statement that laboratory work was the most important aspect of science courses. A recommendation from the committee was for schools to allocate 25% of the student's class time to the subject of science (Andersen, 1994; Bybee & DeBoer, 1994; DeBoer, 1991).

The Commission on the Reorganization of Secondary Education (CRSE) was formed in 1918. Its purpose was to examine each school subject to evaluate the usefulness of the course to society (Bybee & DeBoer, 1994, DeBoer, 1991). The commission identified seven goals of education: "(1) health, (2) command of fundamental processes, (3) worthy home membership, (4) vocation, (5) citizenship, (6) worthy use of leisure, and (7) ethical character" (Bybee & DeBoer, 1994. P. 368). The science committee of the CRSE said that science completed six of the seven goals. Science courses could satisfy the health goal by educating people about illness and disease and the means necessary to protect oneself from such calamities. Worthy home membership was achieved with the knowledge of the operation and repair of household machines, both operational and repair (Bybee & DeBoer, 1994, DeBoer, 1991). Applied science courses could fulfill the needs of many students if the subjects are approached in the correct manner (National Education Association [NEA], 1920). "Concerning the goal of citizenship, science courses could make individuals more appreciative of the role of scientists in society and better able to select technical experts for their special roles in society" (Bybee & DeBoer, 1994, p. 368). An appreciation of the natural world and its beauty was achieved for leisure times by the introducing of science courses. The study of science helps develop ethical character "by establishing a more adequate conception of truth and a confidence in the laws of cause and effect" (NEA, 1920, p. 14). Command of fundamental processes was the one area that science did not fulfill (Bybee & DeBoer, 1994).

The years from 1917 to 1957 were called the Progressive Era in American education (Cremin, 1964; DeBoer, 1991; Pulliam, 1987). A major accomplishment of this time frame was to define a sequence of courses for high school students. General science was suggested for first year students with courses in biology, chemistry, and physics following in subsequent years (Bybee & DeBoer, 1994; DeBoer, 1991).

During the Progressive Era, Gerald Craig (1927) published the results of a study on the scientific knowledge found in children's questions. This study of 1927 influenced changes in secondary curriculum. He suggested that education should make a shift to scientific principles and generalizations instead of staying with the emphasis on scientific facts (Bybee & DeBoer, 1994; National Society for the Study of Education, 1947).

John Dewey was an enormous influence during the Progressive Era. Dewey believed that the methods of science were far more important than scientific facts. Scientific method consists of an organized prescription for problem solving. The route to knowledge was through the scientific method (Bybee & DeBoer, 1994; DeBoer, 1991; Dewey, 1944; Dow, 1991). Unfortunately, textbooks were the main source of science education from the 1930s to the 1960s. The use of books greatly reduced the use of the scientific method Dewey proposed (Bybee & DeBoer, 1994).

The launching in 1957 of *Sputnik* by the Soviet Union created a great concern in the American government, leading to an increase in the financial support to education. Science and mathematics curriculums were completely revised through programs funded by the National Science Foundation (Bybee & DeBoer, 1994). In the late 1950s and early 1960s, three significant changes in the goals of science education took place:

(1) recognition of the personal-social development goal declined; (2) scientific knowledge was modified to emphasize understanding the structure of scientific disciplines and this goal became the primary goal of science curricula, especially at the secondary level; and (3) scientific methods, now discussed as inquiry, discovery, and problem solving, became the means of achieving the knowledge goal and not a means of general problem solving to solve society's problems (Bybee & DeBoer, 1994, p. 373).

Jerome Bruner proposed a method for restructuring science education in *The Process of Education* (Bruner, 1960). Believing that knowledge should be the main goal of science, he suggested that children of all ages were to be taught science in some form (Bruner, 1960; Bybee & DeBoer, 1994; DeBoer, 1991).

The emphasis of science had shifted from space to the problems on Earth by the end of the 1960s. Once again, the goal was leaning toward personal-social development. This goal was continued through the early 1970'. Science was to be taught in a way that is relevant to the students' lives. Environmental issues became a prevalent part of the science curricula and the development of scientific literacy (Bybee & DeBoer, 1994; Watson & Konicek, 1990).

The development of science literacy continued in the 1970s and 1980s (Bybee & DeBoer, 1994; Gil-Perez & Carrascosa-Alis, 1994;

Hodson, 1988). A person who is scientifically literate is defined as being able to use science concepts, process skills, and problem solving to make everyday decisions about his or her life and how to preserve and protect the environment (Bybee & DeBoer, 1994; DeBoer, 1991; Showalter, 1974). Bybee argued for the studying of ecology so that society would be knowledgeable about how to protect the earth (Bybee, 1979). Technology was added as a major focus in the 1980s. At times, there were conflicts between what was needed for scientific knowledge and what was needed for technology and society. This was especially true of any advancement that was detrimental to the environment (Bybee & DeBoer, 1994; DeBoer, 1991).

> Issues of energy conservation, environmental pollution, resource use, and global problems such as ozone depletion and the greenhouse effect were concerns affecting all inhabitants of the earth and were intimately tied to a wide range of science fields and to technology (Bybee & DeBoer, 1994, p. 378).

Late 1980s brought a major reform to science education. Project 2061 had scientific literacy for all people as its main goal. This project led to the publishing of *Science for All Americans* (AAAS, 1989). The road to scientific literacy is laid out in this report. Some recommendations of this publication includes teaching less content instead of more, teaching from the aspect of common themes, and teaching in ways that interrelate math, science, and technology (AAAS, 1989). All of these are needed to reach the present goals of science education: (a) scientific knowledge, (b) processes of science, and (c) recognition of personal-social goals (Bybee and DeBoer, 1994).

Most science educators of today agree that studying science is needed to help a person achieve higher levels of scientific literacy. However, many science teachers still seek clarification of the concept of science literacy (BSCS, 1993; Uno & Bybee, 1994). Some science teachers even question the importance of science literacy (Shamos, 1995).

UNIVERSITY COURSEWORK

The *National Science Education Standards* (1996) document was presented at the Western Area National Science Teachers Association meeting in December 1995. Finally, there was a document that was written in educational language that a practicing teacher could understand. The standards set out several guiding principles for science education. One such principle is a call for science to be taught as a process instead of a subject. Students are to be given the opportunity to develop skills in observation, experimentation and communication (National Research Council, 1996). The standards are presented in a way to facilitate implementing them at all levels of science educators.

Traditional presentations of science involve the teacher lecturing and the student copying a plethora of notes. This banking method of education has as its goal a depositing of knowledge into the students' heads (Rillero, 1993; Shor & Freire, 1987). Classrooms conducted in this manner are typically autocratic.

The banking method was the basic way to teach science until the development of inquiry theories about science education. In the 1950s, Thomas Kuhn, as a physical scientist, and Joseph Schwab, as a biologist, proposed that science should be taught as an inquiry. In 1964, Schwab refined this concept. He concluded that science instruction should involve an 'inquiry into inquiry'. This is described as studying science as scientists do. When a scientist finishes one experiment, it induces a fact or a hypothesis that will start a new experiment. This is still an accepted idea by most science teachers but it is not implemented in the same manner as Schwab intended. The first inquiry is done in order to find a certain conclusion but the second and subsequent inquires are not allowed to be developed (Duschl, 1994). Fortunately, the approach of inquiry has "firmly established the role of the laboratory and the doing of science by children" (Duschl, 1994, p. 449).

The constructivist philosophy is considered the most outstanding contribution to science education in recent decades (Gruender & Tobin, 1991; Resnick, 1983). This approach is democratic in nature. By definition, each person has an individual interpretation of what is to be learned. Constructivism is student oriented. The student gains new knowledge by relating present observations with prior knowledge (Cobb, Wood, & Yacker, 1991; Duschl & Gitomer, 1991: Flick, 1993; Gruender & Tobin, 1991; Matthews, 1990; Posner, Strike, Hewson, & Gertzog, 1982).

Kellough and Kellough (1996) describe constructivist instruction as:

> The methodology uses what is referred to as hands-on learning (i.e., the learner is learning by doing: and minds-on learning (i.e., the learner is thinking about what she or he is learning or doing). These approaches help construct, and often reconstruct, the child's perceptions. Hands-on learning engages the learner's mind, causing questioning, turning a child's mind on. Hands-on/minds-on learning encourages students to question and then to devise ways of investigating tentative but temporarily satisfactory answers to their questions (p. 56).

Other differences separate constructivism from conventional forms of instruction. Watson and Konicek (1990) showed that constructivism is much slower paced that the more commonly used methods. These researchers stated that the reason for this slowness is that the curriculum is studied in greater depth. Thereby, fewer isolated facts are memorized or formally tested.

While many things determine whether a teacher uses the constructivist philosophy or not, one important influence is the way the teacher learned science in college. Beisenherz and Dantonio (1991) note:

> Indeed, it can be hypothesized that, for the most part, the only exposure that preservice science teachers have to science as a process of inquiry, where science concepts are presented using and inductive-deductive approach such as the learning cycle (where appropriate hands-on experiences are provided both preceding and following the introduction of the concept), is in the methods course. While preservice teachers can logically see that strategies and activities provided in the science methods course offer a more appropriate and realistic model for science instruction, the conflict of how they were taught science, their views of how science should be taught, and what they are capable of incorporating into their personal model of teaching science present a real dilemma for preservice teachers (p. 42).

Presently, college level science courses are designed to teach students from many different majors (Anderson & Mitchener, 1994). Preservice science teachers take courses with students pursuing a science-related profession (NRC, 1990). Although science education majors are a small part of the clientele for these college science courses, the preservice science teacher is affected by the science coursework (Beisenherz & Dantanio, 1991; Dusch, 1983; Stake & Easley, 1978).

> University science courses . . . appear to have a common goal: To teach scientific knowledge as efficiently and expeditiously as possible. Students leave the science coursework component of their preparation with a preconceived notion of science "as a body of knowledge" rather than science as a process of seeking knowledge (Beisenherz & Dantonio, 1991, p. 40).

Carter, Heppner, Saigo, Twitty, and Walker (1990) went a step further when they suggested that college science courses teach isolated concepts and rote problem solving. These courses totally left out critical thinking, collaboration, and open-ended laboratory investigations. Therefore, the courses showed an inferior model of teaching.

Teachers need to learn how to teach science in such a way that is relevant and real (Martin, Kass, & Brower, 1990). In order to prepare teachers to teach science in this manner, this approach must be presented in teacher education courses (Yager, 1987; Yager & Penick, 1987). Few science teacher preparatory programs give science teachers the opportunity to study science as a scientist. Instead "teachers are trained to learn the chronological development of scientific ideas, repeat experiments designed by others, collect predictable data in limited quantities, and to work toward finding a single, right answer" (Haakonsen, Tomala, Stone, & Hageman, 1993, p. 129).

Since science courses are not always taught in manner they should be, science methods courses often pick up the slack on how science should be taught. Methods courses are the bridge between the science courses and the student teaching experience. Methods course aid preservice teachers in integrating their science content knowledge and their pedagogical coursework (Anderson & Mitchener, 1994).

STUDENT TEACHING

Student teaching is the final stage of teacher education. During student teaching, a novice preservice teacher is placed in an experienced teacher's classroom for a designated length of time. The experienced teacher is designated as the cooperating teacher for the student teacher. The student teacher takes over the classroom procedures under the auspices of the cooperating teacher. In a study by MacDonald (1994), it was noted that student teachers may not teach in the manner presented in the student teacher's methods course. The methods courses emphasized that science teaching should involve giving the students hands-on activities and opportunities to find out things for themselves. When Marcy, the student teacher in MacDonald's study, did not incorporate the ideology of her method's course in her classroom presentation, Marcy was asked what was the most important influence on her classroom practices. She responded "My cooperating teacher. My cooperating teacher has the most effect on what I do" (MacDonald, 1994, p. 3) This has been found to be true for many student teachers. Other studies (Palonsky & Jacobson, 1988; Price, 1961; Seperson & Joyce, 1973) support the notion that cooperating teachers have a great influence on the classroom practices of student teachers.

Lacey (1977) found that student teachers went against their own beliefs and behaviors to take on the beliefs and behaviors of the classroom and the school. Student teachers want to please their cooperating teachers in order to pass the student teaching experience and possibly obtain a job in the school system of the cooperating teacher. Marie, a student teacher in Abell and Roth's study (1992), felt that the beliefs of the school were a constraint to her student teaching classroom practices. Marie also felt that inadequate equipment, accountability of the test scores of students, an insufficient textbook, and the evaluation of the university supervisor hindered her practicum.

It is generally accepted that the cooperating teach has a greater influence on the student teacher than the university supervisor (Boydell, 1991; Guyton & McIntyre, 1990). Unversity supervisors believe the previous statement. Zimpher, DeVoss, and Nott found that university supervisors believe that they have little impact on the student teacher's classroom practices.

All in all, it is clear that cooperating teachers have more influence on student teaching than the university supervisor. Some teachers perceive that their cooperating teachers had the most significant influence on them during student teaching (Karmos & Jacko, 1977; Manning, 1977). How long does this influence last: McIntyre & Byrd, (1996) stated that the influence of the cooperating teachers also influences "the behavior and beliefs of novice teachers" (p. 173).

OTHER INFLUENCES

Many researchers of the life history and socialization of teachers agree that a teacher's personal life and previous schooling influence a teacher's classroom practices (Brousseau, Book, & Byers, 1988; Feiman-Nemser, 1983). A study of beginning secondary English teachers showed seven major influences on their classroom practices. These influences are adolescent comments, subject-specific education courses, weekly student teaching seminar meeting, cooperating teacher, fellow teachers, professional journals and workshops during the first year, and college English professors (Fox, 1993). Of the previous list, personal beliefs and previous experiences have been researched the most.

Beliefs and past histories in school definitely affect teachers' classroom practices (Clark & Peterson, 1986; Grossman, 1990; Nespor, 1987; Richardson, Anders, Tidwell, & Lloyd, 1997; Zancanella, 1991). Personal beliefs fall into two categories—beliefs about teaching and learning and beliefs about subject matter. Grossman, Wilson, and Shulman (1989) stated that "teachers' beliefs about teaching and learning are related to how they think about teaching, how they learn from their experiences, and how they conduct themselves in classrooms" (p. 3). Thompson studied three junior high school mathematics teachers and found that the teachers' beliefs related to their teaching practices. Other studies have shown that teachers' beliefs, personal philosophies, and values influence their classroom instruction (Duff, 1977; Elbaz, 1981; Tabachnick & Zeichner, 1985). Richardson and colleagues (1991) were able to predict how a group of reading teachers would teach reading comprehension by analyzing the teachers' beliefs about learning and teaching.

Subject matter beliefs involve both content knowledge and the method for teaching the subject content. Grossman, Wilson, and Shulman (1989) suggested that "teachers' beliefs about subject matter, including orientation toward the subject matter, contribute to the ways in which teachers think about their subject matter and their choices they make in their teaching" (p. 27). Wilson and Wineburg (1988) had found the same results the previous year.

Studies about teachers' beliefs and theories about both teaching and their subject matter have shown that teachers' personal histories affect the teachers' classroom practices (Clandin & Connely, 1987;

Clark & Peterson, 1986; Grossman, 1987; Grossman, 1990; Nespor, 1987). In fact, preservice teachers have had " considerable informal preparation for teaching" long before they enter the teacher education program (Feiman-Nemser, 1983, p.152).

Knowles (1992) conducted a case study of five preservice secondary teachers which showed that family influences and previous teachers had influenced all five preservice teachers conceptions of the teacher role. Other studies (Ball & Goodson, 1985; Goodson, 1980; Hargreaves, 1984; Perry, 1970; Woods, 1987) have shown the link between teachers and their biography and experiences. Their past can explain the teachers' decisions about their classroom practices. A teacher's past and personal beliefs can not be discounted when considering the influence on classroom practices.

CURRENT RESEARCH

Beginning science teachers often have to make curriculum decisions without a general agreement of science educators of the content they should teach (Sanford, 1988). Laboratory activities add an extra burden to these beginning teachers because of the extra time needed for preparation. The combination of these two conditions influences what subject matter is studied in a science course and possibly how the subject matter is presented.

Clark, Smith, Newby, and Cook (1985) studied the impact of teacher education coursework on preservice and beginning teachers. Researchers observed the teaching behaviors of the teachers in the study and then conducted interviews. The teachers were asked to give the origin of their observed teaching behaviors. The top five reasons were (a) own idea, 27%; (b) student teaching experience or cooperating teacher, 17%; (c) preservice education, 17%; (d) textbook currently being used in the classroom, 13%; and (e) a fellow teacher, 11%. It is important to notice that the teachers credited their preservice education for many, though not all, of their teaching practices. However, since these results are self-reported, the question of validity is raised. Anderson and Mitchener (1994) have noted that this is a common weakness in the research on science teacher education. They suggest there is a need to research the connections between preservice education and teacher practices by using classroom observations.

Stiles (1994) used a survey to evaluate the effectiveness of the University of Iowa's preservice science teacher education. This research suggests that preservice education has a positive impact on teacher practices. The survey assessed science teaching, ideas about learning strategies, teacher practices, and the objectives of teaching. A comparison was made of the preservice teachers and the science education faculty. A consensus was found in the areas of student-centered teaching and the use of research based teaching strategies. A study by Zeichner and Tabachnick (1981) suggests that these practices may not be maintained when the teacher becomes responsible for a classroom.

Mertz and McNeely (1991) investigated the beliefs about teaching that preservice teachers held prior to their professional education coursework. This study sought to test the impact of preservice education on the teaching behaviors of preservice teachers. Results indicated that the participants generally held naïve ideas about teaching. Seven of the ten preservice teachers felt that the preservice education would be of no benefit to their teacher preparation. Nine of the participants based their teaching practices on their own previous teachers. Rodriguez (1993) discovered that some professional education courses were perceived as more useful than others by six secondary science preservice teachers. The results are as follows:

> Science methods courses—where they had opportunities to try demonstrations, labs, and peer teaching—were considered practical courses. This is because they felt they were actually translating some of the teaching strategies and principles of learning from their notes to an actual situation. The foundation courses (which cover topics on educational psychology and theories of education) were found to have little or no impact on what they did in the classroom. (p. 220)

Rodriguez (1993) says there is a danger in students developing this viewpoint because the students perceive their preservice education as a bag of magic tricks that can be replicated in a classroom. This belief shows an immature understanding of teaching. The impact of the preservice education may not be evident until after the first year of teaching. It is possible that this impact may be completely invisible during the first year of teaching (Zeichner & Tabachnick, 1981).

Loughran (1992) conducted a longitudinal study to investigate the career development of 14 beginning science teachers in Australia. One focus of the study was to explore the factors that shape and influence teaching. Loughran indicated that some preservice education courses appeared to play a significant role in how beginning teachers idealized their classrooms. Once again, the findings should be evaluated cautiously because the answers were self-reported without any classroom observations.

NATIONAL SCIENCE STANDARDS

The *National Science Education Standards* (NRC, 1996) presents standards for science teaching, professional development of science teachers, assessment in science education, development of science education programs, science content, and science educational systems. For the purpose of this study, the section on science teaching is the only part the will be investigated.

Science Teaching Standards

The National Research Council's (1996) science teaching standards are based on five assumptions. They are as follows:

1. The vision of science education described by the *Standards* requires changes throughout the entire system.

2. What students learn is greatly influenced by how they are taught.

3. The actions of teachers are deeply influenced by their perceptions of science as an enterprise and as a subject to be taught and learned.

4. Student understanding is actively constructed through individual and social process.

5. Actions of teachers are deeply influenced by their understanding of and relationships with students. (p. 28)

These five assumptions are developed further into six teaching standards (NRC, 1996).

Teaching Standard A—Inquiry-based Instruction

Teaching Standard A describes the ways to develop an inquiry-based science program. Teachers are to use the curriculum design of their school districts as a framework but beyond that, the teacher should remain flexible. The *Standards* (NRC, 1996) call for lesson plans to be continually revised so that the teacher can be sure of the students' understanding before going on to the next topic. A teacher should be flexible so that students are allowed extra time to study topics they find interesting or to study topics that were not understood adequately.

Teachers should look at the cultural and experiential backgrounds of their students when developing the curriculum. Students who live in farming communities in the central part of the United States have had little or no exposure to oceans or beaches. This topic may not be of much interest to these Midwestern students. At the same time, the study of weather and soil conditions essential to farming may be a major concern (NRC, 1996).

Inquiry practices of real problems should be the basis of study. When more complex topics are introduced, teachers can still use inquiry techniques and studies do not need to be limited to the ones in the textbook. Information can be gathered from libraries and the Internet so that students can interpret data. If the community supports major industries or other jobs of a scientific nature, experts from the field can be used as a resource of information (NRC, 1996).

Collaboration is an essential part of science education. Not only should the students learn to work in cooperative groups but so should the teachers. Science teachers need to have time to work together so that they can develop an entire science curriculum for the school, not just their own classrooms (NRC, 1996).

Teaching Standard B—Teacher Facilitates Learning

"Student inquiry in the science classroom encompasses a range of activities. Some activities provide a basis for observation, data collection, reflection, and analysis of first hand events and phenomena. Other activities encourage the critical analysis of secondary sources—including media, books, and journals in the library" (NRC, 1996, p. 33).

The *Standards* (1996) suggests classrooms should be set up where the teacher guides students through different explorations that will show the students ways to cope with new situations in their environment. Teachers should allow adequate time for these explorations to develop but not so much time that students become frustrated.

Collaborative groups are an essential part of this teaching standard. Teachers need to give their students an opportunity to share data and to develop group reports. These reports can lead to group presentations in which students take responsibility for their own learning.

Teaching Standard C—Assessment

Assessments should come from many different types of activities such as interviews with students, portfolios, models, and written tests. Assessment should be continuous and the results should be used to monitor students' understanding of topics. At the same time, teachers help students to make self-assessments of their understanding (NRC, 1996).

Teaching Standard D—Adequate Time, Space, and Resources

A schedule must be developed that allows time for extended investigations. Interdisciplinary studies help to create a greater block of time available for these investigations. Adequate space is another essential element. Within this space, all of the indispensable safety measures should be available (NRC, 1996).

Variety is the key to the teaching practices. Teachers need to have adequate resources to be able to develop varying teaching practices. Resources outside the school walls should be used as a way to vary the curriculum (NRC, 1996).

Teaching Standard E—Developing Communities of Science Learners

All students must be given the opportunity to learn. Life-long skills and attributes should be developed with the aid of the teacher. Respect for other people and their ideas is one of these skills. New developments in science can only come about when the developments are respected by others (NRC, 1996).

Students should be given the opportunity to be responsible for their own learning. Teachers should allow students to make decisions about the activities and the environment of the classroom.

Communication between the students and their teacher is the key to accomplishing this (NRC, 1996).

Teaching Standard F—School Science Programs

Teachers should develop a cohesive school science program. School districts should allow time for this type of collaboration. "Teachers working together determine expectations for student learning, as well as strategies for assessing, recording, and reporting student progress. They also work together to create a learning community within the school" (NRC, 1996, p. 51).

Summary of Teaching Standards

Inquiry based instruction is a need for any science classroom. Students should have a major role in the decisions of the classroom. This should include what topics they wish to investigate at greater depths. Students should learn science through experimentation and inquiry with less emphasis on lecture and reading about the topics. Understanding of scientific concepts that were developed from this inquiry should outweigh the knowledge of scientific facts. Learning science as a scientist with an insight into how it affects communities should be the norm. The *Standards* (NRC, 1996) recommends that science should be taught as an integrated, interdisciplinary subject instead of separate subjects—earth, life, and physical.

SUMMARY

Science education has changed over the years but more change is needed in order to meet the needs of our modern society. Science education reform documents that are released to the public are written in layman terms. These documents should make reform efforts easily accessible for all educational settings. The problem lies in the limited amount of research on the classroom practices of secondary science teachers and the effects of preservice education on those practices. There is an enormous need for research in this area in order to have a baseline understanding so that true reform can be accomplished.

CHAPTER THREE

RESEARCH STRATEGY

One method of interpreting numerous sources of data is to use the case study method. This method relies on "interviewing, observing, and document analysis" (Denzin & Lincoln, 1994, p. 14). Anderson and Mitchener (1994) state that case studies provide a "deeper understanding of science teachers and their development" (p. 28), and the use of case studies leads to "promising investigations regarding science teaching" (p. 30).

Stake (1988) explains the roles of case studies in research and defines a case as :

> The principle difference between case studies and other research studies is that the focus of attention is on the case, not the whole population of cases. In most other studies, researchers search for . . . what is common, pervasive, and lawful. In the case study, there may be or may not be an ultimate interest in the generalizable. For the time being, the search is for an understanding of the particular case. . .[and is] deemed worthy of close watch. It has character, it has totality, it has boundaries. (p. 256)

Case studies are preferred in studies that answer how or why about a situation. The events the researcher studies is within real contexts. This allows the researcher to explore "individual, organizational, social, and political phenomena" (Yin, 1994, p. 2). The design for this study was a modified case study. A modified case study involves the same multiple sources of data that a case study would contain but it has fewer classroom observations or interviews. This type of study was used in order to research individual teachers in their native teaching situations.

Criticisms of the case study includes the "lack of rigor" (Yin, 1994, p. 2). Many times the researcher is sloppy and misses data that would be pertinent to the study. Other times the researcher is biased and this influences the findings and conclusions (Yin, 1994). Other criticisms of case studies are the lack of generalizability and the length of time needed to conduct a thorough case study. The long study develops a plethora of data that may only be relevant to a small population.

FOCUS OF STUDY

Research Approval

Federal regulations and Oklahoma State University require an approval of all research studies that involve human subjects. The Oklahoma State University Research Services and the Institutional Review Board use this review to protect the rights of the individuals involved in the research. In compliance with this policy, this research project was approved and assigned the following number: ED 96-101. This form is in Appendix B.

Method

Participants

Three first year teachers were selected to participate in this study. These teachers were selected from the seventeen science education majors who graduated from Local University [a pseudonym] in the spring of 1995. All met state certification requirements. Beginning teachers who had urban or out-of-state employment were eliminated from the selection pool. The remaining beginning teachers had a rural teaching position in the fall of 1995 in a community with a population of less than 25,000. For the purpose of this study, rural was considered as a town outside of the major cities that has a single attendance center serving middle school and junior high age students and one high school for the entire community. The state in which this study was conducted has far more rural communities than urban. These beginning teachers were questioned about their willingness to take part in this study. Other selection considerations involved the size of the community, gender, race, and educational background. Participants taught in three different sized rural communities with populations of 1200, 8000, and 19,000. Two males and one female were selected; one African American and two

Caucasian teachers participated. Two of the participants were non-traditional students.

<u>Instrumentation</u>

Data was gathered from the following sources: (a) lesson plans, (b) interviews with the individual teachers, (c) four formal observations of the classrooms in question, (d) *National Science Education Standards* (NRC, 1996), and (e) preservice course syllabi of the science methods courses and science courses. Information was gathered spring 1996, fall 1996, and spring 1997. A singular visit was made to each site during the spring of 1996. The researcher compiled data between the first and second year of the study and made suggestions to the classroom teacher about record keeping for the following year. The data were analyzed to see how science was taught by the individual teachers. A comparison was made to the syllabi of the science methods courses, the syllabus of a typical science course the teachers took during their undergraduate education, and to the recently released *National Science Education Standards* (NRC, 1996).

Analysis of the methods courses came from semester long observations and course syllabi. The methods courses stressed inquiry based activities and introduced the *National Science Education Standards* (1996) in the draft form. The final form was published in January 1996 which was the midpoint of the participants first year of teaching.

Observations and Interviews

All sites were visited the first week of May 1996. Permission slips were signed and suggestions for documentation were given to the teachers. A second visit to Andrea was conducted in the middle of September 1996. Visits in late October and early November 1996 were scheduled for all participants. In December 1996, a visit to Brian occurred. Late February into early March 1997 was the time frame of the next visit to all three teachers with a final visit to Chris in the first week of May 1997.

The first formal interview involving the questions in Appendix A were conducted on the first visit to each teacher in spring 1996. Informal interviews about the lessons were taken after each observation. The final formal interviews were conducted in spring 1997.

Design

This study is presented in a modified case study format. A modified case study format was chosen because of the multiple sources of data (Yin, 1994). The modification involved few observations than a traditional case study. The final design was an emergent design based on the description in *Naturalistic Inquiry* by Lincoln and Guba (1985). The authors give the arguments for using the emergent design as follows:

> within the naturalistic paradigm, designs must be emergent rather than preordinate: because meaning is determined by context to

such a great extent; because the existence of multiple realities constrains the development of a design based on only one (the investigator's) construction; because what will be learned at a site is always dependent on the interaction between investigator and context, and the interaction is also not fully predictable; and because the nature of mutual shapings cannot be known until they are witnessed (p. 208).

Analysis

After the first interviews were completed, two groups of classroom practices, expository and inquiry, were developed in which to place the data. Expository activities involve teacher directed activities such as lecture and the taking of notes. Inquiry activities involve students actively participating such as labs, games, or computer research. From the placement of each activity into one of the two groups, answers were found for the following:

1. How do these novice teachers approach teaching science?

2. In what ways do these teachers perceive their science methods courses affecting the way they teach science?

3. In what ways do these teachers perceive the way they were taught science affecting the way they teach science?

4. In what ways are the *National Science Education Standards* for teaching science (NRC, 1996) reflected by the teacher's classroom practices?

CONCLUSION

This study was about three beginning science teachers first two years of teaching practices and what influenced these teachers to teach in this manner. Multiple sources of data were used for evaluation. Three semesters of the first two years of three beginning science teachers were documented. A final analysis looked at each teacher separately in order to record the classroom practices of each teacher.

A modified case study format was used in order to use data from classroom observations, lesson plans, and interviews. These sources of data, as well as the preservice courses syllabi, are imperative to discovering classroom practices of science teachers. Studies of this nature are needed for science education reform to progress.

CHAPTER FOUR

ANALYSIS OF THE DATA

This chapter shows the data gathered in this study. A series of classroom observations and interviews were used to develop a biography of the teacher, the teacher's view of teaching, and an example of a lesson presented by the teacher. A review of the activities listed in lesson plans was used to evaluate the different classroom practices of the teacher. Each activity was placed in either the expository activity column or the inquiry activity column. When the review was complete, the type and the frequency of expository and inquiry activities was determined.

One thing that should be considered while reading these descriptions is the difference in the length of each teacher's class period. Andrea has a block of one hour and thirty minutes for each class period. Chris and Brian have class periods that are half as long as Andrea's block or forty-five minutes in length. It would be inaccurate to compare the amount and types of activities Andrea can do in one class period to the number and types of activities Chris and Brian can do in one class period.

Another area to be considered is the use of direct quotes from the teachers' interviews. At times, a direct quote would not make sense or would be in colloquial terms. In order to make the quotes understandable, author's notes will be in brackets.

ANDREA

Biography

Andrea (a pseudonym) entered Local University immediately after graduation from high school. Her goal was to become a high school chemistry teacher. The chemistry course on quantitative analysis led her to reconsider the area of science in which she wished to specialize. After this course, Andrea decided to make Biology her science of choice instead.

The decision to become a teacher and her present teaching practices are greatly influenced by Andrea's father, Mr. A. He has been an assistant superintendent or superintendent at a vocational technical school for as long as Andrea can remember. This gave Andrea a daily acknowledgment of the importance of education and the need for good teachers. She never wanted to have any other career.

Context

Andrea is currently finishing her second year of teaching at Near City High School (a pseudonym). Near City High School (NCHS) is an educational institution for grades nine to twelve with approximately three-hundred students per grade. Andrea described the student body as "kind of pleasant, kind of small town attitude. Everybody's pretty friendly even though we're right outside of the big city. We don't tend to have this inner city, big city kind of attitude. We're more country—

countrified, I guess, and most of the kids are pleasant. Everybody kind of knows everybody. Most of them are happy-go-lucky kids."

The community surrounding NCHS is not a wealthy community. It has a middle class socioeconomic base. Caucasian and Native Americans are the two major races represented. The population of Near City is approximately 19,000. A major employer for Near City is a glass company but most of the working population commute to work in the city close by. Agriculture is not a major source of income for the area.

Andrea considers herself lucky to have done her student teaching at NCHS. This gave her the advantage of understanding the A and B block scheduling prior to her employment. The scheduling consists of an A day schedule and a B day schedule. Each day's schedule has four blocks of one and one half hours each. Students attend the four blocks of the A day schedule every other day with B day's schedule on the alternate days. All eight courses are attended for the entire year.

Andrea stated that academics are strongly stressed at NCHS. According to the administration, the A day and B day block scheduling supports this concept. This type of scheduling exposes the students to all subjects all year instead of four classes per semester. According to the administration, this helps keep the students current in the major subject areas and the consistent, all-year courses are intended to increase the standardized test scores. Scores were not available to review.

Andrea does not feel this way about the scheduling. She says that she loves block scheduling because of the amount of time in each block but she does not like the every-other-day routine. She further implied that students seem to forget what you covered two days before, causing the teachers to reteach at the beginning of each new class period and over-emphasize material at the end of each class period.

The worst ramification of this schedule happens when students are absent. If they miss one class period, it is at least two days before the teacher sees them and another two before any make up work can be turned in. If a student is ill for an entire week, the situation escalates, making it hard on the students as well as the teacher.

Andrea is allowed to construct her own curriculum for Biology, Practical Biology, and Physical Science, as are the other seventy faculty members of NCHS. There is a standard text for each subject but the teachers are not mandated to use it. Andrea uses the state adopted text as a guideline for topics and as supplementary material instead of a decreed format. Block scheduling appears to have some effect on what is covered in the course. Some of Andrea's colleagues calculated the number of teaching hours in the block schedule. According to their calculations, the teachers lose six weeks of instruction time with the A and B block scheduling. Andrea believes that this reduces the number of topics she can cover with her students.

Andrea's classroom is a large room with windows along one side. Lab stations line the area below the windows as well as the bottom part of the opposing wall. The lab stations consist of built-in, waist-high cabinets with electrical outlets, gas jets, and sinks equally spaced along the surface. There is no place for the students to sit at the lab stations.

Thirty slant-topped desks/chair combinations are arranged in rows. When a lab or an activity requires cooperative groups, the desks are moved into groupings. If a formal lab setting is needed, Andrea must change rooms with one of the other science teachers who have a laboratory setting that is more conducive to her style of teaching. A formal lab that would better suit Andrea's classroom practices would consist of a room with fully equipped lab stations spread evenly throughout the area. Students would be able to sit down and still see the teacher.

Andrea's View of Her Teaching

Andrea taught two blocks of Practical Biology and four of Biology in the school year of 1995-1996. Practical Biology has the same content as Biology but it is designed for special education students and students who have difficulty learning. Presently, she is teaching two blocks of Practical Biology, two blocks of Biology, and two blocks of Physical

Science. In addition, Andrea coached a junior high girls' basketball team for both of her first two years of teaching.

Andrea says the structure of her Biology class simulates higher education science courses. According to Andrea, the predominant methods for teaching this course are lecture, lab, and worksheets with individual written tests as the standard evaluative tool. Andrea uses games as an alternative, cooperative, fun way to supplement the lesson. "I try to do one fun day where it's all fun and they might get to earn bonus points."

Andrea states that she changes practices for Practical Biology by including more discovery activities. This allows work to be done in cooperative groups. Sometimes these groups consist of two students and at other times they consist of four. Evaluation may be of many different formats. When talking about testing formats, Andrea stated that "I try not to give just a written test that they have to read but—our last one was a flash card test. . . . they had to basically sort the puzzle and put it together. The flash cards matched different sets—the picture with the name of the animal and its characteristics." All written tests are some kind of matching according to Andrea.

Andrea describes teaching Physical Science as a combination of the two previously mentioned classroom practices. She says she uses cooperative groups to present the lesson. The group members grade the individual who 'teaches' the lesson. Andrea recounts that most evaluations are made through a group test taken at the end of the instruction. If a retest is needed, it is an individualized test and the grade from it is averaged with the grade from the group test.

Labs for any of the classes are not handled in the traditional manner. A traditional lab would require lab groups to work at a lab station that contains all of the equipment needed to conduct the experiment. Andrea chooses not to use the lab stations because "they stand with their backs to me. They have to stand. They can't sit and do anything and they get restless." This limitation does not deter Andrea from conducting inquiry activities. For most lab situations, Andrea has the students push the classroom chairs together instead of using the lab stations. If a formal laboratory is necessary for an activity, Andrea trades classrooms with a fellow science teacher who has one of the three formal lab settings.

When asked who or what has had the most effect on her views and practices in her classroom, Andrea quickly answered "My dad. . . . he instilled them [teaching beliefs] in me. . . and living at home still, while teaching, I get even more of that. So he's probably had more influence than anything else." She went on to add " with the hands-on concept, it has made a difference that I have heard the other side of the coin [vocational school classroom practices], not just the college side of the coin."

When asked to describe an ideal classroom, Andrea responded that an ideal classroom is one of "about twenty kids at the most". The students would "do work on their own and without prodding me for every answer." She went on to say " if I had ideal kids it would be a solution to all of our problems." She said that her role would be as "if I could present them with something . . . and have them learn how to discover on their own."

My Evaluation of Andrea's Teaching

Andrea accurately described a part of her varying styles but she limited herself to general, readily accepted terminology—lecture, lab, and test. She has a relaxed atmosphere in which the students appear to be comfortable. Students joke and tease with Andrea on the way into the room and on the way out. Andrea responds with a smile and an acknowledgment of any recent accomplishment the student has achieved.

Andrea's classroom practices are much more developed than she describes. She works hard to reach each and every student. The following is a description of one lesson I observed.

Upon entering the room, I noticed two large, clear pieces of vinyl taped to the ceiling. Objects of various shapes and colors were suspended within each sheet of plastic. A closer examination revealed that the hanging objects were models of plant and animal cells. The students had constructed these models in their previous class periods.

I was prepared to watch a plethora of notes about the cell organelles and their functions, but this did not happen. Andrea had made flash cards for each student. Each flash card contained a picture of an organelle and the name of the organelle on one side and a description of the function of the organelle on the other. The students were asked to review their flash cards by themselves for five minutes. During this time, Andrea walked up and down the rows pronouncing words for students and pointing out the structures in the ceiling models.

Next, the students got into groups of four and practiced quizzing each other with the flash cards. This was done in order prepare the students for the fun activity—Andrea had made a deck of cards for each group. Each card held either a description of the function of an organelle or the name of the organelle. Playing of the game is similar to 'Go Fish'. To start the game, one student would read a function and ask another student for the corresponding name card. Neither of the cards had the correct answer so the group had to agree on the match. Flash cards could only be used to check the answers if there was a disagreement.

The student asking for the name card lost his turn if there was no match. Some students eventually ran out of function cards so they were either passed over or another student shared their extra cards. Play continued until all cards were matched. The next round consisted of playing the game by saying the name card and asking for the function card.

The instruction did not stop here. The students returned to their original positions. A few at a time went to the corner of the room to retrieve their review disks. Review disks are poster board cut into dinner-plate-sized sections. Each circle is divided into equal parts by drawing lines across the diameter. The number of parts in the circle is determined by the number of items in the review. One side of the disk had the cell organelle's functions. The other held facts about cells.

Answers to the review disk were taped to clothespins. Students were given an opportunity to practice on their own review disks. Each slot of the disk had an answer on a clothespin. Answers for each side were printed on different colors of paper. Andrea held races for extra credit, in which the first student to get all of the clothes pins (one side) attached to the correct slots won a candy bar.

Everyone participated enthusiastically. Incorrect answers were left attached to the disks so the students could try again. All of the students were given a chance to correct the answers before Andrea rechecked the disks. Right before the end of class, the students were given a quiz using the review disks. Students followed similar patterns to the previously mentioned. At the end of class, they took the quiz one more time and turned in their review disks with the clothes pins attached for a grade.

Other lessons I observed were similar to this as were the lessons documented in the daily lesson plans. The entire hour and one half were filled with a variety of activities. Some of the activities were done individually but the vast majority were accomplished in cooperative groups of two or four students.

Other Sources of Data

Classroom practices

Andrea uses a variety of expository practices in her classroom. Her lesson plans reflect an almost daily use of classroom practices that would be found in college science courses such as lecture, notes, and worksheets but she does not limit her instruction to these. Visual lessons incorporating the use of videos and laser disk are also used. In order to help her students learn content, she makes flash cards or instructs her students to make review circles.

Inquiry practices are just as varied as the expository. Andrea has labs, presentations, making of models, and research reports practices along with the more commonly used methods of inquiry. The research reports are created using information from the library and the Internet. When other forms of instruction are needed, Andrea is just as likely to use a game or physical activity as she is the above-mentioned inquiry practices.

Classroom presentations are varied. The mixture of the expository and inquiry activities are intertwined in such a way that they create a solid base of science education. Neither of the types of practices, expository or inquiry, appears to be able to stand alone. The expository activities prepare the students for the inquiry activities and the inquiry activities support the content introduced in the expository presentations.

Influence of methods course

Andrea's methods courses stressed inquiry methods. The students in her methods courses were required to develop a wet lab to present to the class. This wet lab, an open-ended experience using manipulatives (which may or may not be liquid) and/or science equipment to teach content, was part of a unit developed to teach at the high school level.

Inquiry practices, such as labs, presentations, making of models, and research reports, are intertwined through each course Andrea teaches. According to Andrea's lesson plans for the Fall of 1995, Andrea introduced twelve inquiry activities in Practical Biology and sixteen in Biology. These activities were spread over forty-two days of instruction. The Spring 1996 brought an increase of these types of activities to Practical Biology, fourteen in forty-four days of class. Biology had thirteen activities in the same time frame.

The school year of 1996-1997 brought Andrea another course to teach, Physical Science. This was in addition to the previous two, Practical Biology and Biology. Biology had sixteen activities in thirty-seven days of class and ten in thirty-nine days for class for the Fall of 1996 and the Spring 1997 respectively. The reason for the fewer days in the semesters of the 1996-1997 school year is because Andrea was absent for a few weeks in the middle of the school year. Physical science had fourteen and seven activities in the same time frames. In the Fall of 1996, Practical Biology had fourteen inquiry activities. Spring 1997 had ten activities that were inquiry in nature. The occurrence of these inquiry activities is a reflection of the material introduced in Andrea's methods courses. Her methods courses stressed the use of hands-on, inquiry activities.

Influence of science classes

Andrea has expository activities almost daily. With the block schedule, there is enough time to do more than one type of activity in a class period. The days there are inquiry activities, there is also an expository activity. Andrea uses lecture and notes occasionally, but she does not limit her classroom practices to these. The other types are listed in the classroom practices section of this report.

When asked whether her methods courses or her science courses had more influence on her teaching, Andrea stated the following:

> I guess probably the way I was taught science because I didn't want to teach that way. I wanted to do it different[ly] than straight out of the book. . . . then my problem was if I'm not going to teach it this way, what do I do? And that's where the other [methods course] came into effect as this is the way to do it now. Cause I know I don't want to do it the old way, the book method. Because of one [science courses], I had to learn the other [methods courses].

<u>Standards</u>

Andrea is aware of the release of the *National Science Education Standards* (NRC, 1996) in 1996 but stated she does not know what is contained within them. Although she is unaware of the *Standards* (NRC, 1996) specifically, she practices many of the concepts suggested within them. Analysis of each teaching standard will be described individually.

When evaluating data for NSES Teaching Standard A (inquiry-based instruction) reteaching by retesting in mentioned in Physical Science. This is the only documented case of reteaching but when I compared the lesson plans to the days I observed, I saw more flexibility. None of the lessons were exactly as written in the lesson plans. Andrea added review activities when the students seemed a little unsure of the material.

Inquiry activities are intertwined through each class period. Each section of content studied by Andrea's students involves at least one inquiry activity. In most cases, there are many inquiry activities per topic studied.

Standard B (teacher facilitates learning) is difficult to describe. Andrea uses every source available to give her students the opportunities to analyze data. Lab activities created first-hand data and the library and Internet were used as resources. Research reports were developed from these forms of data.

Standard C (assessment) is as easy to discover as Standard B was hard. The variety of activities are under constant scrutiny in order to analyze the students' comprehension of the concepts. Class reviews, using flash cards, review games and review sheets, gives Andrea and the students a pre-test evaluation. If Andrea does not think her students are ready for a final evaluation, she gives more pre-evaluations to help prepare her students for the exams.

A variety of teaching practices is part of Standard D (adequate time, space and resources). This is readily evident in both Andrea's classroom observations and her lesson plans. Andrea develops new techniques as she deems necessary. She states that her first year was experimental. She would bring in new activities and see if they worked. If they worked, she started incorporating these new types of activities into her teaching. If the activities did not work, Andrea either reorganized the activity and reintroduced it to her classes or she eliminated the activity from her repertoire of classroom practices.

One way NCHS accomplishes Standard E (developing communities of science learners) is by giving all students the opportunity to learn is by having inclusion of the Special Education students. In Andrea's Practical Biology course, the special education students are given the opportunity to learn science with their peers. Andrea is aided by a Special Education teacher, who is in the classroom during the Practical Biology classes. Andrea develops her lessons with suggestions from the special educator and the special educator aids Andrea in directing the students to stay on task. Although it appears as if the students are aware of those students who have great difficulties learning, mutual respect is encouraged from both educators. No student is allowed to exclude or ridicule another student.

Summary of Andrea's Teaching

On the surface, Andrea appears to be more influenced by her science courses than her methods courses because of her almost daily use of lecturing and note taking. Deeper analysis shows the influence of her methods courses. She develops inquiry activities to aid in presenting the material. Her inquiry activities are intertwined within expository activities. None of the units she presented the two years I observed her were solely lecture, notes, and worksheets. Either a game or a lab or both were included in each unit.

Andrea is very creative in her teaching. For instance, when the students could not grasp the flow of blood through the heart, Andrea developed a 'Twister' game of the heart parts. A diagram of the heart was painted on a white sheet and a dial of the heart parts was turned to instruct the students where to place their hands and feet. After a few rounds of the game, the students understood the blood flow through the heart.

This type of creativity is a regular occurrence. Andrea uses whatever she can to keep her students interested while she is helping them learn new material. All in all, Andrea combines expository and inquiry activities in such a manner that they are interdependent and intertwined in the classroom presentations.

CHRIS

Biography

Chris was a non-traditional student and approaches teaching from a somewhat different perspective. He started college at a major university as an athlete, playing football. After a year, he realized he no longer wished to play football. "I had been playing too long. . . .what I decided from that point on was to get a job and [I] started a family and got married." After four years of work and four years of military, Chris decided to return to school with the intention of becoming a physician. He started his return to education at a junior college and then moved to Local University. In his junior year, for various reasons including having to schedule a time to take the MCAT, Chris chose to change his major to science education. "Since I had all the sciences, anyway, to become an educator, I thought that would be a positive way to take care of my family again. So I went ahead and opted to take that route. I'm glad I did because I love this. It's great." He graduated from Local University and has been a seventh grade Life Science teacher for the last two years.

When asked who has had the most influence on his teaching style, he answered Mrs. C (a pseudonym), his high school English and journalism teacher. According to Chris, Mrs. C is a twenty-four hour-a-day teacher who is strict yet caring. Her students were as much a part of her personal life as they were her professional life. Mrs. C was always there to help her students.

Context

Chris is currently finishing his second year at Little Town Middle School (a pseudonym). Little Town Middle School [LTMS] holds grades sixth through eighth with approximately 540 students in attendance. Chris described the student body as one in which there are "[n]ot a lot of discipline problems".

The community surrounding LTMS is predominantly middle class. Caucasians make up ninety percent of the population of about 8000. The major employers are the school system, a prison facility, and a pipeline company. Little Town used to be a major oil town prior to the crash of the oil industry in the mid 1980s.

Chris has a large classroom that is filled with various furniture. Along the wall between the two doors leading to the hall, there are two three feet high bookcases full of a variety of books, such as encyclopedias and other science textbooks. The front wall has two separate computer stations, a four-drawer file cabinet, and a teacher's desk. Continuing around the room, the side wall is almost entirely windows covered in alternating orange and black curtains, which are the school colors. Science cabinets containing microscopes and other lab equipment stands near a lab demonstration table at the back of the room. There is adequate equipment available to conduct a variety of labs and lessons. In addition, the central area of the room is filled with thirty slant-top desks/chair combinations arranged in five even rows of six.

Chris develops his curriculum from a state adopted text. Lessons are developed in the order of the chapters of the textbook. The scheduling structure of the school consists of seven class periods in which Chris was required to teach six classes the first year and five the second year.

Chris's View of His Teaching

Chris describes his teaching as follows:

> I use a lot of group learning. I do a lot of cooperative learning with the kids. Probably about 30% of the time we're in cooperative learning. [This is] where they get in groups and find facts of their own. They're going through books. They're going through all types of references. And they are teaching each other. And they ask me what they don't understand. Once that ends, we go back to more common types of teaching where I'm lecturing and they're listening.

When asked about what methods Chris uses in his classroom, he described his first year as one of trying different methods of teaching. He said he was "Just trying to find myself. Find out what the kids enjoyed. What way they learned more. So I did a lot of things that was (sic) cooperative learning. We did a lot of field type lab situations where we went outside." He proclaimed that environmental science was a major constituent of his first year's lessons.

When asked who or what has had the most influence on his teaching practices, Chris responded that the person who has had the most influence is a teacher [from the high school in Chris's home town]. Chris went on to say this about the teacher. "She's strict, willing to do what it takes to help. I feel I adopted her philosophy of teaching. . . .

That's what inspires me. Her ways inspire me. I find myself doing the same thing."

Chris' concept of an ideal classroom is "one that is fully equipped with technology and fully equipped with [the] capability to do research we [the class] wanted to do". He went on to say that his role in this ideal classroom is "to just facilitate. When you have an ideal classroom, the students have their own motivation. . . . You just stand back and watch and basically answer the questions that will give them problem."

My Evaluation of Chris' Teaching

All of the lessons I observed involved lecture or class discussion. Each lesson was setup similarly. Chris read out loud from the text, which provides a review of the reading material, students made comments and asked questions, and then notes were written on the board. The students transferred the notes to their science notebooks.

Chris left the notes on the board for the next class. The notes were mainly facts on whatever the topic was for the day. If there was time left at the end of the hour, questions at the end of the section or chapter were orally responded to by the students or were given as homework. .

When a new word was introduced, the students were instructed to enter the word and its definition into the glossary section of their notebooks. In a different section of the notebook, students recorded information about scientists and their discoveries. I did not observe any other types of lessons or classroom practices during my visits.

Other Sources

Classroom practices

I started gathering data on all three teachers in this study in April of 1996. Chris was able to provide me with lesson plans for the last nine weeks of the 1995-1996 school year on my first visit. I had planned to have lesson plans for all of 1995-1996 on all three beginning teachers. The full records were not available for Chris. For this reason, I will discuss only his second year of teaching in the 1996-1997 school year.

During both his first and second year of teaching, Chris also coached the football and track teams at the high school. To complicate things, the middle school at which he teaches is on a different schedule than the high school. The middle school has seven classes a day while the high school has six. During his first year of teaching, Chris would teach six sections of Life Science at the middle school then rush over to the high school and coach. He did not have a true planning period. He was coaching at the high school during the middle school's seventh period.

Chris' second year, the school district alleviated some of the problem. Chris taught the first five class periods and the sixth was his planning period. In actuality, because of the scheduling differences, Chris only had part of the sixth period before he had to go to the high school. Still, it appears that the time requirements of the coaching assignment detracted greatly from the preparation time available for the science classes he taught.

Chris's lesson plans show that he uses the textbook as a guideline for the content of his lectures. He alternates reading textbook passages, providing class notes, and leading a class discussion. This pattern was used on all the days I observed in his classroom. He evaluates students through written tests which included multiple choice, true and false, and fill-in-the-blank questions.

His lesson plans indicate that he used inquiry activities in the form of laboratory activities on eighteen occasions out of 180 days of instruction. Three of these days were a lab practicum of the body systems. The lab activities will be more fully discussed in the next section.

Influence of Methods Courses

Chris believes that "My methods courses have helped me far more [than the science courses] because in science we just did science. We didn't look [at] how to teach it".

Chris' methods course encouraged the use of inquiry activities to teach the content. There are eighteen inquiry activities listed in his lesson plans. Of these, three are lab practicals on the systems using the frog dissection. Chris describes this process. "We'll learn a lesson or two or three lessons and we won't have a paper test over that. Instead we have a lab practicum. [A lab practicum is] where [the students] take all of what they know and apply it to—for instance, dissection. I teach the skin systems, the skeletal system, and muscular system and then we go to the lab. . .and get a frog or. . .mammal. [The students] point out [the systems] on the [animals]."

Chris mostly uses inquiry activities to supplement the content for the course. A few times, these activities were used to test the students knowledge of a certain topic. Chris does not use inquiry methods to introduce a new topic.

<u>Influence of Science Courses</u>

Chris described his science courses as "Content, content, content. If you did a lab, it was so structured". This is the way Chris presented science to his seventh graders. Although he involved his students in open discussions, his main emphasis was on content. In the interview, Chris commented that he felt content was very important. "Getting the knowledge of science is very important." The labs that were mentioned in his lesson plans had specific design. Students were required to make certain observations. Chris' lesson plans and my observations tend to suggest that his science courses had more influence on his teaching than his methods courses.

Standards

Chris is aware of the *National Science Education Standards* (NRC, 1996). "The National Standards give me more of a focus of what they [the students] should be learning in class and what's appropriate in my teaching."

Inquiry activities are in the form of labs or groups researching a topic. Information for these types of activities is gathered from the activity itself as well as a classroom set of encyclopedias and the Internet. This type of inquiry is suggested in Teaching Standard A (inquiry based instruction).

Chris uses group discussion as a way to teach the content. During all of my observations, the discussions involved the entire classroom. Chris would read a passage from the textbook and then individuals in the class would present questions or statements about the topics. Sometimes the students lead the discussions. In this way, Chris uses the collaboration practices mentioned in Teaching Standard B (teacher facilitates learning). At the same time, these activities allow the students to be responsible for their own learning. This is reflected as a part of Teaching Standard E (developing communities of science learners).

Assessment is the main concern of Teaching Standard C. Chris uses both written tests and lab practicum to assess his students.

During my observations, I noticed that during his group discussions he would question the students for their understanding of the topic.

Teaching Standard D (adequate time, space, and resources) addresses the need for extended activities. Three days of measurement labs and three days of frog dissection portray the time needed for extensive investigation. Longer times for these types of activities are needed for comprehension of the topic.

Summary of Chris' Teaching

Chris is a well-liked teacher by his students. Whenever there is a class discussion, the students respond in a positive manner. Enthusiasm is shown by every student in the class. If a student appears to be reluctant or shy, Chris finds a way to include that student in the discussion.

Chris perceives himself as doing a good job. The students appear to be learning when you observe the classroom discussions. Questions fly by so fast that it is hard to keep up at times. Social interaction is a major concern to Chris and he sets up his class in such a way that social interaction can be an important part of the class. Classroom discussions are a more relaxed type of teaching content than lecturing but it has similar results—note taking. Note taking is the main component of university science courses.

Chris is a teacher at all times. Between classes, students come by and ask him questions. The same is true during the times directly before and after school. Lunch time is a repeat performance. Chris can not complete a meal without students stopping to ask him a question. You could say that he is a twenty-four hour a day teacher.

BRIAN

Biography

Brian (a pseudonym) started college at Up North University (a pseudonym) in Michigan. At that time, he intended to become a physician. Half way through his junior year, he left school in order to manage a plasma center. At that time, "the money was too good to pass up." A few years later, he reconsidered this decision and went back to school at Other University (a pseudonym). This time, Brian was attending college in preparation to become a science teacher. After a year at Other University, he transferred to Local University where he completed all of his education courses and met Dr. Local (a pseudonym).

Dr. Local was Brian's science methods professor. Brian credits Dr. Local with having the most influence on his teaching practices. Dr. Local is an evangelist for constructivism and science reform. She has a strong belief in contructivism and considers it the main philosophy for good science teaching. Dr. Local has been a supporter of the *National Science Educational Standards* (NRC, 1996) since the initiation of *Science for All*

Americans (AAAS, 1989). These philosophies were readily presented and stressed in the science methods courses.

Context

Brian is currently finishing his second year at Little Village School (a pseudonym). Little Village School [LVS] is a school for grades Head Start through twelfth with approximately 300 students in the entire school. Brian describes the student body as "Rowdy, undisciplined. Not as school spirit-filled as I'd like to see."

The community surrounding LVS is predominantly African American. The socioeconomic base is on the lower end of the economic scale. Agriculture is the main employer of the area. Little Village has a population of around 1200.

Scheduling for the school consists of eight class periods. Brian teaches seven of these class periods. The secondary teachers teach all of the courses in their field of specialty that are designed for grades seventh through twelfth. Brian uses state adopted texts for all of his classes except the independent research class. The curriculum for the classes using a textbook is designed in the same order as the chapters in the texts.

Brian's classroom has changed from the first year to the second. The first year, the room was very small. Eight-foot ceilings and no windows are the first things I noticed. The lab was next door to the regular classroom. Three rows of black slate lab tables in tight-fitting rows took up most of the room. Walls painted the color smoker's finger yellow contributed to the depressing atmosphere.

The second year brought some change. The classroom section remained the same but the wall between the classroom and the lab room was removed. Four lab stations, containing sinks, electrical outlets, and gas jets, are equally spaced in the lab section. Large cabinets containing equipment are set along the wall areas between the lab section and the classroom. The amount and variety of equipment is extensive, especially for such a small school. LVS has fully stocked Chemistry and Biology cabinets and has all the glassware needed for teaching secondary science. Brian has even found a previously purchased electrophoresis kit which I have rarely seen in a public school. Equipment is not a problem or a deterrent to hands-on activities.

Brian's View of His Teaching

Brian has had a minimum of six different subject preparations in each of the two years he has been at LVS. When asked about his teaching practices, he chose to discuss a recent presentation in tenth grade Biology.

Protein synthesis is the topic of the lessons Brian describes. He states that the first day was spent making a DNA code and learning to decode it. Brian says his students discovered how messenger RNA is made from the DNA template. Part of the class period was spent reading about this topic according to Brian.

Brian went on to describe the next day. He talked about an activity where each student gave the previous day's code to another student and the new student had to decipher the code. After this, the students read about transcription in their textbook. Brian went on to say that the next step was an activity that the students worked through a protein synthesis. The lab area was the nucleus with the master strand of DNA. A student had to decode the DNA into messenger RNA and take it to the ribosome. Brian said that the classroom tables were designated as the ribosomes.

The next step was for the messenger RNA to be translated into transfer RNA. One member of the group went around the room finding out which amino acid matched the transfer RNA. That student called back the name of the amino acid to the group and the name was written on a file label. The next part Brian described is fascinating. He says that the students took the labels and put them on graph paper. When the groups came across certain amino acids, Brian told them to turn the graph paper a certain way before attaching the label. This activity had the students making a model of their polypeptides.

When asked who or what has had the most influence on his teaching practices, Brian responded "This sounds corny, but Dr. Local."

He went on to say that the reason was " because before that methods class, Methods I, I had no idea about what my teaching philosophy would be. She made us really sit down and think about those things".

Dr. Local had all of the students develop their concepts of an ideal classroom. Brian says that for him:

> An ideal classroom would be set up to maximize learning [and to] minimize distraction. Learning [would involve] not only the process of [science and] being able to understand base knowledge of science but [the classroom would be] set up for further exploration.

He went on to say that his role would be "guiding [with] some shoving."

Brian is much more of a disciplinarian than the other two teachers of this study. In response to a question about the reason he is more strict, Brian stated the following:

> Knowing the expectations of my principal has for the classroom behavior, [knowing that] when I do let the students get a little loud in activity, and knowing that he'll [the principal] come down and ask me to get them quiet, I would say it's sixty percent my background and forty percent the environment [in which I teach].

My Evaluation of Brian's Teaching

I will discuss a lesson that involved the seventh grade Life Science students reviewing for a test. The material was on monerans and viruses. Brian used a game called Blackboard Basketball that he developed.

LVS has held a state championship in basketball for the last three years. In fact, they have held this title five out of the last six years. Brian said he wanted to relate this enthusiasm for the sport of basketball to his class. Therefore, he developed the game of Blackboard Basketball.

Before starting the game, two young men were chosen to be team captains. Each captain selected who he wanted on his team. Once everyone was selected and moved to their team area, the game began.

Play begins with a jumpshot. This is a question asked that either team is eligible to answer. The person recognized by Brian as having their hand up first was asked to answer the question. If that person answers correctly, their team has control of the ball. If the person who was considered first answers the question incorrectly, control goes to the other team.

Once a team has control, each person on the team is given an opportunity to control the ball and make a shot. The student picked to answer a question is given the option of a two point or three point question. Three point questions are usually more difficult. One three point question that was asked was "What is the difference between autotrophs and heterotrophs?"

If the student does not know the answer, they may pass the ball to another player on their team. If this person answers the question correctly, the team wins two points. This is true even if the question was originally worth three points. If the question is answered incorrectly, the opposing team gets the question. This is called the rebound. If the question is answered correctly by any person on the team, this team gets the two points.

Fouls are also built into the game. If a student gives the answer out of turn, a technical foul is called. The same is true if a student cheats by giving another student the answer. In both cases, the opposing team gets two points. The students appeared to enjoy the game. When a team would get behind, they would ask for a three-point question. In fact, the teams fought for the lead throughout the entire class period.

Other Sources

Classroom practices

Brian has had an unbelievable schedule both years. He taught six different science courses his first year—Biology, Physics, eighth and ninth grade Physical Science, Chemistry and seventh grade General Science. His second year, Brian taught seven different science courses—tenth grade Biology, ninth grade Physical Science, high school Botany, eighth grade Earth Science, high school Chemistry, seventh grade Life

Science and an independent, original resource course for seniors.

His expository activities are predominantly made up of lecture, notes and worksheets. When you look at the inquiry activities, you find a much greater assortment. He used labs, research reports, models and presentations to aid the students in learning the content. Jeopardy and Blackboard Basketball games were used to review the material prior to an exam.

Brian feels pressure from his administration to have a quiet, clean classroom. He knows that his principal will ask him to get the students quiet if the principal feels there is too much noise. Because of this situation, Brian discards many inquiry activities that have a possibility of being too loud.

Influence of Methods Courses

Brian's methods courses had a major effect on his beliefs about teaching. When ask what the reason was for this effect, Brian stated "Because before that methods class, Methods I, I had no idea about what my teaching philosophy might be. . .[Dr. Local] believes in a constructivist philosophy and I've adopted that and I wish could implement it more fully in my situation."

During Brian's first year, he used inquiry methods in each of the sections he taught. General Science had the most inquiry activities with thirty-five activities throughout the year. Physical Science had twenty-eight inquiry activities during the same time frame. Biology, Chemistry, and Physics had twenty-one, twelve, and eleven inquiry respectively during Brian's first year of teaching.

Brian's second year shows a drastic increase in inquiry activities. Out of one hundred seventy-six days of class, the new independent research class had one hundred twenty-three inquiry activities. Botany, also a new class, had inquiry activities. When the researcher compared the number of activities from the first year to the second, Biology had an increase of thirty-five inquiry activities. Chemistry had an increase of thirty-three inquiry activities. Physical Science, Earth Science, and Life Science had fifty-five, forty-five, and fifty-one inquiry activities respectively.

Brian explains the reason for fewer inquiry activities his first year with the following:

> I was hired two days before the semester [started]. . . . I don't get to do as many activities as I feel I'd like to and the students aren't as hands-on as they will be next year. . . . unfortunately there is an over emphasis on lecture this year [the first year].

I agree with Brian's account of the situation. His predominant classroom technique for the first year was lecture. This is not true of the second year. Inquiry practices consume a greater amount of classroom time in the 1996-1997 school year.

Influence of Science Courses

Brian says that learning science has affected his teaching by serving "as a model of how I don't want to teach and how I try to avoid teaching". Expository activities do fill most of the days Brian taught his first year. As was previously mentioned, Brian felt that this was due to the lack of preparatory time before school started. His second year shows a drastic decrease in the lecture/note format of teaching.

Standards

Brian is knowledgeable of the *National Science Education Standards* (NRC, 1996) and has developed two units that portray some of the content standards. Looking at the teaching standards, you can see that Brian practices many of the guidelines in the *NSES* (NRC, 1996).

Teaching Standard A (inquiry based instruction) is most easily seen in Brian's second year honors class which is an independent research class. This class was almost entirely inquiry-based. Research projects involved the community around LVS as well as resources outside Oklahoma. Students were required to develop their own research projects. Once the research was completed, each student presented the findings to the rest of the class.

Cooperative learning activities were a part of every subject. These situations could be seen in labs, presentations, and in the games. Jigsaw activities were used to introduce content. A jigsaw activity is one in which the information that needs to be presented is divided up among different groups. Each group presents their part of the information to the rest of the class.

Brian's lesson plans shows that he allowed time for extra exploration. The plans would be amended to show this extended time. Reteaching activities are included in all subjects where they were deemed necessary. These reteaching activities most often occurred after an exam or prior to the taking of the nine week's or semester's test.

Student inquiry was a part of Brian's classroom. The first year it was not as extensive as it was the second. In the second year, Brian increased the number of inquiry activities for every class he taught. Make-up days were included to allow adequate time to complete activities. Other times, entire schedules were reorganized by Brian in order to give the students more time to finish a project. These two characteristics, inquiry activities and extended time allowance to complete these activities, are presented in Teaching Standard B (teacher facilitates learning).

Assessment appeared to be mostly written tests. After almost every exam, a time was allotted to reteach any topic that was not well understood by the students. Teaching Standard C proposes this quality for all science classrooms.

Teaching Standard D (adequate time, space, and resources) advocates a schedule that allows for extended investigations. Honors science the second year was repeatedly set up in this manner. As soon as one extended project was completed, another was designed. The lesson plans showed changes in the time length so that the students had adequate time to complete the assignment. The rest of Brian's classes had at least one extended project a year.

Research practices are taught at all levels. These skills are a part of the qualities needed to develop life-long learning skills and attitudes. With these practices, all of Brian's students were given an opportunity to design their own experiments. Students were encouraged to research the topic in area libraries and the Internet for background information for their projects. Teaching Standard E (developing communities of science learners) is fulfilled with these occurrences.

Summary of Brian's Teaching

Brian has done a remarkable job with the situation he has been dealing with the last two years. Trying to plan for six classes, much less seven, is an impossible situation for most veteran teachers. Brian has diligently worked to improve the situation for his students. He increased the number of inquiry activities and decreased the number of expository ones during his second year of teaching.

Brian believes constructivism is the appropriate philosophy for teaching science. His second year shows this concept. In all of his classes, seventh through twelfth, Brian created activities that were not only age and subject appropriate, but were also inquiry-based. He appears to have the ability to know exactly what the students can and cannot handle.

Brian has so little time to plan so many different activities that it would have been easy for him to use this as an excuse. He did not. The first year he struggled finding out what would work and what the students enjoyed. All of this was done in an atmosphere of constraint. His principal believes that a quiet and clean room is a constructive room. This along with the classroom itself would also give most teachers the necessary argument for not striving to fill their students' needs. For Brian, this is not so. He continually and consistently strives to create activities for his students. It would be interesting to see what Brian would do in a less confining atmosphere.

CHAPTER FIVE

INTERPRETATION OF THE DATA

The purpose of this study was to examine how three novice science teachers approached teaching science and how their methods and science courses influenced how they taught. The participants for this study were selected because these teachers graduated from Local University, had the same methods professor, student taught the same semester, and started teaching the same year. However, each of the teachers involved in the study had a different context in which they taught.

All three beginning teachers had a rural placement for their teaching assignments but each community was different. Brian was in the smallest community and was assigned to teach all of the secondary science courses. Chris taught in a community that was large enough to have one science teacher for each grade level of science. Andrea was a part of a larger high school. At Andrea's school, there were three or four teachers for each subject depending on the need of the student population.

Classroom Practices

1. How do these science teachers approach teaching science?

All three of the teachers used lecture, notes, and worksheets in their classrooms. Andrea and Brian use a more formal form of lecturing than Chris. Andrea and Brian will stand at the front of the room and present the notes orally. If more structure is needed, they will use the overhead or the chalkboard to write down outlines or terms.

Chris uses a more open approach to lecturing. He reads a paragraph or two from the text and then opens a question to the students. The entire classroom participates in a discussion until Chris is ready to read another section.

Andrea has other ways she aids her students to learn science facts. She develops flash cards for some of the topics she covers. The flash cards for cells have a labeled picture of the structure located within a cell on the front and the definition and function on the back. The students practice these together as well as alone. Review circles are another way Andrea helps her students learn content.

Both, Andrea and Brian develop games for instructional purposes. The games are designed to be fun as well as factual. When commenting about the games, Andrea and Brian said they use games so that the students don't realize they are studying. The students think they are just having fun.

Laboratory activities can be found in all of the classrooms. None of the teachers use these types of activities to drive their curriculum. Instead, the lab activities are used to supplement or enhance the topic at hand.

The teachers in all three classrooms used computers to gather data from the Internet. Andrea and Brian use this data in two ways. One, they use this data to supplement the content base of the lesson and two, they use this data to direct or initiate an inquiry activity. Chris mainly used the Internet for information about the topic he is discussing.

Research has a different connotation for the three teachers. Andrea and Brian believe it can be student driven and directed where as Chris believes it is used to find facts. Andrea and Brian make the library, computers, and outside resources readily available for the students' use. The students in Andrea and Brian's classrooms direct their own investigations using the above mentioned resources. Chris gives the students topics or uses the students questions as the starting point. When a students asks a question that Chris does not know about, the students are directed to look it up in encyclopedias or on the computer.

Influence of Methods Courses

2. In what ways do these teachers perceive their science methods courses as affecting the way they teach science?

Brian and Chris perceive that the methods courses had a great influence on how they teach. This is readily evident in Brian's classroom. No matter what subject Brian is teaching, he uses open ended labs and long term investigations with his students. These types of activities were greatly stressed in the method courses. Chris, on the other hand, had few inquiry activities. Chris' classroom is predominantly content driven. Inquiry activities are not as evident in Chris' teaching practices as the expository activities he directs.

Influence of Science Courses

3. In what ways do these teachers perceive the way they were taught science as affecting the way they teach science?

Andrea and Brian perceive the greatest influence of how they teach comes from their science courses. You would normally expect this to a positive influence but in this case it is not. Both of the above mentioned teachers see their high school and university science courses as an example of how science shouldn't be taught. These educators practice this belief. Chris also perceives that his science courses were a negative influence. Chris' classroom presentations do not reflect this belief. He commented that his science courses were "Content, content, content". So is Chris' teaching. Content directed lessons are the norm in Chris' repertoire of teaching.

Standards

4. In what ways are the *National Science Education Standards* for teaching science (NRC, 1996) reflected by the teacher's classroom practices?

The *Standards* (NRC, 1996) were released in January 1996, halfway through the participants first year of teaching. Brian and Chris state that they are aware of and practice the guidelines set forth in the *Standards* (NRC, 1996) because a draft form was available for the participants to review during their science methods courses. My observations and Brian's lesson plans readily reflect many of the teaching standards. Brian's inquiry based instruction exemplifies the type of teaching needed to fulfill the guidelines suggested in the *Standards* (NRC, 1996). Brian did not exhibit all of the intricate sublevels of the teaching standards, but part of each teaching standard was portrayed.

Chris was not able to display the same understanding of the teaching standards. Many of the sublevels of Teaching Standard A (inquiry- based instruction), C (assessment), and D (adequate time, space, and resources) were not as evident in either the observations of Chris' teaching or his lesson plans as they were evident in Brian's observations and lesson plans. In my opinion, Chris is not as knowledgeable about the components of the teaching standards as he professes to be.

Andrea is an enigma. She says that she is unaware of the content of the teaching standards but she exhibits all of the standards in her teaching practices. Very few of the sublevels are missing from her teaching. It will be interesting to see if she changes her classroom presentations if and when she studies the *Standards* (NRC, 1996).

Conclusions

Science education reform is needed to prepare our students for the twenty-first century but how it is done will have to be individualized according to the needs of each educational community. This study showed that the science courses had a major effect on the teachers. If the science courses were presented in the format suggested in the *National Science Education Standards* (NRC, 1996), science teachers would not have to wait until their science methods courses to be exposed to the practices recommended by the National Research Council. Life long experiences of hands-on activities would allow the teachers to have a more developed idea of the appropriate use of these activities. This would open up a new world for the methods courses. Instead of presenting and justifying the use of hands-on activities, the methods courses could fine tune the already present attitudes and abilities of the preservice science teachers. In addition, the methods courses should be designed to reflect the needs of the school districts in the state.

Science education reform is a slow process. Even though the teachers of this study were aware of the standards, knowing and practicing the standards are two different things. Studies must be done to determine the best way to initiate the standards to preservice and practicing teachers. But the research can not stop there. Periodic follow up studies must be done to insure that the standards are implemented successfully.

It was surprising to the researcher that the participants did not mention the effects of either their student teaching experience or their mentoring resident year experience. Past studies have shown that these experiences have a great deal of influence on the classroom practices of teachers. Instead, all three of the teachers were influenced by other teaching situations.

This state requires criterion reference testing for all students. The participants did not appear to be pressured or guided by these tests. Teachers have been known to stop the regular curriculum at some point in order to prepare their students for the criterion reference tests.

Suggestions for Further Studies

I will be continuing my study of the three participants for at least three more years. This will involve a similar design to the one I used for this study but it will be expanded to include the influence of any inservice education and graduate school education. Teachers across the nation are required to complete some kind of education each year. The effects of these new experiences needs to be documented.

A study should be done on the beliefs of how administrators think science should be taught. In Brian's situation, the principal has a dampening effect on the classroom instruction. Many studies are done on the equipment needed and the classroom design and how these effect teaching. Yet, with all the oppressing atmosphere Brian's classroom presents, he feels that the principal has a greater influence on how Brian teaches.

Reform of science education can not be a blanket attack on teachers. An educational program about the *Standards* (NRC, 1996) must be developed. Research needs to be done on effective ways to educate practicing science teachers and community college and university science professors about the recent reform before any changes can be made in science education.

Another type of study this report suggests in one that involves other states of the United States. Each state should conduct a similar study of their recent graduates but they should go a step further and include experienced teachers.

Further studies of the influence of cooperating and mentoring teachers is a must. This study showed that there was very little influence from these situations. If this is true in this state, universities need to reevaluate their education programs or redesigned the student teaching and resident year experiences.

Criterion reference testing is becoming a prevalent method of evaluating teachers. A question must be answered. How do these test affect the classroom practices of teachers? A differentiation between the effect on beginning teachers and practicing teachers must be incorporated into this study.

Finally, a study of urban teachers should be initiated. Each school and school district has their own context. This context has a great influence on the teachers and their practices. Urban situations have their own strengths and weakens and the teachers that are teaching in the urban settings have different situations than those of rural teachers. Studies should be developed to answer this question.

Final Thoughts

Practicing science teachers have a great responsibility, as do all teachers, to prepare young people for the twenty-first century. From this study, it is evident that the preservice education has an influence on teacher practices but so do individual teachers prior to the college years. It is imperative that science teachers, both preservice and practicing, become aware of the *National Science Education Standards* (NRC, 1996) in order to give their students the best preparation they can for the future. Then, and only then, can the promise of science education reform can be fulfilled.

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APPENDIX A

Questions for Spring 1996 Interview

1. How would you describe your community? (size, socioeconomic base, major employer)
2. Describe your school. (grades, number of faculty, number of science teachers, etc.)
3. What are the demographics or organizational structure of your school? (scheduling, major emphasis, organization)
4. What is your teaching load? (subjects, number of students, number of preparations, extracurricular duties)
5. What resources are available for you to use? (laboratory structure, equipment)
6. Describe your teaching.
7. Describe your vision of an ideal classroom. What is the teacher's role in this ideal classroom.

Questions for Fall 1996 Interviews

1. Who or what has had the greatest effect on your views and practices in teaching? (specific examples)
2. What is the mood of this school? (prompt)
3. Describe your preservice education.
4. How has the way you learned science affected your teaching? (prompt)

5. How has your science methods course affected your teaching?

   (prompt)

6. What methods of teaching science do you incorporate into your lesson plans? Describe in detail and give the approximate amount of time you use each method.

7. Are you aware of any standards for teaching science.

APPENDIX B

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 04-04-96 **IRB#:** ED-96-101

Proposal Title: HOW SCIENCE IS TAUGHT: A CASE STUDY OF THREE RESIDENT YEAR SCIENCE TEACHERS IN RURAL OKLAHOMA

Principal Investigator(s): Kate Baird, Martha Boedecker

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL.
ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

Signature: John H. Wyckoff

Chair of Institutional Review Board

Date: April 11, 1996

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VITA

Martha Boedecker

Candidate for the Degree of

Doctor of Education

Thesis: WHAT INFLUENCES SCIENCE TEACHING? A STUDY OF THREE NOVICE RURAL SCIENCE TEACHERS

Major Field: Curriculum and Instruction

Biographical:

Personal Data: Born in Enid, Oklahoma, September 16, 1953, the the daughter of Thomas A., Jr. and Karyl Kennedy.

Education: Graduated from Woodward High School, Woodward, Oklahoma, in May, 1971; received Bachelor of Science degree from Southwestern Oklahoma State University in 1975; completed requirements for the Doctor of Education degree in December 1997.

Professional Experience: Secondary Science Teacher, Judson ISD, Converse, Texas, 1985-1990; Secondary Science Teacher, Putnam City Schools, Oklahoma City, Oklahoma, 1990-1995; Teaching Assistant, Department of Curriculum and Instruction, Oklahoma State University, 1996-1997.