MIDDLE SCHOOL ASSESSMENT AND THE NATURE OF SCIENCE AS RELATED TO THE NATIONAL SCIENCE EDUCATION STANDARDS

By

ROSEMARY HORN ESKRIDGE

Bachelor of Science
Central State University
Edmond, Oklahoma
1969

Master of Education
Central State University
Edmond, Oklahoma
1976

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MIDDLE SCHOOL ASSESSMENT AND THE NATURE

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Thesis approved:

Steve Marks
Thesis Adviser

Kenneth E. Wiggins

Eric W. Dugger

Kate Baird

Wayne B. Powell
Dean of the Graduate College

PREFACE

This study was conducted to determine to what extent teachers in Oklahoma City are demonstrating good science teaching behaviors and assessment practices as related to the National Science Education Standard, Part B, Section 1.

There are many people who have contributed in various ways to the completion of this study. My greatest appreciation goes to my husband Gordon who has supported me with many ideas, helped me to express what I though that I was saying, and helped maintain the host of family priorities. I would like to express my appreciation to my dissertation committee which included: Dr. Kenneth E. Wiggins for providing the opportunity for me to continue my education in a newly designed program for aerospace studies; Dr. Steve Marks for setting a great example of how to teach inquiry learning at the collegiate level; Dr. Cecil Dugger for his interest and many helpful comments. Also, I would like to express my deepest appreciation for Dr. Kate Baird for her interest, comments and assistance in the completion of my study. I wish to express my sincere appreciation to the Oklahoma State University faculty and staff: Drs. Doris K. Grigsby, Nelson Ehrlich, and William O. Robertson.

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CHAPTER I

INTRODUCTION

Background

The emphasis given to experimental problem-solving skills in science curriculum innovation has not been matched by the development of compatible assessment tools. Ross and Maynes (1983) suggested that innovations in North American science curricula over the last 20 years stressed, among other things, a shift away from replicate knowledge as the prime end of instruction to an emphasis on inquiry, scientific processes, and problem solving. "Doing science" in the 1980s was a first-order priority, but for some reason the assessment of science made few strides toward any meaningful type of change. Padilla and Okey (1983) described research studies conducted in the seventies that imply there was a direct correlation between the integrated science process skills and intellectual development. Yet few, if any, of these researchers indicated any major change in the assessment process.

According to Kamen (1996) formal research investigation lacked the perspective of what really happens when a classroom teacher attempts to implement new assessment strategies.. He stated factors contributing to the successful implementation such as administrative support, close contact with parents, collaboration with university faculty, teacher's ownership, and the flexibility to try a variety of strategies are not adequately addressed. Kamen (1996) noted that numerous articles were published that make practical and theoretical arguments for the use of a variety of assessment strategies to gain a better picture of what children understand. With the endless array of articles advising teachers to incorporate authentic assessment into the elementary science classroom and the lack of research into teacher implementation, there is a need for formal research examining the use of authentic assessment in the middle school classroom as well. For this study the following shall be used as the definition of authentic assessment

> Worthen in Kamen (1996 p 860) states that:
>
> Alternative assessment (which includes direct, authentic, and performance assessment) is described as having two central features: first, all are viewed as alternatives to traditional multiple-choice, standardized achievement tests; second, all refer to examination of student performance on significant tasks that are relevant to life outside of school.

The National Science Education Sampler (1992) emphasized that the findings of research on student motivation also have impacted strongly on the design of the school science programs. It was shown that discussion was important in the development of understanding. The "quote" incorporation of discussion has transformed a class from a collection of individuals sitting in a classroom to a community of learners seeking a common understanding. Individuals participating in a discussion have communicated their observations and interpretations of the natural world to their peers, and in so doing, test the extent to which their points of view were shared commonly.

According to Kjoernsli and Jorde's (1992) article Kamen (1996) described their discussion of the need to develop instruments that go beyond testing factual information. The instruments assess how children are learning science and provid information on possible misconceptions. Hein's (1991) article reviewed by Kamen(1996) challenged the use of multiple choice and short answer tests—just one point on the continuum of assessment of science achievement.

Dana's et al. (1991) quoted by Kamen (1996) suggested a constructivist epistemology about knowledge supported the need for assessment strategies that invited individual expression of a student's unique understanding of a science concept. Wiggins (1990) quoted by Kamen (1996) added the following abstraction about assessment: "Decontextualized assessment suffers from a lack of validity. We cannot be said to understand something unless we can employ our knowledge wisely, fluently, flexibly, and in particular and diverse contexts." (p. 860)

McIntosh (1996) indicated that challenging alternative conceptions while helping students to clarify and understand new information require more than student-student and student-teacher interaction. McIntosh (1996) has cited the NSES as an aid to refocus the content of his course. In so doing he still considered the priority of addressing the fundamental scientific concepts and principles of the disciplines at the same time assigned greater emphasis to presenting information within a context of students' collaboration to solve complex problems that allow students to demonstrate understanding and information transfer.

Motivation has been one of the rationales for including in the science curriculum the history, nature of science, and examples of the contributions of other cultures to the growth of science information. The student's discovery of the offering of other cultures to the growth of scientific understanding contributed to the student's discovery of science as a basic drive of man to understand the natural environment and as a common human curiosity that existed in all ethnic groups and cultures. Most of all, the motivating power of relevance has been the basic factor in which science is organized around the theme of decision-making. Students were more engaged in learning science when they fully appreciated its relationship to their daily lives. The question is how to assess the understanding of the relationships between science content and everyday lives. Perhaps this can be addressed more simply as the assessment of human curiosity and understanding.

The NSES suggest the need for equality of assessment practices. In the past assessments were the primary feedback mechanisms in the science education system. Through assessment students were provided with feedback on how well they are meeting teacher expectations. Research on assessment has demonstrated that teachers were provided feedback on how well their students were learning, school districts were provided feedback on the effectiveness of their teachers and programs, and policy makers were provided feedback on how well policies were working. By identifying fundamental characteristics of exemplary assessment practices, the NSES serve as guides for developing assessment tasks, practices, and policies.

As science educators were changing the way they thought about good science education, educational measurement specialists were acknowledging change as well. The importance of assessment to contemporary educational reform had catalyzed research, development, and implementation of new methods of data collection along with new ways of judging data quality. The National Science Education Standards A Sampler (1992) emphasize these changes in measurement theory and practice.

Sternberg (1992) stated that current tests, inadequate though they may be, largely responded to the demands of test consumers. However, these demands have shown some signs of changing and the time has come for test publishers to take these signs seriously, rather than continuing to produce products that represent superficial change.

From a marketing standpoint recent developments indicated that computerized testing, quick fix tests and cognitive batteries were coming of age but fill many marketable skills. Computerized testing required for tailored testing is not available in most schools. For a number of years, the market appeared to be indicating that computers were the direction in which things were going, yet computerized testing has not yet arrived on a broad scale to date. Most schools do testing at the same time and few schools have enough computers so that everyone can use a computer at the same time. The varying abilities of students computer skills based on those who do and do not have computers at home could have cause testing bias, as might the lack of teachers who know how to use computers for testing might also be a problem. "Quick-fix tests" promised to eliminate racial bias and differences but do so at the cost of emphasizing measurement of abilities were rather peripheral to most conceptions of intelligence. "Quick fix tests" may have appealed to some market segments, but they are probably even less scientifically defensible than what was currently on the market. Cognitive psychologists attempted to construct test batteries on the basis of current cognitive theories. The subtests of the batteries were not even correlated substantially with each other, much less with external criteria. Sternberg (1992) suggested that basic elementary cognitive processes were not correlated well with other things over a 100 years ago, and they still are not today.

Sternberg (1992) described the efforts of Howard Gardner et all (1988) in their various projects such as SPECTRUM and PROPEL. SPECTRUM has relied heavily on subjective assessments of students' interests and abilities over the course of a long period of time such a year. The assessments were obviously highly subjective, extremely time-consuming with regard to gathering data, expensive, and highly confounded. PROPEL made heavy use of portfolio assessment which, in the current state of the art, was probably more relevant in measuring achievement than in measuring ability.

Pallrand (1996) identified a retrieval system for students' mental receptacles that no longer provided support for the old position that students absorbed and processed new materials in a form that was essentially identical to that in which the information was originally presented. This old view of learning and knowledge was sufficient in the past when what was known changed very slowly. But, this was no longer the case due to the information explosion. Assessment when used to evaluate a students explanation or discussion of a concept provided a window into a student's thinking as he or she demonstrated understanding by explaining phenomena. This process also enabled the teacher to determine how the student had organized his information.

Kirst and Mazzeo (1996) described learning assessment processes as undergoing many conflicts. The California Learning Assessment (CLAS) pioneered new forms of assessment. Yet, parent groups, the governor, religious groups, boards of education, and the California Teacher Association all raised objections to assessment during the 1993 implementation.

The CLAS case illustrated some of the difficulties involved in large-scale transformation of state assessment systems. Advocates of performance-based testing were provided with an exemplary case of the difficulties of moving policy toward more "authentic" forms of assessment and away from the measurement of basic skills through multiple-choice exams.

The NSES (1996) continue to emphasize a shift to "authentic assessment." This called for exercises that closely approximated the intended outcomes of science education. Authentic assessment exercises required students to apply scientific knowledge and reasoning to situations similar to those they would encounter in the real world as well as to situations scientists would encounter.

The NSES (1996) provided criteria to judge the progress toward the science education vision of scientific literacy for all students. The assessment standards described in the NSES should be used to improve classroom practice, to plan curricula, to develop self-directed learners, to report student progress, and to research teaching practices. The assessment standards provide a process for identifying fundamental characteristics of science assessment and provide a variety of process for the implementation of these standards. This research is focused on determining how Oklahoma City middle schools are beginning to implement the NSES for assessment.

Statement of the Problem

In what ways are Oklahoma City metropolitan area middle school teachers implementing Assessment Standard B, Part 1 of NSES? This standard focuses on "the ability to inquire" and "knowing and understanding scientific facts, concepts, principles, laws, and theories" also known as the Nature of Science.

Purpose of the Study

The purpose of this study was to identify many of the good teaching behaviors and assessment practices that are being used by middle school teachers in Oklahoma City. Many science teachers have used inquiry processes to teach students principles, facts, and laws. Subsequently, students were then assessed by standardized tests over a few isolated facts that often failed to give a true picture of what science students were actually capable of achieving much less of what they had truly learned. This study was designed to identify how middle school science teachers determine what their students really have learned though inquiry processes known as the nature of science.

Definitions of Terms

AMERICA 2000: A project that was a bold, comprehensive, and long-range in 1990 to move every community in America toward the National Education Goals adopted by the President and the governors in 1990.

Assessment: A task or series of tasks used to obtain systematic observations presumed to be representative of educational or psychological traits or attributes.

Assessment standards: The science education assessment standards that were presented in Chapter 5 of the NSES as criteria for judging the quality of assessment practices.

Attitudes and disposition: Curiosity, reflection, pleasure in understanding and empowerment to participate

Guided inquiry: A process that involves everyone in a learning situation agreeing to resolve a certain question. (The process may take the forms of, "What would happen if".)

Habits of mind: Intellectual honesty, skepticism, tolerance of ambiguity, openness to new ideas, communication and sharing

Inquiry: Those processes in science that teach about the nature of science. It is the activity process involved in learning science that begins with asking a question.

NSES: The published results of a project that was designed to bring together the scientific community including the National Science Foundation, the National Research Council, the National Committee on Science Education Standards and Assessment, the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. These groups have worked to develop a consensus that emphasizes a new way of teaching and learning about science that reflects how science itself is done, emphasizing inquiry as a way of achieving knowledge and understanding about the world.

The National Research Council: A council organized by the National Academy of Science in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government.

The Nature of Science: A domain of science that included modes of inquiry, habits of mind, and attitudes and dispositions.

Modes of Inquiry: A person's ability to formulate questions, plan experiments, make systematic observations, interpret and analyze data, draw conclusions, communicate, and obtain an understanding of inquiry.

Non-traditional assessment themes: Assessment processes associated with the NSES such as portfolios, rubrics, performance assessments, demonstrations, and discussions, etc.

Project 2061 Science for all Americans: A set of recommendations by the National Council of Science and Technology Education on what understandings and habits of mind are essential for all citizens in a scientifically literate society.

Science endorsement: The state certification that a person in Oklahoma receives to teach science whenever that person does not have a degree in science. Usually the endorsement includes having eighteen hours of science core classes, which can be basically all introductory level science courses. The science endorsement usually qualifies the individual to teach science in a middle school.

A science degree: Completion of at least thirty hours of a particular science degree with more than one/half of the hours including upper level science classes.

Secondary science certificate: A certificate of completion when a person who has a major in a particular science area accompanied by a degree in education.

Traditional assessment themes: Activities used to assess science learning . These activities have been typically designed as true/false, multiple choice questions, and essay questions.

Significance of the Study

This descriptive study was designed to identify fundamental characteristics of assessment as recognized by the NSES that were being used in Oklahoma City middle school classrooms. American Association for the Advancement of Science (AAAS) (1989) has described the cascade of recent studies that has made it abundantly clear that by both national standards and world norms, the United States education system is failing too many students-and hence failing the nation.

AAAS (1989) stated:

> Reform is needed because the nation has not yet acted decisively enough in preparing young people especially the minority children on whom the nation's future is coming to depend, for a world that continues to change radically in response to the rapid growth of scientific knowledge and technological power. (p. 3)

The possibility existed that middle school science students were being taught through one process and then tested by standardized tests that in no way reflected process skills that middle school teachers knew to be necessary for inquiry learning. When middle school students were provided with a standardized test containing thirty isolated questions covering the whole field of science, and success on that test determines how much they knew, something suggested that perhaps statistics created by the student's test scores were somewhat unreliable.

The information derived from this study will enable students, parents, teachers, administrators, and policy makers to determine what areas of reform are being implemented and will provide the information needed to assess scientific literacy through new standards of scientific education assessment. The NSES have suggested that science literacy is of unprecedented importance. First, it is important because an understanding of science offers personal fulfillment and excitement. Second, it is important because Americans are confronted increasingly with questions in their lives that require scientific knowledge and scientific ways of thinking for making informed decisions that will in the long run benefit the individual. Business communities have been asking for entry-level workers with the ability to learn, reason, think creatively, make decisions, and solve problems. Concerns regarding economic conditions necessitated the importance of an educational system that enabled mankind to keep pace with global competition. The design of this study enabled the duplication of its use throughout the states as one of the first attempts to document how schools are beginning to implement the NSES.

Assumptions

The following assumptions were made in this study:

1. All of the participants in the study have been full time middle school science teachers in the Oklahoma City Public Schools during the 1996-1997 school year.

2. The fact that all of these teachers had a science endorsement or a secondary science teaching certificate was assumed to somewhat standardize their background knowledge into the two categories that could be used to identify themes.

3. All of the schools contained a population of approximately 800 to 900 students.

4. Each school's population included Hispanic, Black, Asian, and a minority of white students.

5. Teachers would vary in the number of years of experience in the teaching profession , yet the number of years of experience should not reflect an effect on the change toward use of the NSES. The study assumed that all teachers have had some type of access to either verbal or written information about the NSES directed at assessment.

Limitations

The focus of this study was limited to those participants who teach middle school science in the Oklahoma City Public Schools. The data was used to determine if the teachers have used the NSES for assessment as a part of their curriculum. The study was limited to evaluating activities that reflected the NSES for assessment. The time frame included only the 1997-98 school year. Since our nation has only recently begun setting national science education goals and developing standards to meet them, the length of time since the NSES have been published will determine limitations to this study. This type of research was limited to those, who were committed, to the strategies associated with national science education standards reform.

Organization of the Study

An introduction of the research was specifically organized in Chapter I to identify those aspects of teaching behaviors and assessment that were reflected in Assessment Standard B, Part 1, of the NSES. These are described as the "ability to inquire" and "knowing and understanding scientific facts, concepts, principles, laws, and theories." Included is the statement of the problem, purposes of the study, definitions of terms, significance of the study, assumptions and limitations of the study. Chapter II of this study identified several important precursors to the NSES. It described how educational reform determined that learning science was something students do not something that was done to them. The conclusion focused on assessment practices that were used with active learning processes. Chapter III described how the research was conducted and how the data was analyzed to determine if the Assessment Standard B, Part 1, of the

NSES for assessment have been implemented in the classroom. Discussed are the participants, the instrumentation, design of the research, and how the data will be analyzed. Chapter IV included a discussion of the research participants, and an analysis of the data. It looked at themes determined by the responses of the participants to the questionnaire. Chapter V provides a summary of the research. The chapter was divided into two sections: one, the conclusion; and second, the recommendations that are made from the interpretation of the data.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The review of the literature supported the concepts of Assessment Standard B, Part 1, of the NSES. "Achievement data collected focused on the science content that is most important for the students to learn" is the foundation of this standard. The assessment activities suggest a method of implementing different aspects of the NSES. The review of the literature conceded the following three things. First, expectations for implementation of the NSES must be developed from the concept that writings about reform in science education revealed very little related to a change in how we assessed science learning. Second, the consensus approach represented a valuable means for identifying critical understandings about assessment. These assessments are needed by middle school science teachers to assess a student's "ability to inquire" and to determine the best assessment process for determining how students demonstrated knowing and understanding scientific facts, concepts, principles, laws, and theories. Third, the nature of certain philosophical, psychological, and material support systems have served to either assist or impede the implementation of the assessment aspect of the NSES.

A Historical Look at Standards

Andersen (1994) described science education reform as a topic that has gained increased exposure in such proposals as Scope, Sequence, and Coordination Project and Goals 2000. He characterized the efforts to maximize science teaching and learning experiences as beginning more than 100 years ago. In 1893, the National Education Association (NEA) commissioned a group to study the science curriculum in forty "typical" secondary schools. This group reported that many of the forty science courses were taught for such a short period of time that relatively little value was received by the students.

The NEA established the Committee of Ten. They were charged with the task to develop recommendations for restructuring science curriculum in schools. Andersen (1994) quoted three recommendations that were made by this committee according to Krug in 1969:

- There should only be four science courses taught in the secondary school;
- These courses should be taught in the following sequence beginning in the freshman year and continuing through the senior year; freshman-physiography; sophomore-biology; junior-physics; and senior-chemistry;
- Science should be taught all year during each of the four years.

This Layer Cake Curriculum was developed by the Committee of Ten strongly resisted any attempts to change it. The Commission of College Physics convinced the Committee of Ten that physics was such an abstract subject that it should not be taught until students had a more mathematical background; therefore, so physics became the senior science curriculum study.

Anderson(1994) described John Dewey's theories on how children learned best through direct experience, through being allowed to cultivate their natural curiosity, and through taking responsibility for their own learning. Those schools that attempted to implement Dewey's ideas were unable to sustain his intellectual and pedagogic vision. Andersen (1994) stated that Dow in 1991 described the so-called "Progressive Education" that followed was often a diluted curriculum filled with trivia causing Dewey to disclaim much of the educational practice his writing had inspired.

Andersen (1995) depicted the following fifty years as demonstrating little movement from teaching science as a body of knowledge, or from the notions that the function of the laboratory was to substantiate what the students had already learned. Andersen (1995) further described the initial effort led by the Physical Sciences Study Committee (PSSC) supported by the National Science Foundation in 1956. The changes that this committee desired were so fundamental that the leadership demanded a fresh start, not a revision of the status quo. He described the PSSC as the first to incorporate inquiry laboratories into the curriculum, thereby leading all other science curriculum reform efforts in the nation.

In the 1960s, Andersen (1995) attributed the changes in science education to Jerome Bruner's (1962) emphasis on four major themes. First "the teaching and learning of structure rather than simply the mastery of facts and techniques is at the center of the classic problem of transfer." Second, "...our schools may be wasting precious years by postponing the teaching of many important subjects on the grounds that they are too difficult." Third, "Intuitive thinking, the training of hunches, is a much neglected and essential feature of productive thinking, not only in the formal academic discipline, but in everyday life." Fourth, "The teachers are the principal agents of instruction, not the teaching device." The Woods Hole Conference encompassed the philosophies of the country's most eminent scholars whose major focus was improving science education in primary and secondary schools.

The results of the conference forced educators to realize that teachers would have to be trained. The majority of the science teachers had not been trained in inquiry nor had they even seen curriculum materials that incorporated Bruner's themes. A number of National Science Foundations sponsored summer and academic year institutes which began to fill teachers up with more "good science" content exhibiting very few opportunities to learn about and practice scientific inquiry. New science curriculum was now available but only about half of those using it taught science in a manner consistent with the developing of the materials. No consistent leadership provided for training teachers or curriculum specialists on how to assess the new focus on learning that teachers were to have implemented.

Padilla and Okey (1983) described Gagne's (1965) work arguing that acquisition of the science process skills should be a major goal of science instruction. This viewpoint had been accepted and was reflected in curricula developed specifically to reflect on the integrated process skills of hypothesizing, identifying, and controlling variables, defining operationally, interpreting data, and experimenting. Again, no references were made as to how teachers were to assess these newer concepts of science learning.

Andersen (1994) described the scientific community through Dow's (1992) portrayal of the tone of the period surrounding Sputnik as stimulating more practicing scientists to become involved in science curriculum reform than at any other time. He described Jerrold Zacharias (1969) and his colleagues with the following quote:

> If children could not understand something they (the developer) were trying to teach, they assumed that it was they who were not clever enough, not the children. The scientists realized that "to be maximum effective, the lesson must stir the heart as well as the head.(p. 50)

Zacharias (1969) continued to develop curricula. Many of the other scientists returned to their laboratories when Congress withdrew their support of the NSF. State authorities developed long lists of things that students should learn and textbook companies responded by collecting the lists and designing textbooks that satisfied everything by including at least one line about every fact on the state list.

Faison and Schlagel (1998) conducted a visual check of all the science departments in the Oklahoma City Schools. The researcher viewed 300 photographs of the general conditions of the science classrooms, science equipment, and supplies. Photographs included sinks that were no longer connected to drains and sinks that were beyond use. Most of the equipment and lab tables had been purchased around the time of Sputnik when an emphasis on science provided funding for such needed items. The lack of materials and equipment was the most commonly reported theme. At this point Faison and Schlagel (1998) have identified a common problem among inner city schools and in fact a common problem where lack of science leadership demonstrates unequal access to learning science.

The NSES (1996) completed this historical look at endeavors for standards by listing their important precursors. In the 1980s the American Chemical Society (ACS), the Biological Sciences Curriculum Study, the Education Development Center, the Lawrence Hall of Science, the National Science Resources Center (NSRC) and the Technical Education Resources Center all developed innovative science curricula. In 1989, the American Association for the Advancement of Science (AAAS), through its Project 2061, published Science for All Americans which defined scientific literacy for all high school graduates. The National Science Teachers Association (NSTA), through its Scope, Sequence & Coordination Project, published The Content Core. In 1983, a call for reconsideration and reform of the United States educational system was prescribed in a book called A Nation at Risk. Andersen (1994) concluded that critics seemed resolved to write more reports about the poor state of science education.

Andersen (1994) ventured to suggest that the documents which appeared to really invigorate the reform process were Jacobson and Doran's (1989) "Science Achievement in Western Countries," American Association for the Advancement of Science (Rutherford1989), Project 2061: Science for All Americans (1989), and Aldridge (1989) "Essential Changes in Secondary School Science: Scope, Sequence & Coordination." Bybee and Champagne (1995) stated that the significance of science teachers was also recognized in the assessment standards, recommending greater opportunities for teachers to employ their professional discernment about students' understanding of science and the quality of science programs and teachers' methods. Recognition of the fact that assessment standards were not examined was paramount to Bybee and Champagne (1995) in that the standards present a vision of change and improvement for science education and goals for student achievement.

Implications for Science Teachers

Bybee and Champagne (1995) believed that science teachers must have advocates in their formidable task of implementing the NSES. The burden for the improvements implied by the national standards cannot be placed on science teachers in elementary, middle, and high schools. It was easy to recognize the changes that must occur in the science curriculum, the teaching methods, and in assessment practices that will align the curriculum with national science standards, but the charge was a great responsibility as are the changes too extensive for teachers to assume responsibility without support. The total education community including school administrators, scientists, legislators, and parents must become involved, but science teachers must assume part of the leadership needed to achieve the vision and goals of the NSES.

The NSES suggested that these assessment standards can be applied equally to the assessment of students, teachers, and programs; to formative and summative assessment practices; and to classroom assessments, as well as large scale external assessments. Assessment was a systematic, multi-step process involving the collection and interpretation of educational data.

In this new view, assessment and learning were identified as two sides of the same coin. The methods used to collect educational data define in measurable terms what teachers should have taught and what students should have learned. When students engage in an assessment exercise, they should have learned from it. The National Science Education Standard's (1996) view of assessment placed greater confidence in the results of assessment procedures that sample an assortment of variables using diverse data collection methods, rather than the more traditional sampling of one variable by a single method. Using the NSES, the ability to inquire, scientific understanding of the natural world, and the utility of science were measured using multiple methods such as performances and portfolios as well as conventional paper-and-pencil tests.

Authentic Assessment for Intended Outcomes in Science

Ross and Maynes (1983) have questioned the kinds of measuring devices that are required for the function of measurement. The value of measurement devices should have been judged by the extent to which the data they generate indicate improvement in the experiences of students in schools. The absence of an appropriate paper-and-pencil instrument to measure experimental problem-solving skills has made it inordinately difficult to evaluate classroom programs responsive to the reform movement in science education. Experimental problems were not the only type of problem encountered in science programs; there were also problems that required correlation analysis, comparative thinking, decision making, and prepositional logic.

Pate, Homestead, and McGinnis (1993) challenged the description of a good problem solver. They were also concerned with documenting a student's involvement in social action, integrated studies, or small-group or whole-group activities. Regular tests, pop quizzes, and exams given to the entire class made little sense. Using alternative assessment in integrated curriculum had made sense. Pate et al. (1993) suggested that Aschbacher and Winter's (1992) description of performance assessment required students to actively accomplish complex and significant tasks while bringing to bear prior knowledge, recent learning, and relevant skills to solve realistic or authentic problems.

Pate et al. (1993) also have described a rubric as a scaled set of criteria that clearly defines a range of acceptable and unacceptable performance measurements for the student and teacher. Criteria was used to provide descriptions of each level of performance in terms of what students will be able to do and values were assigned to each of these levels. Process and content are evaluated equally as well by rubrics as they have been by assessment of writing performance, advanced organizers, portfolios, and in evaluating district outcomes. Rubrics have been a useful tool to evaluate student performance in an integrated curriculum. The flexibility of rubrics had met the needs of middle school students who desired structure both for security and freedom to try new things.

Assessment Through Portfolios and Journals

The recording of these tasks was a direct function of journal keeping and led directly to portfolios and their cross curriculum inclusion capability. Portfolios had been used in assessment for language arts, reading, social studies, math, technology, mass media, and gifted/talented classes. Teachers had investigated the place portfolio assessment held in both integrated and interdisciplinary learning. The change to student centered schools required teachers to become colleagues on interdisciplinary teams. This was accomplished by integrated writing skills in all subjects. Individually, staff members visualized how to integrate portfolio strategies into their personal teaching styles. Writing served as a major tool for providing evidence of student learning. Teachers provided a self-check list for students of what should be found in the portfolio. They also included a personal assessment sheet of the portfolio using rubrics to grade the materials in the portfolio, how they rated their effort in completing the work, plus an overall rating of their portfolio. Then, the grade was computed by the teacher and sent home with the report card. The parents were then asked to respond to the portfolio in writing and return it to the teachers.

Portfolio Performance

Portfolios have taken their place in the assessment areas, but Martin, Miller, and Delgado (1995) have an additional feature to add called the Portfolio Performance. Students in California were asked to show their understanding of science through creative expression, writing, or problem solving. These students knew that a high level of accomplishment was expected and were able to amaze many science educators. A portfolio was added for biology, chemistry, and coordinated science test of the Golden State Examination in 1992. About 500 volunteer science teachers representing all regions of California collaborated to develop and revise guidelines, conduct research, and outline scoring parameters for the portfolio. This activity provided students with the opportunity to demonstrate a unique way of showcasing and constructing personal meaning projects consisting of cumulative accomplishments. In this activity students had been asked to submit three portfolio entries with the understanding that each could be revised and improved to show greater conceptual understanding in science.

Three distinct categories were offered for the student portfolio performances. The Problem-Solving Investigation required students to design and conduct a research project. The project included using scientific methodologies such as detailed observation, appropriate data collection and display, and relevant analysis and conclusions. Real life applications to the individual student's daily life had been required as a critical component of this category.

The second category evaluated Creative Expression of a Scientific Concept and required students to express a scientific theme, idea, or concept through the use of art, poetry, video, or music. The presentation was required to enhance the expression of the concept, and the concept had to be clearly represented, not drowned by the work. Students submitted a board game, for example, called "SCI or DIE". Players had to correctly answer questions about the periodic properties of the elements in order to save the planet.

A third category designed was Growth in Understanding a Scientific Concept Through Writing. This phase required students to demonstrate progress toward mastery of a scientific concept, theme, or idea by submitting original and revised writings. In one classroom, students wrote monthly essays on a particular unifying theme of science, and summarized their learning in a comprehensive essay about their understanding of the theme.

Teachers were trained in two statewide workshops focusing on scoring parameters for the portfolios. Research results demonstrated that female students obtained significantly higher scores on all segments of the biology portfolio than did their male counterparts. In contrast, two of the three sections of the multiple choice and open-ended sections of the GSE (Golden State Examination) had reflected higher scores by male counterparts. The GSE science portfolio proved to provide many opportunities to investigate how students performed when given a variety of tasks designed to show what they knew or had achieved in science. Those working with assessment development gained new insights about the interrelationships involved in student performance in a variety of circumstances.

Demonstration Assessments

Radford, Ramsey, and Deese (1995) characterized alternative, authentic assessment techniques such as journals, concept mapping, performance task assessments, and student projects as valuable but as time or equipment intensive. Current reform initiatives in science education have emphasized the importance of teaching students to be critical thinkers and problem solvers. The expectation for students to demonstrate science process skills such as observing, hypothesizing, predicting, and inferring is prioritized as a process for helping students develop new understanding based on prior knowledge. An approach that can assess whether students understand basic science concepts and have the ability to solve problems has required a process that is very different from traditional tests that primarily measure the recall of isolated facts.

Radford et al. (1995) has found that science demonstration assessments are valuable tools for assessing students' critical thinking and problem solving skills and their understanding of science concepts. A clear understanding of how students' answers will be evaluated was required before they could participate in a science demonstration assessment. Radford et al.(1995) provided scoring criteria to students in the form of a rubric, a formalized assessment scale that described appropriate answers for increasing levels of accomplishment. This type of rubric had been used to prepare students for the assessment and to assign final grades. From these rubrics the instructor gained, a clear understanding of a student's knowledge and ability to apply that knowledge in new situations in addition to an objective evaluation score.

Rubric Assessment

An increasing number of rubrics have been used as tools for assessment. Rubrics often state the ideal achievement at the highest level, with progressively lower levels further and further from the ideal achievement. Rubrics demonstrated that high standards were set and the students knew what was expected to maintain this level of achievement. Students who understand what is expected of them are more likely to accomplish more because of that understanding. How we have defined success in our science classes defines science for our students and thus for much of society. Rubrics help students take responsibility for their own learning. If expectations are presented in writing beforehand, the rubrics have become the standard against which students measure their work. Rubrics have defined success. Liu (1995) suggested that we try to think about the importance of rubrics as if this class was to be the last science class the student ever took. Liu questioned what skills will be needed in the future and declared the rubric type skill evaluation will be of value to students as they approach college or the workplace. Additive rubrics allowed students to assume responsibility for the quantity and quality of their work. Additive rubrics also enabled students to see its value beyond the letter grade received.

Evidence in Assessment

Sternberg (1994) described the phenomena that as teachers we often find ourselves wondering why so few, if any, of the techniques of instruction and evaluation we have used worked for everyone. Theoretically, Sternberg worked from the concept that triarchic intelligence specified a set of processes that, when applied to familiar problems, were formally analytic. Among these processes were the following. First, recognizing that a problem exists was critical for change. Second, identifying the nature of the problem was necessary. Third, deciding on a strategy for solving the problem was required. Fourth, allocating resources to problem solving must be initiated. Fifth, monitoring problem solving while it is going on involves evaluation. Sixth evaluating the quality of the problem solving after it is done provides for accountability.

Sternberg described three types of evidence that should have been used in assessing abilities keeping in mind that it is important to remember evaluation of these abilities occur for only a given point in time. These included looking at the analytical side of thinking, looking at work on insight problems, and looking at evidence found on tests of practical intelligence. The first kind of evidence identified the analytical side of thinking. For example, it can be related to how specific and detailed information had been processed and modeled. These models described how students actually solve problems such as analogies or syllogisms in real time.

His theory further suggested that a second kind of evidence had been in process on insight problems that required students to think creatively and to go beyond the information given. This evidence demonstrated that students who were good at insightful problem solving were often not particularly good at more ordinary forms of problem solving. In other words, standardized tests had not measured the creative side of intelligence, a side that perhaps is as important-or more so-than the analytic side. His third concept included the idea that scores on tests of practical intelligence had not been correlated with scores on the tests of analytic intelligence such as standard IQ tests, SATs, etc.

Portfolio assessment and performance-based testing described more than cosmetic attempts to change issues about assessment. Unfortunately, when tests were used to test abilities, the problems of using these approaches were significant in terms of issues of reliability and fairness. Portfolio and performance tests have been more difficult to score and to demonstrate reliability and if, anything, have been much more susceptible to background differences than are conventional tests.

Alternative versus Performance Assessment

Katims, Gnash, and Toss (1993) characterized performance assessment as one of the many terms (e.g., alternative assessment, authentic assessment) currently in use by educators to refer to assessment techniques in which students demonstrated their knowledge, abilities, talents, and understandings in ways that directly represented the educational objectives of interest. While disagreement continued to exist as to what the essential ingredients of performance assessment included, there has been a definite consensus of what performance assessment is not. Performance assessment that is not an assessment set in a multiple-choice format.

Why has performance assessment earned so much attention? Katims et al. (1993) questioned why an institution like ETS, best known for its standardized multiple-choice test, was in the process of developing performance assessment materials. The answer to both of these questions has been the same. The stimulus behind the development of performance assessment in general stemmed from changes occurring in educational practices and in the delivery of instruction and curriculum. The blurring of boundaries between subject matter categories emphasized cross-curricular learning. It also emphasized more active and collaborative learning roles for students. The trend was designed to stress higher-order thinking skills with a concurrent lessening on the amount of detail students must retain.

With the active force behind assessment in the schools traditionally being policy makers and governing boards, standardized testing has existed until recently as external to the instructional process. Progress in the instructional change has called for a transition in assessment practices to appropriately reflect the learning outcomes in this new educational environment. Assessments designed to serve the purposes of teaching and the educational community has desired learning above all other factors.

Ruiz-Primo, Baxter and Shavelson (1993) conducted a study to examine the stability of scores on two types of performance assessment. They emphasized the idea that cognitive research, curriculum reform, and limitations of multiple-choice testing have all motivated the search for alternative methods for assessing science achievement. They suggested an alternative to multiple choice testing, congruent with curricular reform and constructivist learning theories called hand-on performance assessments. For example, in science a performance assessment has provided students with laboratory equipment, posed a problem, and allowed them to use these resources to generate a solution. Hands-on testing was administered on a one-to-one basis, and performance judged in real time as experts watched students do science.

The adequacy of the student's solution provided a hands-on assessment score as does the procedures used to arrive at the solution. Although observed hands-on assessment has not been practical on a large-scale basis due to cost of equipment, personnel, and testing time, in practice students typically conduct an investigation and record in a notebook their experimental procedures, results, and conclusions. These notebooks have been scored in roughly the same manner as the actual performance. Ruiz-Primo et al. (1993) described the research of Shaveleson, Baxter, and Pine (1991) where the development and examination of psychometric properties of three observed hands-on science investigations and their corresponding notebooks had been analyzed. These experiments included investigating the absorbency of paper towels, the components of circuits hidden in black boxes, and the preferences of sow bugs for a variety of environments.

Over a two-year period more than 300 fifth- and sixth-grade students received a battery of performance assessments, a traditional multiple choice science achievement test and a cognitive abilities test. All of the data had been investigated on issues of reliability and validity. Two evaluators scored the students during the first year. During the second year, based on the results of the former study, only one evaluator scored students' performance. A second observer (shadow) evaluated the performance of a sample of students (N between 10 and 20), and interior reliability was estimated on this sample.

The results were consistent over the two years. For the observed hand-on investigations (a) interior reliability was consistently high for all investigations (<.90) and varied little by the curricular experience of the students; and (b) interior agreement was high on procedures students used to conduct the investigation (>.90). This study addressed three questions. First, is performance generalizable across occasions for the observed investigations and the notebook surrogates? Second, is the estimate of students' achievement, based on all three investigations, stable across occasions? And third, do students conduct the investigations in the same way on each occasion?

Ruiz-Primo et al. (1993) suggested that their findings led to the following conclusions for all three investigations. Conclusion one is that student performances had changed from one occasion to the next G-coefficients for absolute decision had been consistent for observed investigations and notebooks-on average .48. The second conclusion suggested that when students' scores on the individual investigations had been aggregated to produce a science achievement score, generalizability for absolute decision had been increased substantially (i.e., .65 and .62 for observed performance and notebooks, respectively). The third conclusion suggested that the procedures students used to conduct the investigations changed from one occasion to the next. In general, their performance was more focused on Occasion 2 than on Occasion 1. This study examined the stability (test-retest reliability) of performance assessment-observed hands-on investigations and their notebook surrogates. This investigation of the stability of performance measures adds to understanding how well performance assessments have described students' achievement. Stability studies have been costly and time consuming but the study of stability of performance assessments has rarely been considered despite its importance.

An Alternative Final Evaluation

Gondree and Tundo (1996) described their hands-on, process and concept skills, and concepts-oriented processes in their classroom. The problem was that their final evaluation had always been conducted as a district-wide, general-knowledge exam. A group of science teachers decided two years ago to attempt to design an evaluation that would more accurately measure the knowledge and skill that their students had gained throughout the school year and not just their ability to take an exam.

This project had to be acceptable to all teachers and equitable for all students. It had to fit in with the school's vision and follow the school district's expectation, and most of all is able to manage. This resulted in a general-knowledge test worth 60%; a laboratory skills section worth 15%; a critical thinking and problem solving skills worth 15%, and a teacher-specific assessment worth 10%. The teachers decided to spread out the evaluation over a period of time to ensure that students had been evaluated in the same style and language used throughout the year.

The most difficult segment of the assessment attempted to evaluate scientific critical-thinking and problem-solving skills using a variety of methods. The main goal had been to have students use scientific methodology to solve a problem that they had not previously encountered. Teachers designed a series called Science Sleuths on videodisks by Video discovery. Students practiced solving the mysteries in class, then teachers asked them to solve selected mysteries on their own. Also involved in this assessment was the process of having students design and perform actual experiments to demonstrate application, synthesis, and evaluation skills. The techniques described by Gondree and Tundo (1996) had been used before but had now been applied to serve a different purpose. Instead of evaluating only one objective, the teachers combined these techniques to evaluate a broader spectrum of scientific skills. With this approach, every teaching and learning style was included. This approach not only emphasized retention of basic knowledge, but also evaluated a student's ability to apply that knowledge to new and real scientific problem-solving situations.

Misuse of Assessment

Hoffman and Stage (1993) stated that schools have "some science" for "some students" considering the current situation in science education on the elementary and secondary levels in United States schools. The majority of students in junior and senior high school courses have been ruled out by a "plethora" of vocabulary that can only be memorized, not understood. The abstract thinking has been at a level required to go beyond the intellectual capacity of most young people. Science expectations for elementary-age children have been dependent on the interests of individual teachers and only 25% of them had described themselves as "well qualified" to teach science. Thus, although 70% of elementary students had stated they were interested in science, science enrollment in high school has dropped by more than half each year as students have entered high school.

In order to bring science to all children, several national projects have been under way. Among these are Project 2061; the Scope, Sequence, and Coordination Project; and the NSES. Project 2061 has taken a decade to produce curriculum models and blueprints for teacher education, assessment and other systems that needed change to realize the vision of 'Science for all children." NSTA's Scope, and Sequence, and Coordination Project has recommended that biology, chemistry, physics, and earth science should be taught each year starting in the sixth grade. Their slogan, "Every Student, Every Science, Every Year." The NSES has highlighted the best practices of teachers, their curriculums, and examples of good assessment practices.

Competitive Grading Sabotages Good Teaching

How does authentic assessment vary from competitive grading systems? Krumboltz and Yeh (1996) contributed the idea that students have not been the only victims of the competitive grading system. Sometimes teacher values have been skewed and ultimately the system robs teachers of the satisfaction inherent in promoting student learning. This was typically demonstrated by the pride in the bell-shaped curve generated from students' scores on final exams.

Assigning competitive grades affected teachers' behavior in five ways: (1) students and teachers had become opponents; (2) inadequate teaching methods have been justified; (3) course content had become trivialized; (4) methods of evaluation that misdirected and inhibited student learning had been encouraged; and (5) teachers were rewarded for punishing students. Consequently, sorting and ranking students inevitably created a contentious relationship between students and the teachers when the original intent was designed as a means of sorting students according to their performance. Sometimes competitive grading caused controversial opinions about class work. Classes in which most of the students mastered the material had been perceived as unchallenging. High grades had been often dismissed as "grade inflation," not as a sign that the teacher and the students successfully achieved their mutual objective.

Haney, Czerniah, and Lumpe (1996) described the state of Ohio's initiation of its own science reform movement through the development of a Competency Based Science Model. The Ohio Model was best illustrated by explaining the model's "Spirit and Intent" document. The "Spirit and Intent" outlined the overriding philosophies and goals of science education as being typical of most science reform movements. Their assessment objectives stated that instructional and performance objectives should have emphasized higher-order thinking skills and complex performances. Haney's et al. (1996) study helped to determine the factors that influenced teachers' intentions to implement the four strands of the competency based science model.

This study had been typical of the complications involved in attempting to change basic educational philosophies that have been in place so long. Results of this study indicated that the attitude toward the behavior construct held the greatest influence of Ohio teachers' intent to implement all four standards of the science model. Haney et al. reminded researchers that previous attempts at science reform had fallen short of successful change because they had not been systemic in nature and usually had embodied a top-down model of change. It had been thought that teacher belief systems had been significant in understanding the teacher belief-intention-behavior relationship. Teachers perceived that they did not possess the ability to bring about educational change. They believed that barriers (lack of effective staff development opportunities, available resources, administrative organization support, and similar factors) provided conditions that prevented implementation in any form of educational change.

Assessment and the NSES

The view of assessment of the NSES placed greater confidence in the results of assessment procedures which sample an assortment of variables using diverse data collection methods rather than the more traditional sampling of only one variable by a single method. Thus, all aspects of science achievement-ability to inquire, scientific understanding of the natural world, understanding of the nature and utility of science-have been measured using multiple methods such as performances and portfolios, interviews, observing students, transcript analysis, as well as paper-and-pencil tests.

A typical assessment activity might have been as follows: after an egg drop activity the students each prepared a report on one thing they proposed in order to have improved their team's container and how they would have tested the effectiveness of their improvement. The report included both a written response and a sketch of the new design. The teacher used the information to assess student understanding of the process of design and assign the grade. Achievement in science must be focused on data collection based in science content, and assessment must have a clear relationship between the activity and type of assessment used.

NSES would prefer the vision of assessment that provided feedback to the students, teachers, and parents on how well the students were meeting the expectations of the educational environment. The educators involved in the standards believed that assessments also provided feedback on the effectiveness of teachers and programs to the policy makers which would have led to stimulating changes in policy, guiding teacher professional development, and ultimately encouraged students to improve their understanding of science. The choice of assessment form should have been consistent with what one wants to measure and to infer. Assessment tasks must have been developmentally appropriate, must have been set in contexts that have been familiar to the students, must not have required reading skills or vocabulary that were inappropriate to the students' grade levels, and must have been as free from bias as possible. Finally, assessment tasks should have clearly related the products of student work to the valued goal of science education.

Summary of the Literature Review for Assessment

This review of literature is somewhat limited as the NSES have been available for such a short time. As state science curriculum adopt these concepts and implement them into curriculum, the resources for more documented information will become more available. This review acknowledged that the nature of certain philosophical, psychological, and material support systems have served to either support or obstruct the use of the NSES. A general process needed to exist for identifying strategic perceptions that were needed by teachers to implement assessment activities that were authentic, performance based. Reflected learning is more important than memorized facts. Expectations for implementation of the NSES for assessment must have been set in accordance with a support system that had contributed to the development of critical-response skills. Prepared students have been able to carefully judge the assertions-especially those that invoked the mantle of science-made by advertisers, public figures, organizations, the entertainment and news media. Students have been challenged to subject their own conclusions to the same kind of scrutiny so as to become less bound by prejudice and rationalization.

CHAPTER III

DESIGN AND METHODOLOGY

Introduction

This chapter describes the characteristics of the middle school science teachers and the schools in which they teach. It describes the instrument, its purpose, and context as well as the research design and procedures. This chapter also discusses the procedures used and the analysis of the data. The expected results should be generalizable to most inner city school systems where teachers who have the opportunity to work in better conditions, less troublesome teaching atmospheres, and new buildings have left inner city teaching. The generalizability of the information learned from individuals, who teach in inner city schools, should indicate to educators that inner city problems have not even begun to be addressed in the context of looking at NSES.

The data describes basic assessment behaviors that focus on the inquiry processes. The analysis of the data was intended to identify teaching strategies that included the inquiry process and those assessment behaviors that have been used to evaluate these strategies. These teaching strategies were the results of grouping responses given by the participants as they answered the research questionnaire. Themes from the teacher interviews have been categorized into six basic areas. These areas include science teaching behaviors, teaching observations, teaching the scientific method, using science fair to teach the scientific methods, assessment methods, and assessment practices.

Teachers were selected from a listing of teachers obtained by calling the secretaries of ten Oklahoma City middle schools for the names of middle school science teachers. All teachers were contacted via an introductory letter requesting their participation in the middle school research. Of the fifty-seven letters mailed, six immediate responses were received and these interviews were completed over the telephone or in person at a designated meeting area. Twenty-four additional respondents participated in the research and the remaining interviews were completed during an inservice day by visiting with the teachers during breaks and finally by telephone interviews.

The interview consisted of a demographic component with twelve questions and a questionnaire. The dissertation questionnaire consisted of ten questions focusing on the nature of science, systematic observations, interpreting data, drawing conclusions, assessing science processes skills, communicating conclusions from experiments, and a discussion of assessment procedures used to evaluate a student's understanding of the nature of science.

Data was consistently collected by discussing the interview with the participant, followed by a process that included reading each question and then recording the response on the interview sheet. A tape recorder was used for some of the interviews, but some teachers preferred not to be recorded. The first interview was conducted after school for one teacher. A second teacher came in and agreed to complete her interview at this time. She did not appear comfortable being interviewed in front of her department head and continually gave flippant answers. Both interviews were discarded, and a decision was made to only interview teachers individually. This gave the teachers an opportunity to respond more openly. (This reaction was surprising as the researcher had taught with both teachers and considered them equally excellent teachers.)

Subjects

The subjects are middle school science teachers in Oklahoma City who were assigned to teach in grades six through eight for the 1997-98 school term. The district science curriculum included a set of three books called Interactions which focuses on life, earth, and physical science in an interrelated scientific approach. All three subjects are covered in some form each year. All teachers in the study use this specific science series as their basic science text.

The Oklahoma City Public School System is a metropolitan district with ten middle schools. A large variety of ethnic groups make up the student population including Asian, Hispanic, Black, and a minority of white students. Participants were selected to provide a non bias gender and ethnicity population. More important for this specific research, teachers were divided into two science education groupings consisting of secondary science certified and science endorsement.

The schools all range in size from 800-900 students and are found to be in the middle to lower class socioeconomic status. All of the schools have a majority of their population on free or reduced lunch. All of the schools were built prior to the sixties and display the characteristics of aged school buildings. Few have adequate air conditioning and teachers work under numerous challenging conditions.

Instrument/Materials

The interview process was selected because the researcher felt that more insight into applications of the NSES would be revealed than if the participants had responded to a written questionnaire. The researcher felt that individuals often think of other responses when they are discussing their teaching behaviors. Sometimes, when a teacher is asked to respond to a written questionnaire they respond with brief answers and leave out other details.

The questionnaire was specifically designed to gather information, which could be discussed in terms of the NSES. The interview process involved reading the responses to the participant and then recording the teacher responses. All participants were questioned by a standardized procedure.

This can be further explained by explaining that the questions were read in the same order each time and that the interviewer did not attempt to lead the teachers to any specific response. First, two teachers read the questionnaire for clarity of the questioning process and for the identification of potential misunderstandings. Second, the participants were encouraged to make comments and suggestions concerning directions, recording procedures, and specific items. The cover letter included a commitment to share the results of the study when completed. Confidentially of the respondents was also assured.

Two instruments were used in the study. The first instrument was a survey that asked demographic questions that would help identify gender, teaching experience, school population characteristics such as ethnic groups and socioeconomic status. See

Appendix A. This survey was also designed to help the researcher determine if the teacher had participated in workshops or experiences that would reflect understanding or knowledge of the National Science Education Standard B, Part I. The survey also included identifying the type of science taught by the teacher, the most recent professional development in which the teacher has participated and a question about whether the teacher had a personal copy of the NSES.

The second instrument was an interview questionnaire consisting of ten questions. See Appendix 1. This was used to identify the teaching behaviors and activities used by the teachers that were specifically listed in the NSES that would demonstrate use of new standards to assess students in the inquiry processes. These ten questions were designed to stimulate the teacher thinking about the nature of science.

More specifically, the questionnaire was used to determine how teachers questioned their students about their understanding of process skills before, during, and after experiments. The questions were also oriented to determine if the teacher had a special way of teaching their students to interpret and analyze data, and to draw conclusions. In the questionnaire teachers were also asked to express what methods of assessment they used to evaluate student's understanding of the nature of science. In the assessment aspect of the questions, teachers were also asked to describe their philosophy for assessing science process skills. This provided teachers with the opportunity to express personal opinions that might not reflect specified school requirements for student assessment.

Research Design and Procedure

The research questionnaire was designed to determine if teachers had actively engaged students in the use of hypotheses, the collection and use of evidence, and the design of investigations and processes as well as assessment. The questionnaire focused on these process skills, while attempting to measure how teachers assessed progress toward knowing and understanding scientific facts, concepts, principles, laws, and theories. Therefore, results might be consistent with the spirit and character of scientific inquiry and with scientific values. Finally, the researcher correlated those assessment aspects of the NSES that were reflected in the science process skills assessed by the middle school teachers.

The process overall determined who had been using the standards, who had been taught by the standards, and where the standards had been implemented, thereby determining in what ways these standards had been used. The demographic section of the questionnaire reflected information that is characteristic of many metropolitan areas found across the United States.

Procedures

A list of science teachers was obtained by calling each of the ten schools and asking the secretary for the names of each of the science teachers. From this list, fifty-seven packets consisting of a letter that explained the research, a request for their return of the informed consent form, a copy of the demographic survey and the research questionnaire. If the personal interview could not be arranged, then participants were asked to respond to a telephone interview where information given would be recorded on a narrative sheet. Participants were asked to return the informed consent form in the self-addressed, postage paid, return envelope at their earliest convenience.

Participants received information about how the data was to be used and were offered an opportunity to have results shared with them. Seven informed consent forms were received back immediately. The researcher followed up this invitation by calling the teachers and arranging a time for the scheduled interview. Twelve teachers were interviewed in an interview session and eighteen teachers were interviewed through telephone participation.

Analysis of the data

As the interview was conducted, the researcher recorded a narrative of the information that was being given by the participant. This data that then organized into specific themes that became obvious to the researcher as reflecting "traditional lecture oriented" science teaching behaviors" or "inquiry oriented" science teaching behaviors.

The data was then analyzed in terms of the NSES.

Assessment Standard B, Part 1, was written to specifically identify the spirit and character of scientific inquiry and also identify scientific values. Comments from the participants about assessment would indicate to the researcher that the participant was more or less concerned with traditional or non-traditional forms of assessment. This information was organized into tables and charts to provide the researcher with specific themes to analyze. The questionnaire enabled the researcher to compare the actual implementation of the NSES with what data could have been attained had all of the teachers implemented the assessment activities.

The demographic section was used to determine if any participant consistently differed from the others. No participants appeared to vary extensively and the data consistently followed one or two of the specific themes the researcher was trying to identify. Teachers represented typical minority and gender groups. Their level of experience varied but did not appear to suggest any abnormal trends in science teaching behaviors nor assessment standards.

The research questionnaire focused the teacher's thoughts on their teaching of the nature of science or process skills and assessment behaviors. The particular phrase, "nature of science" frequently caused a brief moment of silence. The "nature of science" is a specific category on the ITBS, which the majority of the teachers have given repeatedly, yet most of the teachers stopped before responding to the question.

Participants were asked how they question their student's understanding of process skills before, during, and after experiments. These process skills included questioning teachers about teaching students how to make systematic observations, to interpret and analyze data, to draw conclusions and to communicate those conclusions. The research questionnaire also asked the teacher to describe their philosophy for assessing science process skills and to describe how to evaluate a student's understanding of the nature of science. Finally, the questionnaire asked the teachers to explain how one knows that a student understands the process skills that are included in the nature of science. This question was designed to determine if the teacher was evaluating process skills in addition to the content or facts that was being taught about the science.

Summary

The study described the current status of procedures that were being used in Oklahoma City middle schools. By comparing responses the researcher identified common themes that indicated if the teachers had begun to implement behaviors or assessments as designed by the NSES. The study revealed a need for help in implementing the NSES. At the present time, little research has been published to identify the usage of the NSES.

The study recognized the level of implementation of NSES. School districts throughout the state or nation, who recognize where they are, and know the goals behind NSES can produce changes in science education. The achievement of these goals is designed to help our state and nation reach a higher level of scientific literacy for all our children.

The researcher plans to demonstrate that inner city schools are in need of specific training to help better prepare teachers for dealing with a plethora of problems not found in the suburbs and rural areas. Only then perhaps the standards will pave the way for achieving the science literacy that the National Research Council, the NSTA, the council for writing the Standards, Project 2061 and other that have planned to address throughout science teaching.

How can gate keeping courses that NCTM and ACT recommend be the focus of science and math learning if those teachers, who are expected to promote the content, are not qualified to teach these concepts? The lack of qualified science instructors often results in personnel directors hiring industry-trained individuals who lack secondary teaching skills and science endorsed teachers who lack upper level or inquiry based training? This study should support the need for more training for inner city science teachers.

CHAPTER IV

RESULTS OF THE STUDY

Introduction

Implementation of NSES standards lacks formal research about what happens when a classroom teacher attempts to implement new assessment strategies and teaching behaviors especially directed at the inquiry processes. The population of the study varied in their qualifications, racial origin, and experience. Sixteen male and fourteen female teachers participated in the interviews. The following ethnic groups were represented followed by the number from each group who participated: Caucasian (20), African-Americans (5), Norwegian (1), Ghanaian (1), Hispanic (2), and Native American (1). Each teacher was chosen based on a random sample that was stratified to represent all groups of ethenticity.

Of the thirty teachers interviewed, sixteen have science endorsements and thirteen have degrees in related science disciplines including technology, education, biology, chemistry, metallurgy, and engineering. One teacher has a degree in English as a Second Language, but also has a science endorsement. Ten teachers reported having a copy of the NSES with twenty of the participants stating that they did not. Class teaching assignment ranged from 100 to 150 students. Nineteen teachers had participated in a specifically science-oriented inservice within the past nine months. All of the participants listed their schools as being in the low to middle socioeconomic group. The years of experience ranged from one year to twenty-seven years.

One special education science teacher reported having sixteen students and described numerous labs that he had done with his students. Another special education teacher described a number of the activities in which his students were involved. Another teacher who had honors students never completed any labs with the students stating that the students were too unruly. The majority of the teachers did not describe lab-oriented activities.

Themes mentioned in the interviews were responses to the research questionnaire that described how to teach the scientific method, how to teach the process of making observations, data collection, interpretation of data, science fair competitions, and assessment of science activities. As different responses were made with words that described the scientific method, process skills, assessment, and science teaching behaviors, these terms were labeled as themes and were listed into a database. When a participant responded to a theme or indicated evidence of the theme, it was logged as an X under the theme title in the database. Fifty-four specific themes were identified in the database.

Discussion of the Research Participants

This information was given by the teachers in response to the questionnaire prepared by the researcher. The structured interview followed the same format with each teacher. Teachers were permitted to explain or respond to questions in an open manner with no judgments indicated by the researcher. Teachers were presented with a written copy of the interview responses and were permitted to change any response that might have been misinterpreted. All of the teacher demographics have been listed in the following table.

Table I

Participant Demographics

Participant	Area of Certification	Last Professional Development	NSES WKSH	Socio-Economic	Class Size	Years of Exper.	Grade Level	Teacher Ethnic Group	Gender
Charles	B. S. Geo.	1997	NO	Mid.	150	4	6	C	M
Hardy	Biology		NO	L-H	16	13	6 7 8	C	M
Hebert	Sci Endorse.		NO	Low	125	12	7	B	M
Harriet	B S Biology	1995	NO	Mid.	110	5	8	B	F
Harry	B S Tech Ed		NO	Low	120	27	8	C	M
Hannah	Sci Endorse.	1997	YES	Mid.	100	8	6	C	F
Jason	Second. Sci.	1997	NO	Low	120	1	6	C	M
John	Ma in Ed.		YES	Low	110	5	8	H	M
Jared	B S Biology	1995	NO	Low	120	10	6 7 8	C	M
Jerrie	Second. Sci	1997	YES	Low	140	4	7	C	F
Jennie	B S Biology		NO	Mid.	140	8	8	C	F
Mary	Sco Endorse.	1997	NO	Low	100	1	8	C	F
Melvin	Second Sci.	1998	YES	Low	100	0	7	B	M
Mickey	Sci Endorse.	1997	NO	Low	100	21	6	C	F
Marion	Second. Sci.	1997	NO	Low	100	4	7	C	M
Mimi	Sci. Endorse.	1997	NO	Low	110	1	6	C	F
Miriam	B S Chemistry	1997	NO	Low	100	1	6 7 8	H	F
Michael	Ma in Engineer.	1997	YES	Low	110	5	8	GH	M
Rae	B S Biology	1997	YES	Low	117	12	8	B	M
Randy	Sci Endorse.		NO	Low	125	1	7	C	M
Risa	Sci Endorse.	1997	NO	Low	110	6	6	C	F
Randle	Sci Endorse.	1997	NO	Low	120	6	8	C	M
Ruth	Sci Endorse.	1997	NO	Low	120	15	6	NA	F
Ted	Sci Endorse.		NO	Mid.	116	13	7	C	M
Winona	Sci Endorse.	1997	YES	Low	115	3	6	C	F
Wendy	Sci Endorse.	1997	NO	Low	125	15	7	B	F
Wrylon	Sci Endorse.	1997	N0	Low	156	11	8	S	F
Winchester	B S in Educa.	1997	YES	Low	110	4	6 7 8	C	M
William	Sci Endorse.	1997	NO	Low	150	5	7	C	M
Wilma	B S Biology		YES	Low	140	5	7	C	F

Charles has a degree in geology and has worked as an oil and gas geologist for eleven years. He recently transferred to take over a sixth grade class at an advanced school. His most recent science workshop participation was in the summer of 1997 and was called "Rocks in your Head" which was designed and presented by the American Association of Petroleum Geologists.

In discussing the nature of science Charles believes that "truth is not absolute. Science is at best an explanation to fit what we currently know". He describes his teaching of observations as erratic. Systematic observations are taught by starting with inquiry, followed by small hints and a great number of props. Charles also uses a great deal of dramatics to emphasize points. He uses graphs as much as possible and tries not to give answers away. Wait time is considered extremely important. When a question does not receive a desired response, he tries to rephrase the question. Students are asked to keep a journal. In describing his philosophy for assessing science process skills, he has done labs and activities such as identifying rocks and making graphs about radiometric dating. For communicating conclusions, his students write results in a notebook. Cooperative learning groups are used and these students give oral results to the class. He tests for understanding of process skills, but these tests consist of "do it" type activities such as calculating areas or perimeters metrically on the test paper. His methods of assessment are written tests, short quizzes, notebook responses, and verbal responses in class.

Harry by chance happened to be a special education science teacher. He stated that he uses his students' interest in icebergs to help teach science process skills. His students understood about part of plants, root systems and germination of seeds. He uses bar graphs to teach about analyzing data and feels his oldest students can form conclusions.

Hebert taught technology education prior to teaching science but has taught science for fourteen years. When asked what he teaches, he is animate about teaching children not subject matter. He is most comfortable with teacher demonstrations, does not care for science fair, and states that many students still think hypotheses are big, green bugs. His favorite experiment is a coke taste test that he designed as a double blind experiment to help students learn about variables and controls. He believes students need time to assimilate information and often shows a video more than once so students have this assimilation opportunity. He attributes his philosophy of teaching to his grandmother, who stated, "You can lead a horse to water and he will drink if you lead him deep enough." He presents students with questions called "what you ought to know" and teaches from that aspect. His students are described as lacking the vocabulary to explain science, and he encourages them to make sure that the vocabulary makes sense to them when the assignment is completed.

Harry uses cooperative group learning, lectures, and independent study to teach about the nature of science. To teach systematic observations, he encourages students to use their five senses and likes problem solving activities. He uses written and oral tests, special projects, and student-made bulletin boards to motivate his students. By having students bring in demonstrations to share with the class, he is able to provide more lab activities. He believes everything offers some type of science principle whether it is an aquarium or poster. He likes to challenge his students to discover why something is done in the first place and considers their "far fetched" ideas as a spin off for beginning to see how a particular phenomenon leads to scientific principles or inventions. His whole room is designed for cooperative and group learning. He would like to do more labs but lacks equipment and materials for experiments.

Harriet enjoys teaching outdoors. She likes the critical thinking questions designed in the textbook and tries to dig deeper when students give responses. She is interested in their prior knowledge when hearing their answers. When teaching students to make observations, she emphasizes using the five senses. She stresses using the scientific method and yet feels students lack the vocabulary for expressing their observations and, in fact, understand more than they are able to express in written form. She especially enjoys teaching the biological sciences, uses cooperative learning groups, and has the students keep a science notebook.

Hannah uses the learning cycle, small group activities, qualitative activities, and teaches the scientific method by having the students do science fair projects. One of the activities she uses to teach vocabulary is to give the students about 250 flash cards and, as a quiz, has them design food webs and food chains. She has students make observations through measuring liquids and powders. Students also list the parts of chemical reactions that neutralize acids and bases. She mentioned that her resources are very limited and would like to learn to write grants so her students could have access to more labs.

Jason described his students as mostly Hispanic and American Indian. He had taught high school science but this was his first year in a middle school. He has a secondary education degree with a general science background. He teaches observations by taking the students outside and by trying to establish an accepting rapport with his students. He wants all students to feel equity in what they are seeing in order to begin making observations. He also likes to show the students that sometimes the information does not support a hypothesis. He explained that this conflict in ideas provides a greater opportunity for the student to figure out why or to question the answers.

John has participated in many summer institute programs for science teachers. He has not done hands-on activities, as he does not have equipment or materials. He has taught his students to read solubility curves from graphs. He teaches other skills in data analysis from textbooks or materials he brings from his own disciplines.

Jared has an excellent background in other sciences. He uses questioning and story telling techniques to teach about the nature of science. "What would happen if?" questions are used to stimulate lectures. He uses basic graphs to teach interpretation and prediction of data. He uses tree adaptations to help teach about observations.

Jerrie uses the scientific method as a base for all experiments. She taught the scientific method step by step, has scientific method charts and posters on the wall, teaches variables by using recipes, and uses making a peanut butter sandwich to teach scientific procedure. She uses a Velcro backed copy of the scientific method to continually check their understanding of the processes and has students match the part of the experiment they have completed to the list of scientific method procedures on the chart. As she walks around her room, she asks her students to "show me and tell me" and to write it down. She uses buttons for teaching classification and the properties of metal elements for teaching students how to describe what they have observed. She uses class discussion, lab notebooks and portfolios. At the end of each year she has her students write down what they particularly remembered or liked about learning science. She uses games such as basketball for review and states that she really finds out what they have learned during class competitions.

Jennie uses many of the same techniques as Jerrie. Her favorite activities include displacement of pennies, doing classification with shoes, height, and hair color. She uses graphs and charts to teach students how to interpret and analyze data. She states that the students especially liked working with human growth patterns and found the data a lot of fun to analyze. She uses science fair projects to teach about making, supporting, or rejecting hypotheses. She tries to relate everything to life and explains that math is the best process for seeing how it all fits together. For her methods of assessment she uses a lot of observations and lab grades. Her science fair kids continue to compete in science fair at the high school level and frequently return to tell her of their awards.

Mary is a former math teacher and uses the Dares concept to review science principles. She asks her students if the observations are qualitative or quantitative. She considers it important to teach the students that a hypothesis is not a random guess. She uses scientific essays to assess her students and gives points for participation and keeping scientific notebooks. Cooperative learning is considered very important in her class and she has a process of questioning students in small groups. She keeps records of what students are doing while she is walking around the room. The questioning helps students relate science concepts to phenomena outside the classroom that they may already understand.

Mariam teaches non-English speaking students. She uses the majority of time on having her students write definitions and learning how to pronounce the word in English. She has few supplies and uses many materials brought from her home to do demonstration experiments for her students. She would like to teachers the students about examples of the elements in a manner that the chemistry would be evident to her

Hispanic students. She answers many questions while they students are working. Points are given for getting work done and placing it into a folder.

Melvin will receive a Bachelor of Science in secondary science education in May 1998. Through exploratory activities in diverse applications in a variety of science areas, he attempts to teach the nature of science. He completed microscope activities with onion cells, has students make drawings of scientific phenomena, and believes students communicate their experiments best through writing journal responses that include pictures, graphs and random thoughts. He has taken the students to Camp Goddard for an environmental camp and provides many enrichment activities that encourage his students to participate in activities that incorporate the science process skills automatically and instinctively in the classroom. His student portfolios include classroom assignments, experiment responses, and journal responses. Students are expected to look at experiments from different perspectives and attempt to infer the personal importance of that activity. This means having the students see how a principle or experiment has effected the student personally. He also has the students attempt to apply their hypotheses to everyday life or the job market.

Micky uses many hands on activities. She has students make measurements to describe changes that occurred, uses charts and graphs, and many comparisons. She develops many real life situations for testing a student's understanding of making hypotheses. She then challenges the student on how the scientific method could be used in a different situation. She teaches students about controls through plant growth experiments. She feels that some test purposes are just reading tests and do not really test the experimental process. For assessment her lab activities are graded as part of the whole unit including participation.

Marion has done many experiments and asks the students to make numerous hypotheses. After experiments are completed, students are asked to write them in their journals and determine if their hypotheses were correct. Marion stated that he has learned how effective the writing journals can be through a math teacher. He uses many grouping activities and makes sure that different students are able to do different jobs in the cooperative learning groups. He stated that he knows his students understand the nature of science because they use the process skills in demonstrating a lab activity. He does not have them memorize the steps; he prefers that students learn the scientific method by doing the activities. For assessment he uses testing, journals, participation, and assignments to focus the lab, and assesses how well the students know the vocabulary. He feels that participation grades are important and memorization of the scientific method without being able to apply it is worthless. He feels that if the students understand the objective of the experiment, then all other bases are covered.

Mimi had just finishing her first year of teaching after receiving a degree in health and physical education in 1983. To prepare for her first year of teaching, she took the curriculum tests offered by the state in biology, zoology, middle school science, and physical science. She relates science to everyday life and does not like the textbooks format. She taught a unit on crystals to teach the nature of science and other concepts and completed units on rocks and minerals. She reviews each day with the students to determine what they understood from the previous day. She wants her students to discover "why it did not happen" to be as important as why "it did happen." She teaches measurement and quantitative observations by measuring potato chips on the triple beam balance. She requires a science fair project from everyone and grades their understanding of the nature of science on how well they did on their science fair projects. She explained how students use the scientific method everyday in life situations such as baking cookies. She has students make cookies while changing the variables by varying the amount of the ingredients. She teaches activities that address the state PASS skills. Miriam has a degree in chemistry from Mexico and teaches seventh and eighth grade bilingual students. She spends the majority of time on vocabulary and the teaching of pronunciation skills and dictionary skills. She has no materials and does very few experiments. She has brought consumable items from home if experiments were to be done. She focuses the students on the states of matter to teach them to make observations.

Michael feels it is important to prepare the students before teaching them the scientific method. Most of the experiments are for observations. He wants his students to realize what benefits were gained from doing the experiment. Most of the time he encourages the students to use the data they collect in the form of a diagram or chart. He wants his students to distinguish between accuracy and quality of measurement. He knows his students are learning when they are asking questions. He feels the students learn better if they are the ones asking the questions.

Rae has focused his teaching with hands-on activities. He teaches the scientific method by starting with a lecture, followed by demonstrations, class projects, and finally individual projects. He has students make observations at the end of the lab by describing what happened. He places great importance on scientific drawings. He requires everyone to keep a portfolio. He questions results the students have found. When the teacher has observed an incorrect lab procedure, he redirects the process by having students discuss exact procedures. For assessment he uses group projects, chapter quizzes, portfolios, and homework quizzes.

Randle starts teaching the metric system by measuring plastic dinosaurs. The students graph data about the dinosaurs. Randle has taught the students that observations are 90 per cent of science and you have to see everything in life. He questions the students about what they have eaten for breakfast and what they have seen on the way to school. He teaches students about different densities through demonstrations. He has attempted to find things that students are interest in to relate science to their own environment. He does not do labs. He uses what is in the book and other information to relate science to student activities such as wrestling. He encourages his students to watch educational television by giving credit for writing essays about the program.

Randy has taught the scientific method is everywhere. He teaches the students that the scientific method basically has five steps, but explains to students that each of the steps can be called different things. He reinforces the scientific method with science fair projects. He asks questions during class and uses the overhead projector. He has students match parts of the scientific method with other observations the students have made. He has students describe their own thumb to teach them to make observations. He emphasizes using the five senses but also had students use metrics for their quantitative observations. The scientific method can be used to solve any other problem. He also uses group science competition to review for quizzes. He believes that written tests are not always a good way of testing students.

Ruth has a science endorsement and has nearly completed a Masters Degree in education at OSU. She questions her students on vocabulary and how literature can be science in a different form. She teaches the scientific method by looking at realistic comparisons and making quantitative observations. She encourages the students to use metric estimates of distances of things such as the halls and then has the students place metric tapes to quantify their observations. She has students make models of the solar system using the metric system. To teach systematic observation she expects the students to think about the objects and then describe similarities and differences. At this school the teachers have been grouped in teams. This resulted in her being downstairs in a room with no running water or gas, while an English teacher uses the lab room upstairs so teams could be together. She was most interested in the progress students make from when she first meets them to when they leave her classroom. Her students make clay models and shadow boxes for dioramas to demonstrate ecosystems. Students do book reviews to encourage reading in science. She has also taken her students to an environmental camp to study outdoor education.

Ted teaches seventh grade and has recently participated in the Fernwood Project, an AIDS prevention workshop for middle school students. He does not use hands-on experiments but relates science to every day life. He lectures, draws details on the board and walks students through text material. He uses some metric observations. Generally, he has students read aloud from the textbook and discusses the information by asking lots of questions. He encourages students to weigh the pros and cons and to use thinking skills to review questions. Assessment comes from class discussion and chapter tests. He spends two days on review questions before each test.

Winona teaches the scientific method through science fair projects. She feels this process lends itself to all the other science concepts. She has students write down their observations as they discuss the experiments. After everyone has written down their observations, she questions the students as to why they all have different observations. She has the students predict what could happen when looking at labs and discuss why different things happen with the same experiment. She uses group discussion and encourages each group to come up with its own explanation and presentation. This also includes discussion of information within the chapter. She reads through their observations to check for understandings. When groups do presentations, she receives an accurate idea of how they learn and how their minds were working through the concept that was being taught. She believes that it takes time to work on higher level questioning and emphasizes giving the students time to work through the thought questions.

Wendy likes teaching outdoors with leaf hunting, fish ponds, and gardens. Critical thinking skills are listed as being important as were chapter questions and chapter discussions. She teaches her students how to use the scientific method and stresses that it is important to follow the steps exactly for the experiment to come out correctly. She often models experiments in the classroom. She does not use a lot of written testing. She gives short essay questions over the critical thinking activities.

Wrylon has a Bachelor of Science degree in English as a second language with a background in physics and chemistry. She has taught middle school science for eleven years. Wrylon uses a specific concept of distinguishing between vocabulary and a meaning chart. The students are asked to write a vocabulary definition but must also have a written chart that lists how the meaning of the word relates to their own understanding. She uses a lot of hand-on labs and has students make scientific drawings in a lab notebook. The notes and vocabulary meanings are often turned into essays or paragraphs about science concepts. She does not believe in a lot of grades but tries to create a family atmosphere where each student helps to assume responsibility for the other's learning. Students are expected to do demonstrations of what has been learned at the end of each quarter.

William is a special education science teacher and teaches the students to form hypotheses as they carry on their daily life. To help students make observations, he inquires, "What happened when you did this?" He encourages the student to not do just anything. Instead, he tries to encourage the students to set goals for what they are doing in their science activities. These types of questions provide students with a focus other than just going through a science process. He is committed to teaching students that the scientific method is the way to do everything.

Winchester is interested in teaching students how to integrate the science fair process into learning the nature of science. His major field is counseling psychology yet has a science endorsement and an elementary education certificate. His students record observations, use different types of quantitative and qualitative graphs and higher level thinking skills. He uses numerous tests, written papers, student demonstrations and cooperative learning. He does not use lab sheets but has students answer questions on notebook paper. He grades on daily work, class participation and science fair projects.

Wilma uses the weather to teach students how to make observations. They watch the moon for weeks and watch when leaves start to change colors. She uses Slinkies to demonstrate waves. She used real life examples for her students like noting how weather changes. She has students make observations by giving them real life events to observe. She uses brainteasers like TriBond (a science oriented game that teaches analogies), activities for teaching students how to think about relationships, and what things have in common. She quizzes them with real life scenarios and encourages students to analyze and determine conclusions. When students interact verbally, she enables them to make presentations to the class. When they do experiments, the groups tell the class what was discovered or what happened.

Analysis of the Data

This chapter has identified major themes that were collected into a database to emphasize the assessment of science process skills. It identified how teachers perceived these skills in relation to teaching the scientific method, teaching science fair competition, teaching students to make observations, assessing students with traditional standards, and assessing the students with the recently implemented NSES. In addition, this chapter has identified specific teaching behaviors that relate to science process skills. The final chapter has used this data to make conclusions, implications, and recommendations.

The NSES (1996) state that equal attention must be given to the assessment of opportunity to learn and the assessment of student achievement. These standards state that students cannot be held accountable for achievement unless they are given adequate opportunity to learn science. Therefore, achievement and opportunity to learn science must be assessed equally.

Teaching Qualitative and Quantitative Observations

Participants were asked to discuss how they taught their students to make observations. These responses were documented in the chart following the analysis of their responses. Analysis of the "Teaching Observations" had led to conflicting interpretations. For example, 25 of the 30 (83.33%) teachers interviewed reported that they had taught students how to make observations. This statistic would have sounded great, before the NSES were printed. As the standards increased our focus on what is good science and what is not, these statistics demonstrated that only 12 (40%) teachers discussed teaching their students to make both qualitative and quantitative observations. Only 6 (20%) of the teachers with science certification that taught qualitative and quantitative observations had seen a copy of the NSES. Of those teachers who had science endorsement, only 6 (40 %) of the 15 had read a copy of NSES. Three other teachers who had science endorsements yet had not read information from the NSES also reported that they taught making observations as recommended by the NSES.

Making observations has been identified as a major component of process skills.

Nine (60%) of the teachers who had certificates in science reported that they taught their students how to make observations. Only two of those nine (13 %) reported that they taught students how to make both qualitative and quantitative observations while 6 (40 %) of teachers with science endorsement taught both. Thirteen or (87 %) of the teachers with science endorsement taught their students how to make observations. Of the participants that responded, the trend that was most evident was that teachers with science certification were less likely to use quantitative and qualitative observations as a teaching method. Another trend that was evident was teachers who had been exposed to the NSES were more likely to use qualitative and quantitative observations as a teaching method as demonstrated in the chart below.

Table II

Teacher Usage of National Science Education Observation Standards

Name	Area of Certification	NSES	Quantitative Observations	Qualitative Observations	General Observations
Charles	B S Geology	YES	0	0	0
Hardy	B S Biology	NO	1	0	0
Hebert	Science Endorsement	NO	0	0	1
Harriet	B S Biology	NO	0	0	1
Harry	B S Technology Education	NO	0	0	0
Hannah	Science Endorsement	YES	1	1	0
Jason	Secondary Science Education	NO	1	0	1
John	Masters of Education	NO	0	0	0
Jared	B S Biology	YES	0	0	1
Jerrie	Secondary Science Education	NO	0	1	1
Jennie	B S Biology	YES	1	1	1
Mary	Science Endorsement	NO	0	1	1
Melvin	Secondary Science Education	YES	0	0	0
Mickey	Science Endorsement	YES	1	1	1
Marion	Science Endorsement	YES	1	1	1
Mimi	Science Endorsement	NO	1	0	1
Miriam	B S Chemistry	NO	0	0	0
Michael	Masters of Engineering	YES	1	1	0
Rae	B S Biology	NO	0	0	1
Randel	Science Endorsement	NO	1	1	0
Risa	Science Endorsement	NO	1	1	0
Randy	Science Endorsement	NO	0	0	1
Ruth	Science Endorsement	NO	1	1	0
Ted	Science Endorsement	NO	1	0	0
Winona	Science Endorsement	YES	0	0	1
Wendy	Science Endorsement	NO	0	0	0
Wrylon	Science Endorsement	NO	0	0	1
Winchester	B S Education	NO	0	0	0
William	Science Endorsement	NO	0	0	0
Wilma	B S Biology	YES	0	1	0

Teaching about the Scientific Method

Participant responses to teaching the processes used in the scientific method were recorded in the following chart. If the response mentioned any of the science processes such as: making hypotheses, making observations, process skills and science procedures, collecting data, or communicating data, the researcher to documented a positive use of the method.

The statistics compared the number of teachers mentioning identifiers of the scientific method in relation to the total number of participants in the study. Nine teachers (30%) mentioned using process skills. Fifteen teachers (50%) discussed teaching students to make hypotheses. Twenty-five teachers (83%) discussed teaching students to make observations. Seven teachers (23%) discussed teaching students to learn scientific procedures. Nineteen (63%) thought it was important to be able to communicate conclusions. Only nine teachers (30%) reported they taught their students to collect data.

The majority of the teachers with a positive response to the scientific method use an average of four different science processes to teach the scientific method. However, less than half (40%) of these teachers taught the students to collect data. The majority of the teachers with a negative response to the scientific method use an average of 2 science processes to teach the scientific method. The emphasis of teaching the scientific method employed by all of teachers focused on educating students to make hypothesis and communicate data. Only seven teachers (23%) discussed teaching their students scientific procedures. The emphasis on making hypothesis was not supported by the process skills needed to prove or disprove their hypothesis.

Table III

Teacher Use of the Scientific Method

Name	NSES	Process Skills	Scientific Method	Making Hypothesis	Making Observations	Science Procedure	Communicating Data	Collecting Data
Charles	Yes		X					
Hardy	No						X	
Hebert	No				X		X	
Harriet	No	X		X	X			
Harry	No			X				X
Hannah	Yes			X			X	
Jason	No				X		X	
John	No						X	X
Jared	Yes				X			
Jerrie	No	X	X	X	X			X
Jennie	Yes	X	X	X	X	X	X	X
Mary	No		X	X	X		X	
Melvin	Yes			X			X	
Mickey	Yes		X	X	X	X	X	
Marion	Yes	X	X	X	X		X	X
Mimi	No	X	X	X	X	X	X	
Miriam	No							
Michael	Yes		X	X			X	
Rae	No	X	X		X	X	X	
Randel	No		X					
Risa	No	X	X				X	X
Randy	No		X		X	X	X	X
Ruth	No	X	X				X	X
Ted	No							
Winona	Yes	X		X	X	X	X	X
Wendy	No		X			X		
Wrylon	No			X	X		X	
Winchester	No		X	X			X	
William	No			X				
Wilma	Yes			X				

The following terms were used to describe themes that were used in connection with teaching students how to do science fair projects: science fair, scientific method, graphing, communicating conclusions, making hypotheses, collecting data, and making observations. For this category, teachers had to mention that they participated in science fair. Seven (23%) teachers specifically identified using science fair to teach the scientific method. Eleven (36.6%) teachers used the science fair competition to teach about graphing. Twelve (40%) teachers used science fair projects as their focus for teaching students how to make conclusions. Nine (30%) teachers used making hypotheses as a part of teaching the scientific method through science fairs. Four (13%) teachers used data collection in their students' science fair projects to teach the scientific method. Twelve teachers (40%) used making observations to teach the scientific method through science fair participation. Nine teachers (25%) used science fair competitions to teach the scientific method.

Table IV

Using Science Fair to Assess Science Process Skills

Name	Science Fair	Scientific Method	Graphing	Communicating Data	Making Hypothesis	Making Observations	Collecting Data
Charles		X	X				
Hardy			X	X			
Hebert	X		X	X		X	
Harriet			X		X	X	
Hannah					X		X
Harvey	X			X	X		
Jason				X		X	
John			X	X			X
Jared			X			X	
Jerrie		X	X		X	X	X
Jennie	X	X	X	X	X	X	X
Mary	X	X	X	X	X	X	
Melvin			X	X	X		
Mickey	X	X	X	X	X	X	
Marion	X	X	X	X	X	X	X
Mimi	X	X	X	X	X	X	
Miriam			X				
Michael	X	X	X	X	X		
Rae	X	X	X	X		X	
Randel		X	X				
Risa	X	X	X	X			X
Randy		X	X	X		X	X
Ruth		X	X	X			X
Ted							
Winona	X		X	X	X	X	X
Wendy		X					
Wrylon				X	X	X	
Winchester		X		X	X		
William	X		X		X		
Wilma					X		

Traditional Assessment of Science Process Skills

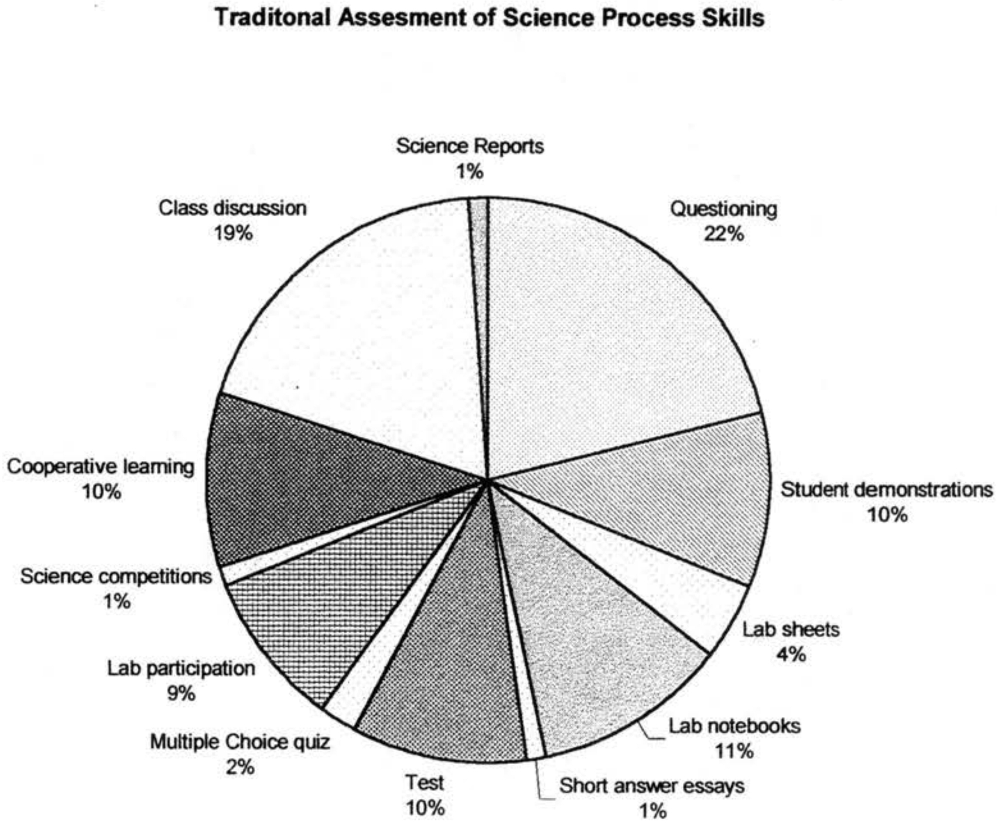
The participants identified traditional procedures for assessment as: multiple choice quizzes, essay exams, matching quizzes, chapter quizzes, homework quizzes, and other test for determining knowledge gained in a science class. Assessment of science process skills were associated with other evaluation techniques. Teachers were asked to identify any other processes that were used to test for process skills.

Teachers also identified the following traditional assessment themes:

Table V

Traditional Assessment Themes	Number of Teachers
Questioning	19
Student demonstrations	9
Lab sheets	4
Lab notebooks	10
Short answer essays	1
Multiple choice quiz	2
Test	9
Lab participation	8
Science competitions	1
Cooperative learning	9
Class discussion	17
Science Reports	1

Figure 1


Traditonal Assesment of Science Process Skills
Science Reports
1%
Questioning
22%
Class discussion
19%
Cooperative learning
10%
Student demonstrations
10%
Science competitions
1%
Lab sheets
4%
Lab participation
9%
Lab notebooks
11%
Multiple Choice quiz
2%
Test
10%
Short answer essays
1%

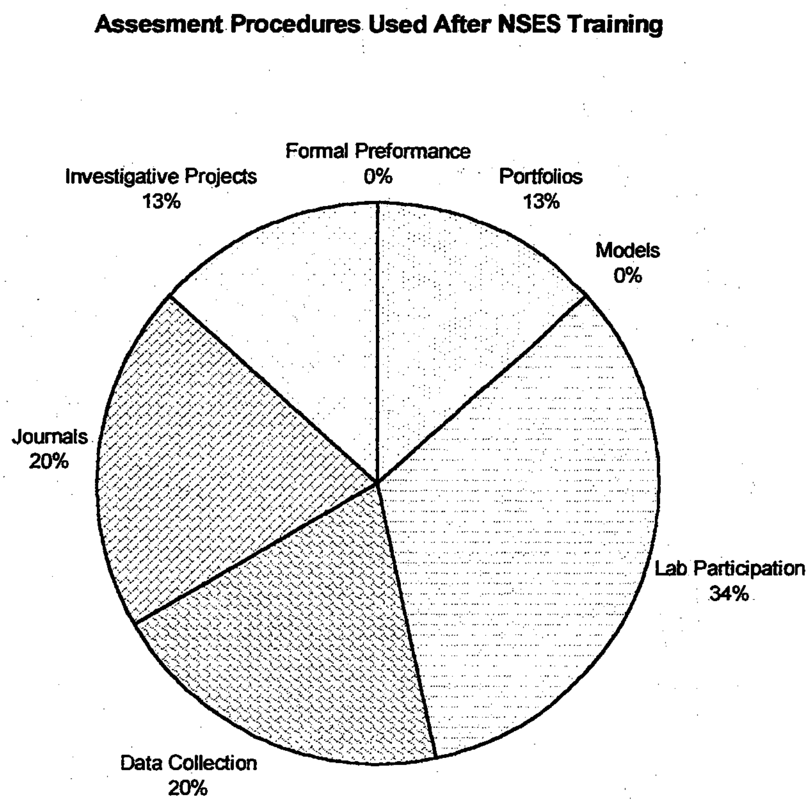
Class discussions and questioning appeared to be the most common processes used for assessing knowledge gained from the traditional methods of assessments.

Teachers identified the following from the NSES:

Table VI

Assessment Themes	**Number of Teachers**
Formal performances	0
Portfolios	4
Models	1
Lab participation	8
Collecting data	9
Journals	3
Investigative projects	6

Figure 2



Science Teaching Behaviors

The final theme looked at science teaching behaviors that would indicate process skills. The categories were modeling, student demonstrations, lab participation, science competitions (excluding science fair), cooperative learning groups, science reports, class discussions, science games, teacher demonstrations, variables, journals, science fair, and questioning.

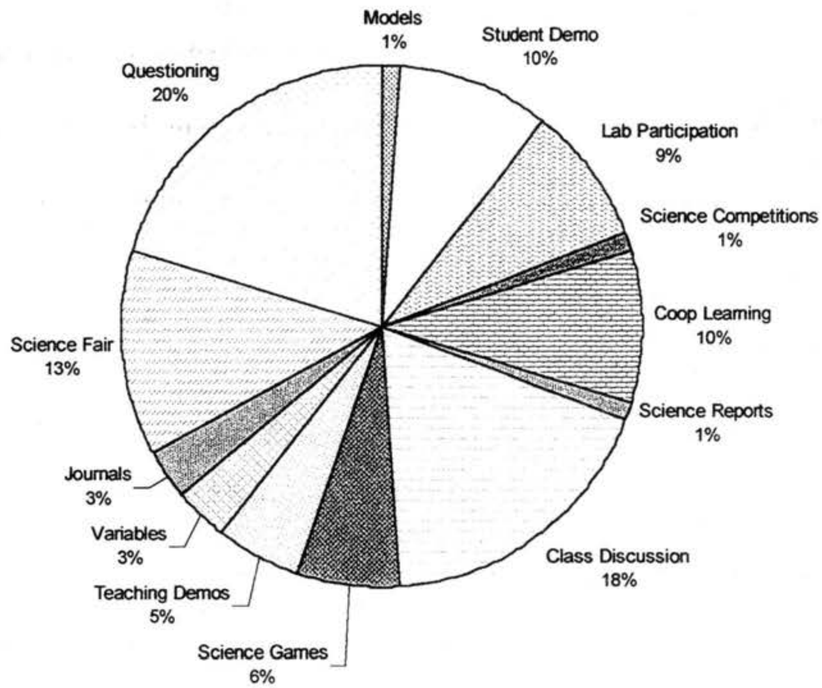
The following number of responses were made by teachers to identify a science teaching behavior that would indicate teaching process skills to students:

Table VII

Teaching Behavior	**Number of Teachers**
Models	1
Student demonstrations	9
Lab participation	8
Science competitions	1
Cooperative learning	9
Science reports	1
Class discussions	17
Science games	6
Teacher demonstrations	5
Teaching variables	3
Journals	3
Science fairs	12
Questioning	19

Figure 3

Science Teaching Behaviors Implemented to Teach the Nature of Science



CHAPTER V

SUMMARY OF RESEARCH

Introduction

The purpose of this research study was to identify how much of the Assessment Standard B, Part 1, of the NSES was being used by Oklahoma City Public Schools middle school teachers. A look at historical research had not offered any documentation on how educators have attempted to teach alternative methods of assessment for those teachers that were using inquiry learning in their classrooms. This research offers an alternative look at science teaching and offers data for making decisions that will address science literacy in the inner city.

Summary

In the two years that have passed since the adoption of the state science standards, Oklahoma City Schools have had little leadership in implementing those standards. Teachers have continued to teach science in the way that they experienced science or were trained. Few of these teachers have used the true concept of portfolios, rubric assessment, and performance assessment much less lab activities. Yet, through participation in a traditional competition such as science fair, the majority of teachers provide students (usually at their own expense) with some laboratory experiences and techniques. It is through these science fair competitions that the majority of teaching about the science processes occurs. The cost of science supplies and equipment is at an all time high. Yet, if any one opens any middle school textbook, approximately five pages of consumable materials are listed as necessary to teach each chapter. These textbooks have also included four to six pages of laboratory equipment, and usually from five to ten variations of living organisms for use during the year's curriculum. School boards and educators have continued to adopt these lab-oriented textbooks, because they know that it is the best way to teach science. Then these same educators who fund the textbooks totally disregard the pages in the textbook that require these materials for the lesson activities. Teachers continually expressed the fact that if they wanted to do the labs they had to buy the consumable materials themselves or not do the lab. The research suggests that most inner city students have a variety of reading experiences when it comes to doing science.

The NSES have suggested that science has been a subject area that catered to those students who could memorize facts quickly and do well on standardized exams. By not doing the labs, science classes had offered students who could think abstractly the success that students who were concrete thinkers could never achieve. This lack of lab participation has not provided equal access for concrete learners. Science literacy through national standards has offered a new, more serious look at science focusing on the collection of quantitative and qualitative data and the communication of results. By using technology to communicate and compare their students' research with other students across the world, a new version of science literacy has taken form.

To address the issue of assessment, the NSES had approached scientific literacy as the ability to work with scientific knowledge at the level of the students. Portfolios, journals, and rubrics have been used for evaluation which has provided assessment that is non-threatening yet can be extremely motivating. One of the teachers in this research project stated that she experienced an unusual motivating factor when students were required to graph their individual grades. She contended that they rarely reacted to grades of D or F when papers were returned, but when the student had seen the grade in the vision of a line graph, the next grade invariably went up. She stated that the students hated seeing the line illustrating their failure. This example illustrated why rubrics have been so successful. It was easier to admit; that one is a beginning rocket designer than to admit to having learned nothing about the physics concepts needed to explain Newton's Law of Motion. Rubrics have enabled students to perform a self-evaluation that is non-threatening leaving the door wide open to improvement of that self-evaluation.

The lack of opportunity provided for students to learn science can be attributed to a number of explanations as described from the research responses. This research suggests that low scores in inner city school could be attributed to factors other than student achievement. First, placement of science teachers in non-science rooms for the sake of grouping or teaming students, while English, social studies, and math teachers reside in classrooms designed for science labs is a great factor in inquiry oriented teaching. Second, the lack of running water in addition to a lack of safety equipment such as goggles, vents, and fire extinguishers set a climate that does not allow for science process skills to be taught. Third, the lack of focus on those process skills that are stated in the nature of science in Iowa Test of Basic Skills and the criterion referenced tests provide even less opportunity for learning science. Fourth, teachers lack the necessary supplies for even the most basic science experiments. Fifth, the time delay, between when the teacher orders supplies and when the teacher receives supplies, makes planning labs focusing on process skills next to impossible. Sixth, the hoarding of supplies is a frequent occurrence. The longer a teacher has been in a building directly relates to the amount of materials readily available to that teacher to teach science. Newer teachers often reported having absolutely nothing with which to teach, and often were placed in non-laboratory classrooms. The research in this study consistently supports the concept that some inner city facilities do not provide equal access to science literacy. It also suggests that the majority of Oklahoma City teachers because of science endorsement certification or science degrees that lack secondary science education skills and gate keeping courses cannot offer students inquiry oriented labs and NSES assessment that could better provide equal access to science literacy for middle school students.

Recommendations

A number of recommendations have been made that will help accomplish Assessment Standard B, Part 1, of the NSES.

1. Teachers must have structured staff development that has modeled those activities and assessment procedures they are being expected to implement. The research in this project has identified two major areas reflecting needs in the majority of science teachers. For those teachers who have entered the education field from industry and other specialized science fields, staff development in laboratory management skills are mandatory. Managing adolescents with glassware,

chemicals, and electricity requires different skills than those used in the management of adults. Most teachers stated emphatically that safety regulations suggesting no more than twenty-four students in a lab situation have proven critical to the safety of all students. This rule must be reinforced at all levels of education if educators want to get serious about safe science education. For those numerous teachers with a science endorsement, the research supports the fact that they lack secondary science education laboratory, management skills. Many teachers have not been trained in laboratory management nor do they have a concept of the skills that their students need to be ready for science in upper grade levels. Many of these teachers had recognized these deficiencies and would have readily participated in activities that would remedy the situation. This was evidenced by the large number of teachers who had attended staff developments in the summer of 1997. One weakness was that the staff development workshops had not discuss the NSES, which focuses on the whole picture of systematic change in the field of science education especially science education assessment.

2. Middle school teachers cannot make this change alone. Elementary teachers must prepare their students to work in middle school labs. At the elementary level, students should have learned to make qualitative and quantitative observations to equip those entering middle school with basic lab skills that permit informed participation in lab activities. Middle school students frequently enter science classes having never participated in any type of lab activity.

3. Those who are in leadership and administrative positions need training in the NSES and what these standards are trying to achieve. When teachers are placed

in a non-science classroom for the convenience of teaming and have no running water or lab facilities, it is obvious that science laboratory activity is not a priority.

4. Teachers from this study indicated a lack of knowledge of the current state of scientific research. It would be a great advantage to bring in staff development people who could help update these teachers in modern research ideas. This training could provide resources for these teachers to help students design modern research projects beyond simple bean seedling growth, soil erosion, volcanoes, and computer games.

5. The whole pre-Sputnik atmosphere of the middle schools in Oklahoma City should be disbanded. Buildings built before 1955 need major renovations. The teachers who had computers did not have access to electrical outlets. The teachers who had a large amount of equipment had it sitting on the floor. Fire resistant lab tables are needed and many plumbing problems such as water pipes without faucets and sinks that are not connected to drains need to be replaced. Sinks are corroded and contain surfaces that are incapable of being cleaned. Science labs need a facelift if teachers are to be motivated and excited about any kind of change.

6. Teachers need inservice training in teaching process skills, assessment of process skills, laboratory management, and current research practices.

Conclusion

During this study teachers mentioned that they had taught students how to make observations, but few teachers had the knowledge on the qualitative observations that identified change and the quantitative observations that enables the nature of science to be interpreted through the field of mathematics. Textbook and recipe-type laboratory experiences must be balanced with original research where the conclusion is based on data personally collected by the student and not on a single observation of a demonstration.

The NSES has many components. Assessment B, Part 1, is a critical issue because the standards themselves state that students cannot be held accountable for learning science if they do not have equal access to the opportunity to learn science. This paper documents that lack of opportunity. Assessment must be viewed in a different context if teachers are to feel more confident about using different forms of assessment that truly reflect the performance of their students in the process skills. The acceptance of performance-based assessment, lab demonstrations, rubrics for evaluations, and portfolios must become a reality and fully understood in the evaluation of students in the field of science. Scientists in the community have used many resources to communicate their data. Few of them have been required to memorize facts or tables that are easily accessible to their needs. Science teachers must come to terms with modeling that scientific community in all aspects of their teaching and assessment.

The NSES encourage teachers to model the scientific community, to use the techniques of modern research in their classrooms, to focus on teaching students about controlling variables, and to create a learning environment that includes multidisciplinary approaches to science instruction. The scientific community has identified the best possible process for systematic change in science education through the NSES. The future of science education depends on the leadership of those who believe in what the NSES contain. This leadership must provide the ability to help others understand the need for change. NSES leaders may not have addressed the issue of how to get complacent educational leaders to focus the issue of science assessment as seen through the interpretation of process skills. In this approach science educators must consider equal access in all forms: teacher training, materials access, teacher focus on process skills, assessment based on performance and science products, and facilities and equipment. Most of all equal access must follow the guidelines that state science should no longer be taught in a manner that encourages success for those who can memorize scientific facts. For the development of greater science literacy in our students and therefore the creation of a more informed citizen for our country, our responsibility as educators is to advocate the NSES as the number one focus for all science learning.

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APPENDIXES

APPENDIX A

OSU INSTITUTIONAL REVIEW BOARD

APPROVAL FORM

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: November 17, 1997 **IRB #: ED-98-035**

Proposal Title: **ASSESSING THE NATURE OF SCIENCE IN THE MIDDLE SCHOOL CLASSROOM**

Principal Investigator(s): Steve Marks, Rosemary H. Eskridge

Reviewed and Processed as: Expedited

Approval Status Recommended by Reviewer(s): Approved

ALL APPROVALS MAY BE SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING, AS WELL AS ARE SUBJECT TO MONITORING AT ANY TIME DURING THE APPROVAL PERIOD.
APPROVAL STATUS PERIOD VALID FOR DATA COLLECTION FOR A ONE CALENDAR YEAR PERIOD 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 Disapproval are as follows:

Signature: [signature]

Chair of Institutional Review Board

Date: January 7, 1998

cc: Rosemary H. Eskridge

APPENDIX B

RESEARCH COVER LETTER

RESEARCH COVER LETTER

2114 Hummingbird Lane
Edmond, Oklahoma 73034
405-341-7890

Date
Name
School
Address
Address

Dear ____________:

How are middle school science teachers assessing students today? Many science historians have looked at the question of why science reforms have not included an assessment component of science process skills. Perhaps the problem is not in the curriculum or the teaching but in how testing of our middle school students is being accomplished. This question has become the foundation for my doctoral research, therefore I am very interested in knowing how middle school teachers assess science process skills.

Through a short interview I would like to include your ideas about middle school science assessment of process skills in my research project. There are no right or wrong answers to this interview; I am more interested in what works for the individual teacher. I think it is important to identify current successful assessment practices that are not being reflected by standardized testing. Many times we feel that our students have learned much more than these scores reflect. For this project I am interested in how individual teachers know that their students have learned a specific process. Reforms in science are trying to develop science education methods: namely decreasing the amount of rote memory responses, increasing student experiences with functional science, decreasing book work while increasing activities that reflect real world experiences which improve critical thinking and problem solving skills. Yet, in the history of assessment, we have failed to give teachers alternative methods to assess student achievement in higher order thinking process such as application and assimilation of science processes. .

This is an opportunity for you to anonymously share your assessment practices with the educational community and policy makers. To participate in this study the following activities are required.

1. Return the informed consent form indicating your agreement to participate in the study.

2. Take part in a brief interview either in person or by telephone.

3. Review and react to the written transcript of our conversation. Feel free to make any changes in the transcription of the interview until you feel it truly reflects your personal assessment strategies.

Your assistance in this study will enable a baseline of actual middle school classroom assessment practices to be documented for use in future assessment research. Absolute confidentially will be maintained at all times. Participants will be identified by a randomly generated code of which only the principle investigator will have access. I am looking forward to talking with you about your ideas on assessment.

Sincerely,

Rosemary H. Eskridge

APPENDIX C

RESEARCH QUESTIONNAIRE

RESEARCH QUESTIONNAIRE

1. How do you teach your students about the nature of science?
2. Do you question your students about their understanding of process skills before, during, and after experiments?
3. How do you teach your students to make systematic observations?
4. Do you have a special way of teaching your students to interpret and analyze data?
5. Do you have a special way of teaching your students how to draw conclusions?
6. How do you find out what your students are thinking/learning?
7. Can you describe your philosophy for assessing science process skills?
8. How do your students communicate their conclusions derived from experiments?
9. How do you know that students understand the process skills that are included in the nature of science?
10. What methods of assessment do you use to evaluate student's understanding of the nature of science?

APPENDIX D

DEMOGRAPHIC SURVEY

DEMOGRAPHIC SURVEY

1. What is the name of your school?
2. What is the size of your school population?
3. What socioeconomic factors influence your student population?
4. What science do you teach?
5. How many years have you been teaching this particular science?
6. What is your latest degree completed related to science?
7. What is the most recent science related workshop or inservice in which you have participated?
8. How recently have you taken a science class or science workshop presented by a university or college?
9. How many students do you carry as your class size load?
10. Do you have a copy of the National Science Education Standards?
11. Are you familiar with any workshops or activities that make information about the National Science Education Standards available?
12. Are you male or female?
13. What is your racial origin?

APPENDIX E

SAMPLES OF RESEARCH QUESTIONNAIRE NARRATIVE

RESEARCH QUESTIONNAIRE NARRATIVE

1. How do you teach your students about the nature of science?

   "through exploratory *activities* in diverse application and areas of science, particularly with *student interest* in mind"

2. Do you question your students about their understanding of process skills before, during, and after experiments?

   "I have my students think about how the experiment could be useful in every day life and then ask them to make a hypothesis that is related to that factor."

3. How do you teach your students to make systematic observations?

   "Through profound *observation* that I can set up; through using vocabulary appropriate to what we are studying and spending time on a unit that includes how and what systematic observations are supposed to be like"

4. Do you have a special way of teaching your students to interpret and analyze data?

   "Students are taught to graph and interpret data in a unit that focuses on these concepts. I also provide them different ways and opportunities to *interpret* data"

5. Do you have a special way of teaching your students how to draw conclusions?

   "Students are encouraged to look at the experiment from different perspectives and *infer* the importance to their own person. .....I encourage them to develop *a personal perspective for the experiment*"

6. How do you find out what your students are thinking/learning?

   "through classroom discussion, student *journals*, questions box, and questionnaires"

7. Can you describe your philosophy for assessing science process skills?

   "My philosophy is to provide students multiple opportunities to express their growth in the attainment of *science process skills*."

8. How do your students communicate their conclusions derived from experiments?

   "Through journal responses that include *pictures, graphs,* and random thought, etc."

9. How do you know that students understand the process skills that are included in the nature of science?

   "Mainly through classroom activities when they begin to incorporate the *science process skills* automatically"

10. What methods of assessment do you use to evaluate student's understanding of the nature of science?

   "Student *portfolios* that include classroom assignment, *experiment responses, journal* responses. All components should show student progress toward their *personal* journal on the the *nature of science*"

APPENDIX F

FOLLOW UP LETTER

FOLLOW UP LETTER

2114 Hummingbird Lane
Edmond, Oklahoma 73034
405-341-7890

Date
Name
School
Address
Address

Dear ____________:

I would like to take this opportunity to express my appreciation for your participation in my research dissertation. I believe the information you have shared with me will enable our school district to better plan for professional development activities and better implementation of the National Science Education Standards. I appreciated your quick responses and comments about your teaching behaviors and assessment practices.

I have enclosed a copy of the participant responses and hope that you will enjoy reading about your middle school associates. The names have been changed to ensure privacy for those who have contributed to the research. If you have any questions or comments, please feel free to contact me.

Thanks again for your participation,

Rosemary H. Eskridge

2

VITA

Rosemary Eskridge

Candidate for the Degree of

Doctor of Education

Thesis: MIDDLE SCHOOL ASSESSMENT AND THE NATURE OF SCIENCE AS RELATED TO THE NATIONAL SCIENCE EDUCATION STANDARDS

Major Field: Applied Educational Studies

Biographical:

Personal Data: Born in Big Spring, Texas on December 22, 1944, the second daughter of eight children of Jack and Christine Horn. Has five daughters and five grandchildren. Married Gordon William Eskridge, son of John and Lena May Eskridge.

Education: Graduated from Big Spring High School, Big Spring, Texas in December 1962; Received a Bachelor of Science in Elementary Education in May1969 and a Masters in Education, December 1975, from the University of Central Oklahoma, Edmond, Oklahoma; completed the requirements for the Doctor of Education degree in Applied Studies from Oklahoma State University in July, 1998.

Experience: Middle School Science and Math teacher for 28 years; Currently employed as the Science Specialist by the Oklahoma City Board of Education, Oklahoma City, Oklahoma.

Writing Activities: Curriculum Editor and writer for Young Astronauts Project—Earth Search, 1996-1997; Outdoor Curriculum Guide-Oklahoma State Department of Education; Curriculum writer for Camp Classen School of Outdoor Education; Articles published in outdoor education journals for students; Family Life curriculum guide writer for Oklahoma City Public Schools; 1976-1980 Science curriculum writer for Oklahoma City Public Schools 1980-1986; Astronomy curriculum writer for Oklahoma City Public School-1998

Awards and Grants: Oklahoma Conservation Award—Soil Conservation Service Tapestry Award for $10,000, 1993 Christi McAuliffe Fellow for $ 25,000, 1986 Inducted into the Oklahoma State Science and Engineering Fair OSSEF Hall of Fame, 1990 Grant Awards from Oklahoma City Public School Foundations 1996--Oklahoma City Public School Foundation Grant, $500.00, called "Juvenile Engineers" 1995--Oklahoma City Public School Foundation Grant, $500.00, called "In Search of Newtonian Physics and the Edible Kaleidoscope" 1992--Oklahoma City Public School Foundation Grant, $500.00, called "Building Space Stations in the Classroom" 1990--Oklahoma City Public School Foundation Grant, $500.00 called "Magnetic Levitation-An Alternative to the Model T" 1989--Oklahoma City Public School Foundation Grant, $500.00, called "Weather—You Like It or Not" 1989--Oklahoma City Public School Foundation Grant, $500.00 called Teaching Math Activities in the Great Outdoors" 1988--Oklahoma City Public School Foundation Grant, $500.00 called "Children Writing Workshop-Communication through Student Newspapers" 1978--Oklahoma City Public School Foundation Grant, $500.00 called "Games People Play, interactive games between parents, teachers and students"

Leadership Positions: Oklahoma State Coordinator for Space Student Involvement Program Oklahoma State Presenter for Oklahoma Energy Resources Board Program—"Fueling Around" Served on the Board of Directors for State Science Fair,1982-1992 Team Teacher with the Technology Teacher, 1990-1994

Conferences: Participant in Total Quality Management, April 1998 Participant in Space Science Involvement Program, May 1998 Participant in Principles of Effective Leadership, June 1998 Participant in Laser K-8 Oklahoma Strategic Planning Institute, June 1998 Participant in the NEWMAST (NASA Educators Workshop for Science and Math Teachers) Program at Johnson Space Center Participant in the "Teacher in Space" Education Workshop, Kennedy Space Center Participant in the "Hubble Space Telescope Conference," Kennedy Space Center Participant in the Johnson Space Center Family Workshop for Space Educators Participant in the Jason Project Workshops, Johnson Space Center

Professional Presentations: National Science Teachers Association- Anaheim, California –1993 Regional Science Teachers Conferences-Tulsa, Oklahoma-1992 Oklahoma State Science Teachers Conferences 1991-1992