EFFECTS OF A TEACHER INSERVICE TRAINING MODEL ON
STUDENTS' PERCEPTIONS OF ELEMENTARY SCIENCE

DISSERTATION

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF EDUCATION

BY

Dawn Haynes, B.S., M.Ed.
Denton, Texas
May, 1995
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The purpose of this study was to test a teacher inservice training model which was designed to increase the number and use of hands-on science activities, increase the number of times teachers teach science, and improve students' perceptions of science.

Five hypotheses predicted significance when the treatment group was compared to the control group. The Student Science Questionnaire was used to gather data from both groups.

The first hypothesis, which was related to increasing the number of hands-on science activities was tested using a t-test. The results indicated that students in the treatment group performed a significantly greater number of hands-on science activities than did students in the control group. It was concluded that teacher participants increased their use of hands-on science activities.

The second hypothesis, which was related to increasing the times teachers teach science, was also tested using a t-test. Results indicated that the students in the control group studied science a significantly greater number of times than did students in the treatment group. It was
concluded that teacher participants did not increase the number of science lessons they taught.

The third hypothesis, which concerned students' descriptions of most of their science lessons as reading, doing, or listening, was tested using a $z$ value. The results indicated that students in the treatment group reported doing a significantly greater number of times than did students in the control group. It was concluded that teacher participants conducted mostly hands-on science activities.

The fourth hypothesis, which was related to improving students' perception of science, was tested using a $z$ value. The results indicated that the perceptions of students in the treatment group were significantly more favorable toward science than were the perceptions of students in the control group. It was concluded that by conducting more hands-on science activities, teacher participants influenced their students' favorable perceptions of science.

The fifth hypothesis, which related to students ranking science higher than other subjects, was also tested using a $z$ value. The results indicated that students in the treatment group ranked science significantly higher than did students in the control group. It was concluded that the students preferred science because teacher participants actively involved them in hands-on science activities.
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CHAPTER 1

INTRODUCTION

Significance of the Problem

Kober (1993) reported that 2 decades of data from the National Assessment of Educational Progress (NAEP), a federally funded project to measure changes in student achievement in key subjects, show that despite upturns in the 1980s, the average science achievement scores of students 13 and 17 years of age remain below 1969 scores. Achievement of 9-year-olds is about where it was in the 1970s.

Students in the U.S. rank near the bottom in science achievement when compared with their counterparts in other countries (International Association for the Evaluation of Educational Achievement, 1988). The International Association for the Evaluation of Educational Achievement conducted a study of achievement in science among 10-, 14-, and 17-year olds in the mid-1980s in which 24 countries or systems of education participated. A preliminary report included initial results from 17 countries, including the U.S. Among 14-year olds, population 2 in the study, the U.S. had dropped from 7th to 15th in the period from 1983 to 1986. As noted in the report,
Population 2 in this report is of great importance because, for most countries, this is a point near the end of full-time compulsory education and the science achievement levels are one indicator of how scientifically literate the general public and work force will be (p. 42).

In a 1988 National Assessment of Educational Progress study, Mullis and Jenkins reported a number of serious problems with science achievement in the synthesis of five national assessments on the science proficiency of 9-, 13-, and 17-year-old U.S. students. The findings include the following:

More than half of the nation's 17-year-olds were inadequately prepared, either for jobs that require technical skills or to benefit substantially from specialized on-the-job training. Only 7% of high school students had the knowledge and skills necessary to perform well in college level courses.

The authors of a report by the National Science Board's Commission on Precollege Education in Mathematics, Science, and Technology (1983) stated that "alarming numbers of young Americans are ill-equipped to work in and contribute to, profit from and enjoy our increasingly technological society" (p.1). It seems, therefore, that the U.S. may suffer in the future if its citizens are unprepared for life in the 21st century.
Becker (1991) warned that the education of U.S. citizens is a key if the country is to assert its dominance. He stated:

There is a growing recognition that our basic resource is an educated and skilled people. Such a view suggests that a main component of economic competitiveness is educational competitiveness, what we can do in the global economy is shaped by what we know. Further, the belief is that U.S. citizens must have the knowledge and skills at least equal to those of our competitors. (p. 77)

Recognizing the seriousness of the problem, President Bush and the Governors of the States, at an Education Summit in Charlottesville, Virginia, September 1989, adopted a set of national goals for education. One of the goals which was focused on science and mathematics achievement, stated: "By the year 2000, U.S. students will be first in the world in science and mathematics achievement" (National Education Goals Panel, 1991, p. 68). In July 1990, the National Education Goals Panel (NEGP) was created to measure the progress made in achieving these goals. In February 1993, the panel reported that American students continued to rank significantly behind their peers in other advanced countries in science (Staff, 1993).
Concern for the state of science education in the U.S. is further exemplified by the fact that the Department of Education has funded a National Center for Science Teaching. According to Blumenstyk (1991), the National Science Foundation awarded 10 states over $75 million to improve the teaching of science and mathematics. The National Science Foundation allocated more funds to the elementary level than the secondary level. The National Science Foundation anticipated funding state systemic initiatives in science and mathematics in all 50 states.

The National Center for Improving Science Education (1989) has formulated its own set of national goals for education. The center's goals were aimed at elementary science education, grades kindergarten through 6, because of the belief that it is the elementary level at which science learning must be enhanced. At the core of the National Center for Improving Science Education vision is the concept that elementary children need to build their knowledge of science on direct experiences. In the book, Getting Started: A Blueprint for Elementary School Science (1989), the authors noted that the case for hands-on science is extremely powerful, yet few elementary teachers provide such experiences for children; they rely instead on lectures and textbooks.

When considering teacher development and support, the National Center for Improving Science Education (1989)
formulated two goals to guide its recommendations for elementary school science. One goal was to develop the support at local and state levels to ensure that teachers who know how to teach science can teach professionally. The other goal was to provide the means "for all teachers to develop the understanding, positive attitudes, and abilities to teach good science and to continue to grow throughout their careers" (p.ix).

Loucks-Horsley et al. (1990) noted that the time is right for promoting science in school. While the attention science education is currently receiving is not all positive, those concerned realize that all children must be better prepared to make decisions that require scientific thinking than they are now. Efforts are underway to accomplish that.

This study was designed to investigate the effects of a teacher inservice training model on students' perceptions of science.

Statement of the Problem

The problem of this study was to address the following question: What effect will a hands-on teacher inservice training model have on the teacher participants' students' perceptions of science when compared to the students of teachers without the training?
Purpose of the Study

The purpose of this study was to test a teacher inservice training model designed to (a) increase the number of hands-on science lab activities students perceive their teachers use per week during science instruction, (b) increase the number of times students perceive their teachers teach science per week, and (c) improve students' perceptions of science and science lessons. The data to test these objectives were collected using a 14-item Student Science Questionnaire.

Hypotheses

The objectives, to increase the number and use of hands-on science lab activities and the number of science lessons per week as perceived by the students of teacher participants, were assessed using the following hypotheses:

1. Students of teachers with training will report engaging in hands-on science lab activities a significantly greater number of times each week than will students of teachers without training (item 12).

2. Students of teachers with training will report a significantly greater number of times they study science in a week than will students of teachers without training (item 11).

3. Students of teachers with training will describe most of their science lessons as "their getting to do
science lab activities themselves" a significantly greater number of times than will students of teachers without training (item 13).

The objective to improve students' perceptions of science and science lessons was assessed using the following hypotheses:

4. Students of teachers with training will respond positively regarding their perceptions of science and science lessons a significantly greater number of times than will students of teachers without training (items 1 through 10).

5. Students of teachers with training will rank science significantly higher as their preferred subject than will students of teachers without training (item 14).

The terms used in the study are defined as follows:

Definition of Terms

Hands-on science lab activities are science investigations by students who manipulate materials to find solutions to science problems.

Student Science Questionnaire is a 14-item questionnaire, developed for this study, that is designed to obtain student responses regarding their (a) feelings toward science as a subject (items 1, 3, 4, 5, 7, 8, 9, and 14), (b) perceptions of science lessons (items 11, 12, and 13),
and perceptions of classroom climate during science lessons (items 2, 6, and 10).

Suburban school district is a school district outside the city limits of a larger city with a student population of approximately 25,000 students, 42% of which are ethnic minority and 30% of which are economically disadvantaged.

Teachers with training are fifth grade teachers who participated in the teacher inservice training model in which they performed 69 hands-on science lab activities compiled for this study.

Teachers without training are fifth grade teachers who did not participate in the teacher inservice training model.
CHAPTER 2

SYNTHESIS OF RELATED LITERATURE

Historical Background

Since earliest time, education has been a way for a society to inculcate its citizens to its culture. Historically, education began with man teaching himself, by accident, experimentation, observation and through the use of natural forces. Man abundantly possessed the drive to share his acquired information. Thus, father taught son, klan or groups would, in turn, teach their children both skills and realities of life. Man's eternal quest to enhance his living conditions mandated that education be pursued as an absolute matter of cultural survival. (Allan, 1984, p. 3)

In modern times, scientific discoveries and technological advances which are accelerating as never before in our history, require that we acquire scientific literacy. Throughout this century, many a treatise has been offered and applied to education generally and science education specifically in an attempt to answer the question: What is the best way to make it possible for individuals to adapt successfully to the environment and to participate fully in American society? It is important, therefore, to
examine educational history as a bridge from the past to the present in order to gain a sense of the past so that present dilemmas in science education can be studied with some degree of confidence.

For the purpose of this literature review, educational history is divided into four periods in which historically significant aspects of science education are addressed. The first three periods, identified by Hansot and Tyack (1982), are (a) the common school movement, (b) the progressive movement, and (c) fragmentation and demystification. The fourth period is the reform era, identified by Hurd (1986), Passow (1989), and Cuban (1990).

The Common School Movement (1820 to 1875)

The common school movement was led by Horace Mann and others "who shared a providential conception of American destiny and used that belief as a means of mobilizing their fellow citizens in support of public education" (Hansot & Tyack, 1982, p. 2). During this period, state education authorities prepared and approved lists of subjects to be taught in public elementary schools in their states. The subjects were divided into those that were skill-oriented (such as reading and arithmetic) and those that were content-oriented (such as history and geography). Students who mastered the skill subjects were then thought to have the tools to master the content subjects (Tyler, 1981). If
reading and arithmetic were prerequisites to subjects such as science, then reading scientific texts and using numbers in science were the methods by which students learned about science during the common school movement era.

It is important to remember that the society of the U.S. at that time was rural agrarian (Parker, 1981). Children who lived on farms had hands-on experience with scientific phenomena every day of their lives. During the progressive era, society became more mobile. People moved to the cities where the industrial revolution was booming. Children had fewer hands-on experiences with scientific phenomena there.

The Progressive Era (1875 to 1957)

Education became professionalized during the progressive era. The factory model was used as a model for public schools and the first use of centralized authority to enforce policy was instituted (Hansot & Tyack, 1982). In an article entitled "Ideas that Shaped American Schools," Parker (1981) credited John Dewey and his work, particularly his book Democracy and Education (1916), with having a profound effect on education in the U.S.

John Dewey (1916) was a chief advocate of the student-centered curriculum, as contrasted to the subject-centered curriculum. He believed that the interests and needs of learners should be incorporated into the curriculum, and
that by so doing, learners would be intrinsically motivated to learn (Ornstein, 1982). Parker (1981) quoted Dewey, who said that education "has no end beyond itself; it is its own end; and . . . the educational process is one of continual reorganizing, reconstructing, transforming" (p. 316). Science education, as part of the educational process, is continually being reshaped.

Hurd (1986) noted that the need to reconceive science education to better prepare "citizens to live in a culture most often described in terms of achievements in science and technology" (p. 355) has been an issue since the 1920s. He noted that three organizations influenced the role of science education in the 1920s, 1930s, and 1940s. They were the American Association for the Advancement of Science, the National Society for the Study of Education, and the Progressive Education Association. Their influence is illustrated in the following statements:

In 1928, the American Association for the Advancement of Science took the position that school science should: "function more completely in the lives of people generally." . . . In 1932, a study commissioned by the National Society for the Study of Education recommended that science in the schools help people "interpret the phenomena of common experience." . . . [In 1937], a five year long study committee of the Progressive Education
Association saw as the central purpose of science education: "To make it possible for individuals to realize their fullest potentialities for effective participation in a democratic social life." . . .

[In 1947], a committee reporting in the National Society for the Study of Education yearbook took a similar position in recommending that school science should be made "functional" through applications related to the personal and social experience of students. (p. 355)

Another undertaking of the Progressive Education Association which occurred during the Great Depression of the 1930s and is regarded as a significant event in education, is known as the Eight-Year Study. Ralph Tyler was involved in the study throughout. In an interview with Nowakowski (1983), Tyler explained his involvement. He related how during the depression, more children than ever before (up from 20% to 50%) were enrolled in high schools. There was a need, therefore, to change the college preparatory curriculum to a curriculum that would better prepare recent enrollees for the work force. The Progressive Education Association took the responsibility of arranging a conference of school, college, and state department representatives to determine how best to accomplish that end. The outcome was the Eight-Year Study. Thirty high schools were freed from state-mandated
restraints and college entrance requirements in order to experiment with their curriculum for 8 years.

Tyler was charged with aiding school personnel in the evaluation of the new curriculum. He stressed to teachers the need to write objectives that clearly defined the student outcomes they sought. According to Tyler (1981), however, the plans drawn up by expert consultants were not carried out by most teachers. He stated, "Unless they believed in the programs, understood their roles, had the necessary skills, and felt confident they could use the new programs successfully, teachers would not try them" (p. 600). Seeing this as a problem, the leaders of the study established summer workshops and weekend committee activities to provide teachers the opportunities to develop interest, skills, and materials.

**Fragmentation and Demystification (1957-1983)**

In the 1950s, interest in science education waned (Hurd, 1986). However, when the U.S.S.R. launched Sputnik I in 1957, interest in science education was renewed. The U.S. government viewed Russia's space feat as a threat to international security and began a serious effort to improve science education. Many other issues began to emerge, and the era known as fragmentation and demystification was born.

The launching of Sputnik intensified the desires of many to reconceive science education. Sputnik gave us the
goal to strengthen science education to make the U.S. more competitive in the space race.

The purpose of the National Defense Education Act which was passed in 1958, was to improve science education, as well as other subjects such as mathematics and foreign language, and to attract academically able students to the field (Parker, 1981). The National Science Foundation was authorized to support activities to strengthen the teaching of science and mathematics in schools and colleges (Tyler, 1981). The reforming of science education was put into the hands of research scientists who were backed by millions of dollars of federal monies for the improvement of science course content and teacher training. Science curricula were written to display science in its purest form as a set of research disciplines. However, the place of science in culture and its relation to human affairs and technological achievement was largely ignored (Hurd, 1986).

Another significant event during the fragmentation and demystification era occurred at Woods Hole, Massachusetts, in 1959, and became known as the Woods Hole Conference (Parker, 1981). Recognizing the need to reconceive science education, 35 scientists, scholars, and educators met to discuss how education in science might be improved in elementary and secondary schools. Jerome Bruner, a psychologist at Harvard, chaired the event and later wrote a book The Process of Education (1960) to describe what
happened. **Bruner** (1977) held that basic notions in scientific fields are perfectly accessible to children of 7 or 10 years of age provided they are studied through materials that the child can handle. Bruner believed in the inquiry method of learning the structure of a subject. He held that learning the structure of a subject through discovery allows the learner to solve problems.

During this period, according to Hansot and Tyack (1982), important issues in education began to multiply and the goals for education became fragmented by what was going on in the larger society. Hansot and Tyack explained that radical historians sought to demystify public education as one in which class, racial, sexual, and ethnic divisions were being perpetuated. "Beginning with blacks and their white allies in the civil rights campaign, successive groups--feminists, Chicanos, the handicapped, native Americans, and many others--have mounted powerful protest movements to win symbolic and practical gains from the educational establishment" (p. 10). Educators were forced to become responsive to groups that had previously been largely ignored in the policy-making process. Reconceiving science education then became just one of many important issues facing education.

In 1964, as part of the Civil Rights Act, research was commissioned to study the effects of desegregation. The Coleman Report, released in 1966, was the nation's first
report on 10 years of school desegregation (Parker, 1981). Among other findings, the Coleman Report revealed that empirical evidence showed no significant relationship between a school's material resources and the achievement of its students. Fuller (1987) noted that this basic finding was not overturned by a decade of research that followed the release of the report. Fuller did note, however, that material inputs can influence students' achievement in certain subjects such as science.

Further fragmentation continued into the 1970s. Declining test scores heralded the "Effective Schools Movement" (Orlich, 1987), which was sometimes referred to as the "Back-to-the-Basics-Movement" (McCormick, 1989). McCormick reported that the increasing pressure of standardized testing had focused the nation's academic concerns on boosting achievement in reading and mathematics, leaving science as a secondary concern. She noted that in science classes, teachers returned to more direct instruction, with teachers doing the talking and students doing the listening and being tested on information obtained mostly from textbooks.

Hurd (1986) reported that during the 1970s, the Advisory Committee for Science Education of the National Science Foundation proclaimed the need for science students to appreciate the role of science and to have the desire and ability to use science in the solution of broader problems.
of society. In that regard, the foundation supported curriculum projects such as the Man-Made World, Intermediate Science Curriculum Study, Project Physics, and Human Sciences.

Although these new science courses were a significant contribution to curriculum theory, especially the elementary science programs, Hurd (1986) noted, they were considered too difficult for students and teachers who did not understand their conceptual structure or master the inquiry style of teaching that was essential to the success of the new courses; consequently, they were vetoed in the classrooms.

In reviewing studies of educational change conducted in the last 25 years, theorists have concluded that most curriculum development and educational change "adoptions" of the 1960s and the 1970s were not put into practice (Poole & O'Keafor, 1989). Orlich (1987) noted that the most important issue to be addressed by school reformers is how to provide the high-quality staff development that is necessary to produce the desired results.

The Reform Era (1983 to Present)

In the 1980s, with large deficits and huge losses in foreign trade, public and corporate officials "reasserted the values of economic efficiency and competitiveness as one to which school must . . . heed" (Cuban, 1990, p. 9). When
A Nation at Risk: The Imperative for Educational Reform
(National Commission on Excellence in Education, 1983)
proclaimed that if an unfriendly foreign power had attempted
to impose on America the mediocre educational performance
that existed at the time, it would have been viewed as an
act of war, another round of educational reform began.

The National Commission on Excellence in Education,
authors of A Nation at Risk, identified science as one of
the new basics and recommended a science program to
emphasize "the application of scientific knowledge to
everyday life" (Hurd, 1986, p. 356). The term "excellence"
became a watchword of the reform movement: excellence in
terms of tougher academic requirements, more tests, more
homework, longer school days and years, more mathematics and
more science (Passow, 1989).

Chance (1988) reported that more than 275 education
task forces were organized in the U.S. in the early and
mid-1980s. In addition to the reports generated by task
forces, at least 18 books or book-length national reports
intending to fix the schools were published during
the 1980s.

Several topics in the reports of the 1980s and 1990s
relate to this study. They are as follows: (a) the need
for reform in elementary science, (b) hands-on science,
(c) teacher and student attitudes toward science, (d) staff
development, (e) assessment, and (f) what teachers do.
The Need for Reform in Elementary Science

In *The Science Report Card*, Mullis and Jenkins (1988) reiterated that high school students should be expected to complete their high school studies with sufficient science understanding "for assuming their responsibilities as voters and as efficient contributors in the workplace" (p. 6). Unfortunately, they continued, these expectations have not been met. In reviewing the National Assessment of Educational Progress assessments in 1986, Mullis and Jenkins found that many of the problems facing science education began at the elementary level. Their notable findings on elementary school science included the following:

1. Eleven percent of third graders assessed in 1986 reported having no science instruction (p. 9).

2. At grade five, the U.S. ranked in the middle of science achievement relative to 14 other participating countries (p. 6).

3. More than two-thirds of third grade teachers responding to the National Assessment of Educational Progress questionnaire reported spending 2 hours or less each week on science instruction (p. 9).

According to McCormick (1989) the National Science Foundation selected the elementary level as its focus for several reasons. First, younger students have more interest in and better attitudes toward science. Second, students at this level do not have the pressure to get good grades.
And third, elementary students adapt more easily to significant reform in science study. In addition, McCormick noted that researchers want to communicate to elementary teachers the idea that they do not have to be science specialists to teach science; that, given the proper training, curriculum and materials, these teachers can spark their students' interest in science.

Other reports have stressed the need for an early start in quality science instruction. According to the National Science Board Commission on Precollege Education in Mathematics, Science and Technology report *Educating Americans for the 21st Century* (1983), students' curiosity is stifled by science instruction, or the lack of it, in the early grades. The report added that students are discouraged from consideration of serious study in the science field early in their school career due to inadequate teaching which leads to lack of motivation. Mullis and Jenkins (1988) suggested that the inadequate science instruction students experience in elementary school may convince these students that they are incapable of learning science, and thus contribute to low enrollments in secondary school science courses.

Another reason that quality science instruction should begin in elementary school is that science learning is cumulative. A report published in 1989 by The National Commission for Improving Science Education revealed that
current approaches to science instruction assume that serious study in science can be delayed until a student reaches secondary school. However, considerable evidence on the cumulative nature of science learning suggests that quality instruction should begin in kindergarten and continue until high school graduation (Kober, 1993).

If the foundation for good science education begins early and science learning is cumulative, as is suggested, then it is imperative that science educators provide quality science instruction for elementary students. The National Commission for Improving Science Education (1989) recommended that those responsible for elementary school curriculum give science equal billing with reading, writing, and mathematics.

**Hands-On Science**

The guiding principle of brain research, according to Caine and Caine (1991), is that it establishes and confirms the belief that multiple complex and concrete experiences are essential for meaningful learning and teaching. The authors added that because the learners are constantly searching for connections, educators need to orchestrate the experiences from which learners extract meaning. Rutherford (1993) reinforced this concept with the assertion that hands-on learning and learning by experience are powerful ideas. Engaging students actively and thoughtfully in their studies pays off in active student learning (Kober, 1993).

Bredderman (1983) used meta-analysis techniques to synthesize research on the effectiveness of three major activity-based elementary science programs (The Elementary Science Study, Science-A Process Approach, The Science Curriculum Improvement Study). He warned that while overall effects of the activity-based programs for elementary students were clearly positive, the "advantage may be lost for elementary students when they are later enrolled in classrooms where more traditional methods prevail" (p. 513).

According to the National Science Board Commission on Precollege Education in Mathematics, Science and Technology (1983) authors of Educating Americans for the 21st Century, programs in schools that produce high student achievement share similar characteristics, one of which is early hands-on experiences. The American Association for the
researchers cautioned, however, that hands-on activities in and of themselves are of no importance unless they are linked to scientific concepts, include a relationship to scientific literacy needs, and are consistent with the spirit and character of scientific inquiry. Hands-on science activities should start with questions about phenomena rather than with answers to be learned (American Association for the Advancement of Science, 1989; Kober, 1993).

Bennett (1986) emphasized that children learn science best when they are able to do experiments. He added that reading about science is not enough, that students need to witness science in action. The phrase "hands-on and minds-on" (Bybee et al., 1989; Hammond, 1992; Kober, 1993) is descriptive of science as a compilation of science experiences that engage students' hands and minds. Hands-on science activities give students opportunities to use their knowledge and skills to solve problems and to find out why things happen, thus enabling them to obtain both the concepts and skills necessary to organize and carry out projects in an increasingly complex world (National Assessment of Educational Progress, 1987).

**Teacher and Student Attitudes Toward Science**

Bonestinl (1992) noted that schools can no longer be delivery systems for discreet and fragmented bits of
data, but instead must be places where individuals cultivate their "yearning for learning" (p. 32).

Attitudes may be hard to define, but by observing others, it is fairly simple to determine if someone likes or dislikes something. Mager (1984) asserted, that whatever else we do in the way of influencing students, the least we must strive for is to send them away with favorable rather than unfavorable feelings about the subjects we teach.

Pedersen and McCurdy (1992) indicated that because young children formulate their attitudes at an early age, elementary science education is extremely crucial in developing positive attitudes toward science. They added that the way teachers choose to teach science can affect their students' attitudes toward science, either favorably or unfavorably.

Several factors have been cited as affecting students' perceptions. Interest (Hidi, 1990) and enjoyment (Eisner, 1991) are factors in determining students' preference for subjects in school. Fort (1993) who mentioned "love" and "curiosity" in connection with science teaching, suggested that the knowledge bases of elementary teachers are not as important as their attitudes toward science. Mager (1984) explained that if a teacher displays interest and enthusiasm, the probability that the students will have similar feelings is greater than if the teacher displays apathy and disinterest.
Horak (1982) found discrepancies in the implementation of science curricular innovations at the junior high school level. The purpose of his study was to find a means to match program characteristics more closely with the personal characteristics and educational beliefs of teachers. Horak believed that the discrepancies found in implementation may have been the result of certain characteristics among science teachers (such as type of college attended, sex, grade level taught) and needs (such as warmth, indirectness, discipline management) that influenced their behaviors in the classroom. He concluded that research to determine differences among teachers in terms of their attitudes toward certain curriculum practices are needed.

After examining an extensive body of data on how teachers perceive themselves, Goodlad (1984) found that elementary teachers showed variations in their perceptions preparedness. Of the basic subject areas considered as part of the core curriculum in elementary school, Goodlad found that teachers perceived themselves to be poorly prepared in only one—science. Kober (1993) found that teachers who felt unprepared were likely to be "science avoiders," thus devoting less time to science than other subjects.

Goodlad (1984) pointed out that teachers make many autonomous decisions concerning their practices once inside their classrooms. According to Cuban (1984), teachers' beliefs form the basis for the decisions they make in the
classroom. Cuban stressed that the ideas teachers hold about the purposes of school, how children develop, the role of subject matter in instruction, and how classroom space should be organized, and how they exercise authority all influence their teaching practices. He added that teachers' beliefs shape what they choose to do in the classroom.

The great majority of elementary schools are comprised of self-contained classrooms in which the teacher spends 5 or more hours with the same students (Cuban, 1984). Porter and Brophy (1988) reported that teachers spend 30% to 45% of their total instructional time teaching reading, and noted that science is rarely taught on a daily basis in elementary school. Teachers in kindergarten through sixth grade spend about 20 to 30 minutes a day on science (Kober, 1993; Mullis and Jenkins, 1988). It is reasonable to assume that teachers spend more time and provide more quality instruction on subjects in which they feel competent. Walberg (1991) indicated that quality instruction is the enhancement of learning time.

According to a report from the National Education Goals Panel (1993), students in higher grades have less-positive attitudes toward science than do students in lower grades. In Getting Started: A Blueprint for Elementary School Science Education (1989), the authors emphasize the idea that instructional approaches that foster positive student attitudes are a serious educational responsibility. Large
amounts of instruction may count for little if students are unmotivated or if instruction is unsuitable (Walberg, 1991).

As an indicator of their attitudes toward science, students were asked to name their most favorite subject in the National Assessment of Educational Progress assessment of student attitudes in 1976-77. Nine-year-olds ranked science a distant third behind mathematics and language arts; 13- and 17-year-olds ranked science fourth (National Assessment of Educational Progress, 1979). In a study of the subjects students like, Goodlad (1984), found that students prefer activities that involve them actively or in which they work with others. Among the subjects students liked most were those that involved drawing, making, shaping, moving, and interacting. Goodlad, who used a table to illustrate the rank order of students' liking of school subjects, found that upper elementary students ranked arts, physical education, mathematics, reading, science and social studies in that order. He also noted that, except in the arts, physical education, and vocational education, students were provided little hands-on activities.

Kyle, Bonnseter, and Gadsen (1988) found that after training teachers in the Science Curriculum Improvement, significantly more students of teachers with their training selected science as their most and second favorite subject than did students of teachers without their training.
**Staff Development**

In studying curriculum change and the school, Czajkowski and Patterson (1980) found that teachers have resisted, and even subverted, efforts to change their classroom practices, particularly when they felt their classrooms were operating successfully. If this is the case, what is the best approach to use in influencing teachers to make changes in their instructional practices?

Many experts (Berman & McLaughlin, 1978; Cuban, 1984; Guskey, 1986; Joyce, Showers, & Rolheiser-Bennet, 1987; Kober, 1993; Sirotnik & Clark, 1988; Walberg, 1991) agree that carefully designed training is the key to change in schools.

Thomas Guskey (1986) advocated high quality staff development as a central component for improving education. He defined staff development as "a systematic attempt to bring about change, change in the classroom practices of teachers, change in their beliefs and attitudes, and change in the learning outcomes of students" (p. 5).

Cuban (1984) listed the following four strategies to upgrade the quality of classroom instruction: (a) revise selection policies in schools of education and districts' hiring of teachers, (b) improve preparation programs for apprentices, (c) remove incompetents, and (d) retrain existing corps of teachers.
Joyce, Showers, and Rolheiser-Bennet (1987) outlined a number of teaching approaches with known potential for increasing student learning; however, they pointed out that few were in use. They indicated that teachers expand their repertoire only when they are provided substantial and carefully designed training. Sirotnik and Clark (1988) noted that the traditional model of school improvement pits experts against practitioners and suggests that knowledge comes from experts and is handed down to practitioners. They added, however, that teachers should not be passive recipients, but should be involved in developing their own understandings if training is to be translated into practice.

In a study for the Rand Corporation of nearly 400 locally and federally funded projects, Berman and McLaughlin (1978) found that the more effective projects included concrete, teacher-specific training. Kober (1993) noted that experts recommend that teachers be taught as they are expected to teach.

From his interpretation of the results of the 1976-77 assessment in which the National Assessment of Educational Progress surveyed 9-, 13-, and 17-year-olds to investigate their attitudes toward science, Johnson (1979) concluded that the major factor in elementary school science is the teacher, and that ways must be found to significantly affect teachers so that science as a subject is considered
important. Johnson suggested that significant curriculum experiences in the form of in-depth inservice programs are the answer.

Studies (Kyle et al., 1988; Luttrell & Shapley, 1990) on inservice training for teachers in the use of hands-on, activity-oriented science instruction support the contention that substantial training is effective in increasing the use of hands-on science in the classroom.

Kyle et al. (1988) had significant results after training teachers in the Science Curriculum Improvement Study. They found the following to be characteristics of an exemplary inservice experience: (a) a longitudinal plan for implementation, (b) strong administrative support, (c) a local subject matter specialist in a central role who facilitates communication and ensures program continuity, and (d) "an atmosphere of personal involvement in "doing" key components of the new curriculum is necessary during the inservice" (p. 118). Kyle et al. noted that

Simply discussing the curricular changes will not effect change in the classroom. Teachers must feel a sense of 'ownership' to the curriculum and must realize that their implementation efforts are valued by their administrators (p.118).

Inservice training was a key factor in Luttrell's and Shapley's (1990) study in which "mentor teachers" were trained in the use of hands-on investigations and who wrote
72 hands-on science lessons for use in their classrooms: The teachers later trained "colleague teachers" in the use of hands-on science with significant results.

Assessment

Student assessment has been an educational issue for many years; however, testing did not become a controversial issue until the 1960s. It was at that time, according to Madaus (1985), that the use of standardized tests as tools became less common among local administrators and began to play a more prominent role at the state and federal levels. The tests assumed a central role in establishing and implementing state and federal education policy.

The American public lost faith in public education during the era of fragmentation and demystification. Only 31% of the respondents to the 21st Annual Gallup Poll (Elam & Gallup, 1989), gave their schools grades of A or B in 1983, the year *A Nation at Risk* was published. To reverse the loss of faith in schools, testing was given an ever-expanding role in schools' accountability. Airasian (1987) noted that in most communities and the nation as a whole, moral and financial support for schools is conditioned by the results of standardized tests because the majority of Americans believe that such tests provide the most credible evidence about schools and learning.
The controversy that surrounds student assessment is multi-faceted. There is concern that with sanctions and rewards tied to test results, teachers will teach-to-the-tests, ignoring sound instructional practices in the process. As Brandt (1989) pointed out, "When the stakes are high, people are going to find ways to have test scores go up" (p. 26). The concern raised by teaching-to-the-tests is shared by experts (Livingston, Castle & Nations, 1989; Shavelson & Baxter, 1992; Shephard, 1989; Wirth, 1993).

Livingston et al. (1989) warned that teachers' principles are compromised when the influence of testing is great. Teachers are placed in awkward positions when the standardized test scores are inconsistent with their students' day-to-day performances in the classroom.

Shephard (1989) suggested that to help alleviate the problem of teaching to the test, alternative forms of assessment should be employed. She emphasized that assessment tasks should more closely resemble real learning tasks. They should acknowledge more than one approach or one right answer, and should place more emphasis on uncoached explanations and real student products.

Science education has suffered from this standardized testing milieu when teachers have focused their attention on the subjects being tested--mostly language arts and mathematics. When science has not tested, teachers have tended to overlook its importance. Currently, there are
attempts to include science in testing situations. Wirth (1993) stated that much of the pressure to cover science material during instruction, a process that tends to suffocate curiosity, derives from an epidemic of testing. Feuer and Fulton (1993) described how researchers and test publishers in some states are developing performance tasks that all students must conduct to demonstrate their understanding and skills. However, Shavelson and Baxter (1992) cautioned that unless teachers are provided the scientific and pedagogical knowledge required for hands-on science teaching, teachers may very well flounder in their attempts to match their teaching to the testing.

In Texas, the Texas Assessment of Academic Skills (TAAS) is a state mandated criterion-referenced test. Originally, the TAAS contained three subject tests—reading, writing, and mathematics. In 1993, however, social studies and science were added. In 1992-1993, the Texas Education Agency, under the direction of a new commissioner, began revamping state-mandated assessment programs. His recommended modifications included the following:

1. Administration of the assessment system based on outcomes within and across content areas that represent the full range of essential elements;

2. Redesign of the assessment program based primarily on performance tasks, projects, portfolios, and criterion-
referenced tests and a norm-referenced program that is reduced in scope (Staff. "Commissioner Meno," 1992, p. 3).

For the 1993-94 school year, the Texas Education Agency drafted the TAAS "Science Objectives and Measurement Specifications" in which half of the science assessment of TAAS is performance-based. The other half of the science assessment includes multiple-choice, machine scorable items.

What Teachers Do

What effect do teachers have on implementing an innovation? Plenty, according to the experts (Cuban, 1984; Goodlad, 1984; Hunter, 1984; Kober, 1993; Lieberman & Miller, 1984; Poole & O'Keafor, 1989; Porter & Brophy, 1988), who tell us that because teachers have a great deal of autonomy in classroom decision-making, there can be vast differences in teachers' practices.

Traditional views of science education include the view that reading from the finest texts is the best way to prepare a future scientist (Pomroy, 1993). Porter and Brophy's (1988) review of relevant literature revealed that in science, teachers normally follow the text closely, although the teacher's edition usually does not have much to say about instruction. Cuban (1984) found that 30% to 40% of teachers teach science largely as a reading-lecture class. He found that incorporating student-centered practices expands teachers' personal investment in terms of
time, energy and effort while posing a threat to established classroom routines.

Goodlad (1984) came to the same conclusion concerning the methodology used in science instruction. He proposed that "circumstances of schooling" explain why teachers most often use the reading-lecture method during science instruction. Teaching science calls for departure from textbooks and workbooks in seeking to use multiple resources, and Goodlad believed that teachers find it much easier to use conventional means.

Before teachers make changes, they must perceive a need. Lieberman and Miller (1984) identified "practicality" as a factor. If a teacher accepts an idea, it must be practical. It must develop from the circumstances of the school, have immediate application, be offered by practical people, and finally, it must address practical problems.

Summary

In summary, the concern for science education in the U.S. is evident; our students rank lower in science than students from other countries on international ratings. There is concern that international competitiveness, notwithstanding, these same students will the lack scientific literacy necessary to live adequately in the future.
Reform in science education has a long history. Historically, it has been viewed as a way for students to get in touch with and understand their natural environment. Evidence supports the idea that science learning is cumulative; therefore, good science instruction should begin as early as kindergarten. There is also much support for student-centered science curriculum in which students are actively engaged in handling materials to find solutions to science problems. Little of this, however, appears to be happening much in the schools.

Research suggests that quality staff development in retraining teachers is a key to improvement in science education. The teacher inservice training model in this study incorporates key elements suggested by this review of literature: (a) beginning quality science instruction in elementary school, (b) integrating hands-on science lab activities as an integral part of science instruction, (c) providing teachers with their own hands-on science experiences during substantial inservice training, and (d) matching performance-based assessment in science to teaching practices as ways to affect students' favorable perceptions of science as a subject.
CHAPTER 3

METHODS AND PROCEDURES

The procedures of this study were carried out in several phases. First, objectives were written. Second, a Student Science Questionnaire was devised. Third, the school district and specific grade level were selected. Fourth, the school district granted permission to conduct the study in the district. Fifth, teacher subjects were selected either as participants or non-participants. Sixth, a teacher inservice training model was designed. Seventh, appropriate materials were selected for the teacher inservice training model. Teacher inservice training sessions were conducted. At the beginning of the 1992-1993 school year, teacher participants and teacher non-participants administered the Student Science Questionnaire pretest to their respective students. Next, the teacher participants conducted the treatment activities throughout the school year. Finally, the Student Science Questionnaire posttest was administered to the students of the teacher participants and non-participants at the end of the 1992-1993 school year. Posttest data were analyzed to test the hypotheses of the study.
Grade Level and Subjects Selection

Grade Level

The target for this study was fifth grade classes in a suburban school district for the following reasons:

1. To ensure that students completed the Student Science Questionnaire honestly and accurately, fifth grade classes were selected. Fifth graders are developmentally more mature, are better readers, and are more accustomed to taking tests than are students in lower grades.

2. The fifth graders had the distinction of having been the first elementary students to take the science section of TAAS while in fourth grade; therefore, they recognized the need for more practice in the hands-on science lab activities approach to science.

3. Students entering first grade are eager to learn about science. As these students progress through elementary school, most are likely to be taught science through textbook reading, thereby becoming less likely to have positive perceptions of science. To have a better understanding of the effect the teacher inservice training model in this study has on students' perceptions of science, fifth grade classes were selected because fifth graders are less likely than younger students to like science.

4. Making major changes in the way teachers teach science requires a significant investment of teachers' time and energy. Teachers must perceive a need if change is to
to occur. The fifth grade teachers perceived a need to prepare their students for future administrations of the science section of TAAS.

Subjects

There were approximately 75 fifth grade teachers in the school district at the time this study was conducted. These teachers represented the population for this study. A sample group of 20 teachers was randomly selected from the population and were notified by telephone. The teachers were first informed of the study and asked if they wished to participate. If they declined, they were asked to represent the teacher non-participants. When less than seven teachers agreed to participate, and less than seven agreed to represent the teacher non-participants, the random selection of 20 additional teachers was held until there were seven teacher participants and seven teacher non-participants. The students of the seven teacher participants represented the student subjects of teachers with training, the treatment group. The students of the seven teacher non-participants represented the student subjects of teachers without training, the control group.

Of the seven treatment and seven control groups, a total of 330 students took the Student Science Questionnaire pretest—149 students in the treatment group and 181 students in the control group. Of the 290 students who
took the Student Science Questionnaire posttest, 132 were in the treatment group and 158 were in the control group. The variations in N on the pretest and posttest were due to student mobility.

Description of the Teacher Inservice Training Model

The teacher inservice training sessions were conducted on August 3, 4, and 5, 1992. The hours each day were 8:30 a.m. to 3:30 p.m., with a break for lunch.

Five preliminary tasks were completed prior to the teacher inservice training sessions. The first was identifying hands-on science lab activities for use in the teacher inservice training sessions. The activities were selected if they met the following criteria: (a) fit within the district's fifth grade science curriculum scope and sequence; (b) were related to the topics of science studied in fifth grade; (c) met the requirements of the district's fifth grade science enabling objectives, the state's science "Essential Elements", and the TAAS Science Objectives and Instructional Targets—grades 4 and 8; (d) presented scientific problems to solve or required simulations or model building to complete; (e) provided materials for students to manipulate in finding solutions, simulating, or model building; and (f) required only materials that were inexpensive and easy to obtain. These activities were derived from sources deemed appropriate for use in the
teacher inservice training sessions. These sources were the district's fifth grade science curriculum guide, Scott Foresman's Discover science text for fifth grade, Optical Data-Grade 5, Full Option Science System Earth Materials Module, and 11 other sources listed on the references page of the teacher handbook. Of all the activities that met the criteria, 69 activities were selected because (a) they required a minimum amount of time to set up, (b) supplemental materials to extend the activities were also available in the district; (c) the activities could be performed in a minimal amount of time; and (d) the required equipment was simple and easy to obtain. The 69 activities allowed the teachers to conduct two hands-on science lab activities per week for the 1992-1993 school year. (For more detailed information, see the Annotated List of Science Lab Activities in Appendix C.)

The second task was adapting the 69 hands-on science lab activities to fit within the framework of the teacher inservice training sessions. Approximately 23 activities were completed by the teacher participants each day of the 3-day sessions. The following framework was used for each day's activities:

8:30-9:30 a.m. Whole group activity
9:30-11:30 a.m. 11 or 12 small group activities
11:30 a.m.-12:30 p.m. Lunch
12:30-3:30 p.m. 11 or 12 small group activities
(See Appendix B, Teacher Inservice Training Sessions.)

The third task was compiling a handbook for teacher participants' use during the teacher inservice training sessions and throughout the 1992-1993 school year. The handbook contains (a) the district's "Suggested Scope and Sequence" for science curriculum and the district's "Fifth Grade Science Enabling Objectives," (b) the State of Texas' science "Essential Elements" for fifth grade and TAAS Science Objectives and Instructional Targets-grades 4 and 8, (c) a letter to the participants, (d) a materials list for the 6-weeks instructional periods, (e) a table of contents, (f) numbered annotated descriptions of each of the 69 hands-on science lab activities performed during the teacher inservice training sessions arranged in sequential order by 6-week periods, and (g) all accompanying hand-outs and related materials.

The fourth task was packaging the materials for each of the 69 hands-on science lab activities in bags with handles for ease in transporting the materials to the training site and for easy access by the teacher participants during the teacher inservice training sessions.

The fifth task was assembling and arranging the materials at the training site so that participants could complete approximately 23 hands-on science lab activities each day of the teacher inservice training sessions.
Agenda of Teacher Inservice Training Sessions

The activities for each day fit into the following framework: The first hour of the first two days consisted of whole group activities. The whole-group activities were designed so that teacher participants could observe, experience, and evaluate the hands-on science lab activities they would conduct during the 1992-1993 school year. The teacher participants were guided to understand that science is tentative; that what we know about science is learned through observing and making inferences. A scientific rule must be consistent with all observations and, when it is not, the rule must be changed.

During the remaining hours each day, teachers in the participant groups performed each of the 23 hands-on science lab activities for that day. There were three participants in one group and four in the other. Membership in the two groups was reassigned daily so that the participants had the opportunity to work with each of the other participants some time during the teacher inservice training sessions. The two groups worked in two separate, but adjoining, rooms in which the numbered bags containing the materials for each activity were placed. The two groups completed the activities in one room in the morning and the other in the afternoon.

Approximately 23 activities were performed during the 300 total minutes each day, for an average of 13 minutes per
activity. No time limit was placed on each activity. Some activities were more involved and took more time, while others were less involved and took less time. Throughout the teacher inservice training sessions, the participants were encouraged to evaluate the hands-on science lab activities among themselves, jotting down notes during the performance of the activity or later on their own time on how to customize the activity for their particular students.

During the first hour of the final day of the teacher inservice training sessions, the following topics relevant to facilitating hands-on science instruction in the classroom were discussed among the participants:
(a) structuring the lesson, (b) managing materials,
(c) organizing the classroom, (d) grouping students,
(e) assessing students, (f) scheduling hands-on science lab activities, and (g) any other topic teacher participants wished to discuss. (See Appendix B for a detailed account of each day's activities.)

Instrument

A single instrument was used in this study, the Student Science Questionnaire. The questionnaire contains 14 items designed to obtain insight into students' personal feelings about science as a subject and their perceptions of science and science lessons in their classrooms. (See Appendix A for a copy of the Student Science Questionnaire.)
Student Science Questionnaire

The instrument was designed to be simple to administer and require little instructional time to complete. The instrument's three components included students':
(a) feelings toward science as a subject, (b) perceptions of their science lessons, and (c) perceptions of the classroom climate during science instruction.

When the Student Science Questionnaire was administered as the pretest for this study, each item contained past tense verbs so students would report their fourth grade science experiences. As a posttest, the verbs were changed to the present tense so students would report their current fifth grade science experiences.

The first component, the students' feelings toward science as a subject, was assessed by eight test items (1, 3, 4, 5, 7, 8, 9, and 14). They are as follows:

1. Was/Is studying science in 4th grade/5th grade usually fun?   Yes No

3. Was/Is studying science in 4th grade/5th grade usually interesting?   Yes No

4. Did/Do you usually enjoy trying to solve science problems when you were/are studying science in 4th grade/5th grade?   Yes No

5. Did/Do you wish you had more time for studying science in 4th grade/5th grade?   Yes No
7. Did/Does studying science in 4th grade/5th grade usually make you feel curious? Yes No
8. Did/Does studying science in 4th grade/5th grade usually make you feel comfortable? Yes No
9. Was/Is studying science in 4th grade/5th grade usually easy for you? Yes No
14. Circle the number that best tells how you feel about these subjects from 1 least liked to 7 most liked . . . reading, math, English, science, social studies.

The second component of the instrument, students' perceptions of their science lessons, was assessed by three test items (11, 12, and 13). They are as follows:

11. How many times in a week did/do you get to study science in 4th grade/5th grade? 0 1 2 3 4 5
12. In how many science lessons per week did/do you get to work with science materials to complete a science lab activity in 4th grade/5th grade? 0 1 2 3 4 5
13. Which describes most of the science lessons you had/have in 4th grade/5th grade: (a) reading about science, (b) doing science lab activities yourself, (c) listening to your teacher talk about science?

The third component of the instrument, students' perceptions of the classroom climate during science instruction, was assessed by three test items (2, 6, 10). They are as follows:
2. Was/Is studying science in 4th grade/5th grade usually problems to be solved? Yes No

6. Did/Does your 4th grade/5th grade teacher like for you to ask questions about science? Yes No

10. Did/Does your 4th grade/5th grade teacher like for you to give your own answers to science problems when you are studying science? Yes No

**Instrument Validity**

In the design of the Student Science Questionnaire, items from other instruments were chosen in which face validity was established. Eight of the items on the Student Science Questionnaire (1, 3, 5, 6, 7, 8, 10, and 14) are similar to items in two other instruments, Kyle, Bonnstetter, and Gadsden (1988) and National Assessment of Educational Progress (1978). Other studies conducted using similar test items include studies by Goodlad (1984), Huefftle, Rakow, and Welch (1983), Luttrell & Shapley (1990), Yager and Bonnstetter (1983, 1984), Yager and Yager (1985).

Face validity is basically judgmental; each item must be judged for its presumed relevance to the property being measured (Kerlinger, 1986). To establish validity for the Student Science Questionnaire, the questionnaire was sent to four science educators who were asked to read each item related to each of the instruments' three components and to
(a) place a checkmark by the items they believed to be valid, (b) reword each item they did not check to make it acceptable, and (c) make any other suggestions for improving the instrument. In addition, they were asked if a change in verb tense from the pretest to the posttest would affect the face validity of the instrument in any way. When the experts returned the questionnaires, their revisions were noted. The revised questionnaire was resubmitted to the four experts. Due to time constraints, the decision was made to use all items that 3 of the 4 experts indicated as valid. Items 1, 3, 5, 6, 7, 8, 9, 11, 12, 13, and 14 were considered valid by all four experts and items 2, 4, and 10 by 3 experts. It was the judgment of all the experts that a change in verb tense from the pretest to the posttest would have no affect on the face validity of the instrument. The Student Science Questionnaire was considered valid for the purposes of this study.

**Instrument Reliability**

To establish reliability for the Student Science Questionnaire, test-retest analysis was used. A school in the same school district in which the study was conducted was selected to participate in the reliability study. Five fifth grade teachers in the school administered the Student Science Questionnaire to their students and administered it a second time 12 days later. Of the 107 students who
completed the first administration of the test, only 89 completed the second administration. For test-retest analysis, \( N = 89 \).

McMillan and Schumacher (1984) defined reliability as the consistency of the measurement. In test-retest analysis a coefficient of stability is provided by correlation scores from the same test of a group of individuals on two different occasions. If the responses of the individuals are consistent, the reliability is high.

To establish reliability for items 1 through 10, percentages from a Phi correlation table were used as shown in Table 1.

Table 1

Percentages of Stability for Items 1 Through 10

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The responses of items 1 through 10 are dichotomous, that is, yes or no. In Standards for Educational and Psychological Testing (American Psychological Association, 1985) Standard 2.2 states that for dichotomous decisions estimates should be provided of the percentages of test takers who are classified in the same way on two occasions. The responses (yes or no) for items 1 through 10 are dichotomous. The responses for items 1 through 10 on two separate occasions were analyzed to determine if students responded consistently. As illustrated in Table 1, the percentages of same responses to items 1 through 10 indicate consistency over time.

When considering coefficients in reliability measurement, Tuckman (1994) stated:

In the case of observations, reliability reflects agreement between observers. In the case of tests, reliability reflects internal consistency over time. Readers should look for these reliability coefficients, and then evaluate their magnitude. Observational reliabilities should be at .75 or above; test reliabilities should be at .75 or above for achievement tests and .50 or above for attitude tests. (pp. 403-404)

For items 11 through 14, the product-moment coefficient of correlation (r) was used to analyze the test-retest results. The highest reliability coefficient was that for
question 13, $r = .95$. For item 12, $r = .77$; the reliability coefficient for item 14d was $r = .54$.

For item 11, a reliability coefficient, $r = .41$, was obtained. In this item students were asked, "How many times in a week do you get to study science in 5th grade?" The responses varied between 0 and 5. The seeming lack of stability (below .50) may have resulted from a number of unknown factors: (a) the number of science lessons may have varied in the 12 days lapse of time between test and retest, (b) students may have counted times when science was discussed outside the appointed time for science, (c) the schedule for science may not have been well established at the beginning of the school year when the reliability study was conducted. For analysis, the Student Science Questionnaire was administered as a posttest at the end of the school year. At that time, the schedule for science had been consistent throughout the year. The number of science lessons should have been well established in the minds of students. Obtaining a number of science lessons per week was necessary to test the second hypothesis of this study. These factors were considered when deciding to retain item 11 in the questionnaire. However, because .50 is the accepted reliability coefficient for attitude tests (Tuckman, 1994), it is recognized that a reliability coefficient of .41 is not acceptable and, therefore, generalizations concerning item 11 are not made. The data
obtained for item 11 are reported as informational and readers are cautioned that item reliability must be established before confidence can be placed in data related to item 11. When making recommendations for future studies, it should be noted that the reliability for item 11 should be determined toward the end of the school year when science instruction patterns have been established.

The stability of performance on the Student Science Questionnaire, not students' specific feelings or perceptions about science and science lessons, were analyzed. Reliability of each item on the Student Science Questionnaire was considered satisfactory for its use in this study.

Procedures for the Collection of Data

In the spring of 1992, permission was obtained from the central administration of a suburban school district to select and train a number of fifth grade teachers using the teacher inservice training model. Following the selection of the teacher participants and teacher non-participants, these procedures were followed:

1. At the beginning of the 1992-1993 school year, both the teacher participants and the teacher non-participants administered the Student Science Questionnaire to their respective students as a pretest.
2. During the 1992-1993 school year, the teacher participants had their students perform the hands-on science lab activities that they had performed during the teacher inservice training sessions.

3. In the late spring of 1993, the teacher participants and teacher non-participants administered the Student Science Questionnaire to their respective students as a posttest.

4. Data analysis was conducted after all data were collected for testing the hypotheses of this study.

Data Analysis

Gardner (1975) stated that if empirical evidence is available to show that attitudes to science, to scientists, and to understanding science are all intercorrelated, then addition to form a single unidimensional scale is justified. In the absence of such evidence, he believed the variables should be measured separately.

The variables in this study, students' feelings about science as a subject and their perceptions of science and science lessons in their classrooms were analyzed separately through the use of the Student Science Questionnaire. At the beginning of the 1992-1993 school year, the Student Science Questionnaire was used as a pretest. At the close of the same school year, the questionnaire served as a posttest. Pretest analysis indicated no significant
differences between the two groups; therefore, only posttest data were used in analysis for this study.

A t-test for two independent sample means was used to analyze the following hypotheses:

1. Students of teachers with training will report doing hands-on science lab activities a significantly greater number of times each week than will students of teachers without training (item 12).

2. Students of teachers with training will report a significantly greater number of times they study science in a week than will students of teachers without training (item 11).

Analyses to obtain a value of $z$ to test for a difference between two independent proportions was used in the following hypotheses:

3. Students of teachers with training will describe most of their science lessons as doing hands-on science lab activities themselves a significantly greater number of times than will students of teachers without training (item 13).

4. Students of teachers with training will respond, positively as to their perceptions of science and science lessons a significantly greater number of times than will students of teachers without training (items 1 through 10).
5. Students of teachers with training will rank science significantly higher as their preferred subject than will students of teachers without training (item 14).
The purpose of this study was to test a teacher inservice training model designed to (a) increase the number of hands-on science lab activities students perceive their teachers use per week during science lessons, (b) increase the number times students perceive their teachers teach science per week, and (c) improve students' perceptions of science and science lessons. To carry out this purpose, the following hypotheses were tested:

1. Students of teachers with training will report doing hands-on science lab activities a significantly greater number of times each week than will students of teachers without training (item 12).

2. Students of teachers with training will report a significantly greater number of times they study science in a week than will students of teachers without training (item 11).

3. Students of teachers with training will describe most of their science lessons as doing science lab activities themselves a significantly greater number of times than will students of teachers without training (item 13).
4. Students of teachers with training will respond positively as to their perceptions of science a significantly greater number of times than will students of teachers without training (items 1 through 10).

5. Students of teachers with training will rank science significantly higher as their preferred subject than will students of teachers without training (item 14).

The first hypothesis, the number of times students reported doing hands-on science activities per week (item 12), was tested using a \( t \)-test for two independent sample means. Response choices for item 12 were zero through five. Results are presented in Table 2.

Table 2

| Students' Perceptions of Science Lessons: Mean Number of Hands-on Science Lab Activities Per Week |
|---|---|---|---|---|---|---|
| Group   | N  | \( \bar{X} \) | SD | SE | df | t  |
| Treatment | 132 | 2.58 | 1.11 | 0.09 |
| Control  | 155 | 1.23 | 1.37 | 0.11 |
| Separate variance estimate: | 284.25 | 9.19* |

\(*p < .001.\)
Examination of Table 2 indicates that the first hypothesis was supported. Students in the treatment group reported a significantly greater number of hands-on science lab activities per week than did students in the control group, \( t (284.25) = 9.19, p < .001. \)

The second hypothesis, the number of times students reported studying science in a week (item 11), was tested using a \( t \)-test for two independent sample means. Response choices for item 11 were zero through five. Students in the control group reported a significantly greater number of science lessons per week than did students in the treatment group, \( t (275.52) = -3.97, p < .001. \) Hypothesis 2 was rejected. See Table 3.

Table 3

Students' Perceptions of Science Lessons: Mean Number of Science Lessons Per Week

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>( \bar{X} )</th>
<th>SD</th>
<th>SE</th>
<th>df</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>131</td>
<td>3.02</td>
<td>0.99</td>
<td>0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>153</td>
<td>3.58</td>
<td>1.35</td>
<td>0.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Separate variance estimate: \( 275.52 \) \(-3.97^* \)

\*\( p < .001. \)
A z test was used to test for difference between two independent proportions ($p_1$ and $p_2$) in the analysis of the third, fourth, and fifth hypotheses.

The third hypothesis, the number of times students described most of their science lessons as doing hands-on science lab activities (item 13) was significant as shown in Table 4.

Table 4
Students' Perceptions of Science Lessons: Proportion of Responses for Doing Hands-on Science Lab Activities

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment ($p_1$)</td>
<td>125</td>
<td>81</td>
<td>.648</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control ($p_2$)</td>
<td>140</td>
<td>17</td>
<td>.121</td>
<td>.059</td>
<td>8.93*</td>
</tr>
</tbody>
</table>

Note. $n$ = Number of responses, $p$ = Proportion of responses.

* $p < .001.$

The treatment group's proportion of responses for doing hands-on science lab activities was significantly greater than that of the control group, $z = 8.93$, $p < .001.$ Hypothesis 3 was supported.
Responses for reading and listening in science contained in item 13 were also analyzed and are illustrated in Tables 5 and 6. The control group's proportions of responses for reading and listening were significant, \( z = 6.22, \ p < .001 \) and \( z = 4.19, \ p < .001 \), respectively.

Upon examination of Tables 4, 5, and 6, it is evident that students in the treatment group were mostly doing hands-on science lab activities in science lessons whereas students in the control group were mostly reading and listening in science lessons.

Table 5
Students' Perceptions of Science Lessons:
Proportion of Responses for Reading

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment ( \text{P}_1 )</td>
<td>125</td>
<td>20</td>
<td>.160</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control ( \text{P}_2 )</td>
<td>140</td>
<td>73</td>
<td>.521</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. \( n = \) Number of responses, \( p = \) Proportion of responses. \( *p < .001 \).
Table 6

Students' Perceptions of Science Lessons:
Proportion of Responses for Listening

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment (p₁)</td>
<td>125</td>
<td>16</td>
<td>.128</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (p₂)</td>
<td>140</td>
<td>48</td>
<td>.342</td>
<td>.051</td>
<td>4.19*</td>
</tr>
</tbody>
</table>

Note. n = Number of responses, p = Proportion of responses.
*p < .001.

The fourth hypothesis, the number of times students responded positively regarding their perceptions of science (items 1 through 10), was analyzed using a $z$ to test for a difference in the independent proportions of each group's positive responses. Each of the 10 items had either a yes or no response. Each item was analyzed separately. Tables 7 through 16 present results for each of the 10 items.

Item one asked, "Is studying science in 5th grade usually fun?" The proportion of positive responses by students in the treatment group was significantly greater than that of students in the control group, $z = 6.93, p < .001$, as shown in Table 7.
Item 2 asked, "Is studying science in 5th grade usually problems to be solved?" The treatment group's proportion of positive responses was significantly greater than that of the control group, $z = 1.88$, $p < .05$. Results of analysis are presented in Table 8.

Item 3 asked, "Is studying science in 5th grade usually interesting?" The treatment group's proportion of positive responses as to science being interesting was significantly greater than that of the control group, $z = 3.89$, $p < .001$ as illustrated in Table 9.

Item 4 asked, "Do you usually enjoy trying to solve science problems when you are studying science in 5th grade?" Results of the analysis are shown in Table 10. For item 4, the treatment group's proportion of positive responses as to enjoying solving problems in science was greater than that of the control group, $z = 3.77$, $p < .001$.

Item 5 asked, "Do you wish you had more time for studying science in 5th grade?" The treatment group's proportion of positive responses as to wanting more time was significantly greater than that of the control group, $z = 6.14$, $p < .001$ as shown in Table 11.

Item 6 asked, "Does your 5th grade teacher like for you to ask questions about science?" The proportion of the treatment group's positive responses was significantly greater than that of the control group, $z = 3.70$, $p < .001$. Analysis pertaining to item 6 is presented in Table 12.
Item 7 asked, "Does studying science in 5th grade usually make you feel curious?" For item 7, the treatment group's proportion of positive responses was significantly greater than that of the control group, $z = 2.30$, $p = .01$, as illustrated in Table 13.

Item 8 asked, "Does studying science in 5th grade usually make you feel comfortable?" Analysis indicated that the proportion of students in the treatment group who responded positively was significantly greater than the proportion of students in the control group who responded positively, $z = 3.00$, $p < .001$ as shown in Table 14.

Item 9 asked, "Is studying science in 5th grade usually easy for you?" Analysis did not indicate significance for item 9. The treatment group's proportion of positive responses and the control group's proportion of positive responses were not significantly different, $z = 1.17$, $p > .05$. The results of analysis for item 9 are shown in Table 15.

Item 10 asked, "Does your 5th grade teacher like for you to give your own answers to science problems?" The treatment group's proportion of positive responses was significantly greater than that of the control group, $z = 3.41$, $p < .001$. Results of analysis for item 10 are illustrated in Table 16.
Table 7

Students' Feelings Toward Science as a Subject: Proportion of Positive Responses to Science as Being Fun

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment ($p_1$)</td>
<td>131</td>
<td>125</td>
<td>.954</td>
<td>.047</td>
<td>6.93*</td>
</tr>
<tr>
<td>Control ($p_2$)</td>
<td>156</td>
<td>98</td>
<td>.628</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. $n$ = Number of responses, $p$ = Proportion of responses.
*$p < .001$.

Table 8

Students' Perceptions of Classroom Climate During Science Lessons: Proportion of Positive Responses to Science as Problems to be Solved

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment ($p_1$)</td>
<td>132</td>
<td>97</td>
<td>.734</td>
<td>.053</td>
<td>1.88*</td>
</tr>
<tr>
<td>Control ($p_2$)</td>
<td>156</td>
<td>99</td>
<td>.634</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. $n$ = Number of responses, $p$ = Proportion of responses.
*$p < .05$. 
Table 9

Students' Feelings Toward Science as a Subject: Proportion of Positive Responses to Science as Being Interesting

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment (p_1)</td>
<td>131</td>
<td>124</td>
<td>.946</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (p_2)</td>
<td>156</td>
<td>124</td>
<td>.794</td>
<td>.039</td>
<td>3.89*</td>
</tr>
</tbody>
</table>

Note. n = Number of responses, p = Proportion of responses.
* p < .001.

Table 10

Students' Feelings Toward Science as a Subject: Proportion of Positive Responses to Enjoying Solving Problems

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment (p_1)</td>
<td>131</td>
<td>103</td>
<td>.786</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (p_2)</td>
<td>155</td>
<td>85</td>
<td>.548</td>
<td>.063</td>
<td>3.77*</td>
</tr>
</tbody>
</table>

Note. n = Number of responses, p = Proportion of responses.
* p < .001.
Table 11

Students' Feelings Toward Science as a Subject: Proportion of Positive Responses to Wanting More Time

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment ($p_1$)</td>
<td>132</td>
<td>109</td>
<td>.825</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control ($p_2$)</td>
<td>152</td>
<td>75</td>
<td>.493</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. $n =$ Number of responses, $p =$ Proportion of responses. *$p < .001$.

Table 12

Students' Perception of Classroom Climate During Science Lessons: Proportion of Positive Responses to Teacher Liking Students to Ask Questions

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment ($p_1$)</td>
<td>131</td>
<td>126</td>
<td>.961</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control ($p_2$)</td>
<td>156</td>
<td>131</td>
<td>.839</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. $n =$ Number of responses, $p =$ Proportion of responses. *$p < .001$. 
### Table 13
**Students' Feelings Toward Science as a Subject: Proportion of Positive Responses to Feeling Curious**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment ($p_1$)</td>
<td>131</td>
<td>93</td>
<td>.709</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control ($p_2$)</td>
<td>155</td>
<td>91</td>
<td>.587</td>
<td></td>
<td>.053</td>
</tr>
</tbody>
</table>

*Note. n = Number of responses, p = Proportion of responses.  
* $p = .01.$

### Table 14
**Students' Feelings Toward Science as a Subject: Proportion of Positive Responses to Feeling Comfortable**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment ($p_1$)</td>
<td>129</td>
<td>95</td>
<td>.736</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control ($p_2$)</td>
<td>154</td>
<td>89</td>
<td>.577</td>
<td></td>
<td>.059</td>
</tr>
</tbody>
</table>

*Note. n = Number of responses, p = Proportion of responses.  
* $p < .001.$
Table 15
Students' Feelings Toward Science as a Subject: Proportion of Positive Responses to Science as Being Easy

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment (p_1)</td>
<td>131</td>
<td>95</td>
<td>.725</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (p_2)</td>
<td>155</td>
<td>103</td>
<td>.664</td>
<td></td>
<td>.052 1.17*</td>
</tr>
</tbody>
</table>

Note. \(n\) = Number of responses, \(p\) = Proportion of responses. *\(p > .05\).

Table 16
Students' Perceptions of Classroom Climate During Science Lessons: Proportion of Positive Responses to Teacher Liking Students to Give Own Answers

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment (p_1)</td>
<td>130</td>
<td>121</td>
<td>.930</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (p_2)</td>
<td>153</td>
<td>122</td>
<td>.797</td>
<td></td>
<td>.039 3.41*</td>
</tr>
</tbody>
</table>

Note. \(n\) = Number of responses, \(p\) = Proportion of responses. *\(p < .001\).
To evaluate the fourth hypothesis, items 1 through 10 were tested. The treatment group's proportion of positive responses on items 1 through 8, and 10 were significantly greater than that of the control group; item 9 was not significant. Due to significant differences in the proportions of positive responses by students in the treatment group when compared to those of students in the control group in 9 of the 10 items, the fourth hypothesis was supported.

Hypothesis 5, students ranking science higher as their preferred subject (item 14), was tested using a z to test for difference between independent proportions. The students were asked to rate science, mathematics, reading, English, and social studies on a scale from 1 to 7, with 1 being least liked and 7 being most liked. The treatment and control groups' ratings of science as a 7, most liked, was tested. The treatment group's proportion of 7 ratings for science was significantly greater than that of the control group, \( z = 6.31, p < .001 \). Results of analysis are presented in Table 17.

When the proportions of 7 ratings for the five subjects were ranked, students in the treatment group ranked science first, mathematics second, English third, reading fourth, and social studies fifth. The control group ranked mathematics first, social studies second, science third, reading fourth, and English fifth, as shown in Table 18.
Table 17
Students' Perceptions of Science as a Subject: Ratings of Science as Most Liked Subject

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>n</th>
<th>p</th>
<th>SE</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment (P₁)</td>
<td>132</td>
<td>70</td>
<td>.530</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (P₂)</td>
<td>158</td>
<td>30</td>
<td>.189</td>
<td>.054</td>
<td>6.31*</td>
</tr>
</tbody>
</table>

Note. n = Number of responses, p = Proportion of responses. *p < .001.

Table 18
Ranking of Subjects Using Proportions of Student Ratings of Subjects as Most Liked Subject

<table>
<thead>
<tr>
<th>Rank</th>
<th>Treatment Subject</th>
<th>P₁</th>
<th>Control Subject</th>
<th>P₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Science</td>
<td>.530</td>
<td>Mathematics</td>
<td>.392</td>
</tr>
<tr>
<td>2</td>
<td>Mathematics</td>
<td>.393</td>
<td>Social Studies</td>
<td>.240</td>
</tr>
<tr>
<td>3</td>
<td>English</td>
<td>.257</td>
<td>Science</td>
<td>.189</td>
</tr>
<tr>
<td>4</td>
<td>Reading</td>
<td>.166</td>
<td>Reading</td>
<td>.170</td>
</tr>
<tr>
<td>5</td>
<td>Social Studies</td>
<td>.128</td>
<td>English</td>
<td>.107</td>
</tr>
</tbody>
</table>
The treatment group's proportion of 7 ratings for science surpassed all proportions of 7 ratings for other subjects by either group. Analysis of 7 ratings for science and the subsequent ranking of science as most liked subject by students in the treatment group provided evidence to support the fifth hypothesis.
CHAPTER 5

DISCUSSION

Summary

The purpose of this study was to test a hands-on teacher inservice training model designed to (a) increase the number of hands-on science lab activities students perceive their teachers use per week during science lessons, (b) increase the number of times students perceive their teachers teach science per week, and (c) improve students' perceptions of science and science lessons. The treatment group consisted of the students of teacher inservice participants. Students of teachers who did not participate in the inservice were the control group. The teachers in the treatment group were encouraged to conduct the science lab activities they had experienced during inservice training with their students during the 1992-1993 school year. The instrument used in this study, the Student Science Questionnaire, was administered to both groups in the early fall of the 1992-1993 school year as a pretest and in late spring of the same year as a posttest. Because no differences between the groups were noted on the pretest, the treatment and control groups' responses on the Student Science Questionnaire posttest comprised the data analyzed for this study.
Although the results of this study are interrelated, they are discussed separately in terms of the five hypotheses of the study. The hypotheses are related to students' reporting of (a) the number of hands-on science lab activities teachers used per week, (b) the number of times teachers taught science per week, (c) whether most of their science lessons per week were doing hands-on science lab activities (d) their perceptions of science and science lessons, and (e) their ranking of science as a subject. Conclusions and suggestions for further research conclude the chapter.

Number of Hands-on Science Lab Activities

Findings

Results, as presented in Table 2, indicate a significant difference between the treatment and control groups in the number of hands-on science lab activities. As hypothesized, the students in the treatment group reported a significantly greater number of hands-on science lab activities per week ($\bar{X} = 2.58$) than did the students in the control group ($\bar{X} = 1.23$), $t (284.25) = 9.19$, $p < .001$. Analysis supported hypothesis 1.

Interpretation

While teacher participants were not required to participate in this study or to conduct the hands-on science
lab activities that they performed during training, the
evidence suggests that they did. Two factors apparently
contributed to the teachers' use of the hands-on science lab
activities. As they worked through each activity during
training, the teacher participants were encouraged to talk
among themselves about each activity and to note any
adaptations in their teacher handbooks that they believed
would better suit the needs of their students. In this way,
the participants probably gained ownership of the hands-on
science lab activities performed during their training.
When planning for hands-on science instruction, the
participants drew on their own experiences because they had
personally performed and gained ownership of each of the 69
hands-on science lab activities.

Another factor that affected the use of the hands-on
science lab activities was that teacher participants knew
the activities were congruent with what they had been
教学 in science. Traditionally, activities presented in
science inservice training are not derived from the school
district's own science curriculum; therefore, teacher
participants must decide if these activities are congruent
and how to incorporate them into their teaching of science.
The hands-on science lab activities designed for this study
were derived from the district's fifth grade science
curriculum.
Number of Times Teachers Taught Science Per Week

Findings

Analysis did not support the second hypothesis in this study, which related to the number of times teachers teach science per week. Examination of Table 3 reveals that the students in the control group reported a significantly greater number of science lessons per week, \( \bar{X} = 3.58 \), \( t(275.52) = -3.97, p < .01 \). Hypothesis 2 was rejected.

Interpretation

It must be reiterated that the reliability coefficient that was established at the beginning of the school year for item 11 was only .41. It has been noted that if the reliability study had been conducted after science instruction patterns were well established, the coefficient might have been higher. Because the reliability coefficient for item 11 in this study was only .41, extreme caution must be exercised in the interpretation of data related to this item. The following considerations are offered if future examination of this item determines that reliability is affected by the time of year this item is administered.

If students' reading about science and listening to the teacher talk about science are the usual modes for teaching students about science, as reported in the literature and as found in this study, then conducting hands-on science lab activities during science was a departure from the way the
teacher participants usually conducted science lessons. It appeared the teachers in the treatment group reduced the number of science lessons they usually conducted so that they could conduct hands-on science instruction. Without any intervention, the teachers in the control group most likely continued science instruction as usual.

Preparation for hands-on science lab activities requires a substantial investment of a teacher's time and effort. The teacher participants made this investment when they conducted the hands-on science lab activities with their students in their classrooms. Because planning hands-on activities, gathering materials, setting up activities, cleaning up after activities, and planning follow-up takes more time than having students read from the science text, the teachers in the treatment group evidently chose to perform fewer science lessons due to the extra effort required.

Doing Hands-on Science Lab Activities

Findings

Several differences in the science methodology used by the teachers were evident between the treatment and control groups as reported by their students. For example, based on the data in Tables 2 and 3 an interesting observation can be made. The mean number of science lessons per week ($\bar{X} = 3.02$) and the mean number of hands-on science lab activities
per week ($\bar{x} = 2.58$) reported by students in the treatment group were evidence that approximately 85% of their science lessons were hands-on science lab activities. The mean number of science lessons ($\bar{x} = 3.58$) and the mean number of hands-on science lab activities ($\bar{x} = 1.23$) reported by students in the control group indicate that only 34% of their science lessons were hands-on activities.

Results, as shown in Table 4, in which students reported doing hands-on science lab activities indicate a significant difference between the treatment and control groups. As hypothesized, the proportion of doing hands-on activities responses by the treatment group ($p_1 = .648$) was significantly greater than the proportion of doing hands-on activities responses by the control group ($p_2 = .121$), $z = 8.93, p < .001$.

As shown in Table 5, approximately one-half of the students in the control group ($p_2 = .521$) reported that most of their science lessons consisted of reading from the science text during science lessons--significantly more than the treatment group. As shown in Table 6, approximately one-third of the students in the control group ($p_2 = .342$) reported that they mostly listened to their teacher talk about science during science lessons--significantly more than the treatment group. Hypothesis 3 was supported.
Interpretations

Significant results for doing hands-on science lab activities were obtained by actively involving teacher participants during inservice training in performing hands-on science lab activities. The teacher participants evidently passed on their inservice training experiences to their students by actively involving them in hands-on science lab activities during science instruction.

Familiarizing teacher participants with the hands-on science lab activities apparently prompted the teachers to change the way they conducted their science lessons.

Personal involvement with each of the 69 hands-on science lab activities familiarized the teacher participants with all aspects of each activity. They became familiar with (a) the materials in each activity by handling them; (b) the procedure for each activity by thinking about and working through the investigation, simulation, or model building necessary to complete it; (c) the outcomes of each activity by observing them firsthand; and (d) the format of the teacher handbook by referring to it when performing each activity during training. This process of familiarization reduced teacher participants' anxieties about changing the way they taught science. It helped them feel comfortable with hands-on science instruction, thus ensuring its use in their classrooms.
Students' Perception of Science

Findings

Results as shown in Tables 7 through 16 indicate significant differences in the treatment group students' perceptions of science when compared to those of the control group students' perceptions of science. As hypothesized, the students in the treatment group responded significantly more favorably than did students in the control group on 9 of the 10 items on the Student Science Questionnaire used to assess their perceptions of science. Each of the following items was significantly different in favor of the treatment group at the .05 level of significance and beyond:

1. Is studying science usually fun?
2. Is studying science usually problems to be solved?
3. Is studying science usually interesting?
4. Do you usually enjoy trying to solve science problems when you are studying science?
5. Do you wish you had more time for studying science?
6. Does your teacher like for you to ask questions about science?
7. Does studying science usually make you feel curious?
8. Does studying science usually make you feel comfortable?
10. Does your teacher like for you to give your own answers to science problems when you are studying science?

Item 9 was not significant. Item 9 asked, "Is studying science in school usually easy for you?" No significant difference was evident between the treatment and control group students' perceptions that science was easy.

**Interpretation**

A focal point of the inservice training for teacher participants in this study was on increasing their feelings of competency in teaching hands-on science and on acclimating them to the idea that science is fun. After having personally performed the 69 hands-on science lab activities themselves, the teacher participants apparently felt competent and confident of their abilities to conduct the activities in their classrooms and conveyed the feeling that science is fun to their students.

In the teacher participants' classrooms, students were actively involved in performing hands-on science lab activities. The students discovered for themselves new things about science phenomena. They observed and analyzed their observations. They devised solutions or understood what and how things work by simulating occurrences or building models.

The evidence as presented is clear; most of the students in the treatment group felt differently about
science than did the students in the control group. They had significantly more favorable feelings toward science as a result of doing mostly hands-on science lab activities during science lessons. The findings of this study affirm similar findings by Kyle et al. (1988) and Luttrell and Shapley (1990).

**Ranking of Science as a Subject**

**Findings**

Results shown in Table 17 indicate a significant difference at the .001 level of significance between the proportions of responses by the treatment and control groups. The treatment group's proportion of responses rating science as students' most liked subject ($p_1 = .530$) was significantly greater than was the control group's proportion of responses rating science as students' most liked subject ($p_2 = .189$), $z = 6.31$, $p < .001$.

The proportions of most liked ratings for the five subjects were used in subsequent rankings of the subjects (Table 18). The proportions of most liked ratings for mathematics, reading, English, science, and social studies as presented in Table 18, show the treatment group ranked science first. The proportion of most liked ratings of subjects by students in the control group showed that of the five subjects, the students ranked science third. Analysis supported hypothesis 5.
Interpretation

The assessment of students' perceptions of science by having them select a preference for one subject over another was used in this study to further determine students' perceptions of science as a subject. Students in the control group were passive recipients of the learning while they were mostly reading from the science text and listening to their teacher talk about science. Students in the treatment group who were performing hands-on science lab activities in most of their science lessons were actively involved in constructing their own meanings for science phenomena.

The findings of this study affirm those presented in the literature which indicate that students prefer subjects in which they are actively involved (Goodlad, 1984) and that interest and enjoyment are factors in students' preferences for subjects in school (Eisner, 1991; Hidi, 1990). The findings of this study are similar to those of Kyle et al. (1988) who found that students responded that science was their most favorite and second favorite subject; the students in the treatment group for this study ranked science first of five subjects.

Conclusions

This study examined the effects of a teacher inservice training model on students' perceptions of elementary
science. As revealed in the review of literature section, numerous works support the need for more hands-on science instruction in elementary schools; however, few studies were found that address the effects of hands-on science instruction on teachers and students. In this study, an attempt was made to show that hands-on science instruction has significant positive effects on elementary students.

The treatment group attained significance in four of five hypotheses. Students in this group did more hands-on science activities per week ($H_1$) and described most of their science lessons as hands-on activities ($H_3$). They had more favorable perceptions of science and science lessons ($H_4$) and ranked science as their most favorite subject ($H_5$). The control group attained significance in one hypothesis; they did more science lessons per week ($H_2$).

The positive effects obtained by the treatment group can be attributed to the teacher inservice training model used in this study. The students of teacher participants benefited from their teachers' involvement in the teacher inservice training model because the model contained these key features:

1. The teacher participants were active learners; they did not listen to an expert tell them how to do it. They performed each of the 69 hands-on science lab activities themselves.
2. By experiencing each of the activities, the teacher participants became familiar with all aspects of each activity.

3. The teacher participants discussed adaptations for the activities as they performed each activity. By personalizing the activities, they gained ownership of them.

4. All of the hands-on science lab activities that the teacher participants performed during inservice training were a part of their required curriculum for science instruction. Implementing the activities in their classrooms ensured the teacher participants they were following district and state guidelines for science instruction.

5. The atmosphere during the inservice training was that of an open forum. The presenter modeled behaviors for teacher participants that are believed to be conducive to learning. In addition to providing the framework and materials for each activity, the presenter facilitated the processes by (a) asking questions to further stimulate participants' thinking, (b) soliciting teacher participants' ideas and questions, (c) accepting and showing interest in any and all reasonable ideas, (d) conveying enthusiasm, and (e) in challenging participants to explore other ideas related to each activity. What was shared extended learning beyond what was presented.
While it appears that teacher participants reduced the number of science lessons per week (H2), it should be noted that the questionnaire item related to this hypothesis was found to be less than satisfactorily reliable and, due to the extra effort required to implement hands-on science instruction for the first time, the teacher participants apparently reduced the number of science lessons they conducted in their classrooms.

While the teacher inservice training produced significant positive results, long-term results are not known. This kind of training is a way to affect changes in students' perceptions of science and science lessons; however, it is not the only way to affect positive changes. Other teacher inservice training models may be equally effective. More quality inservice training for teachers is needed.

Elementary teachers will continue to need inservice training in science content areas and in the use of hands-on science instruction. Administrative support for hands-on teaching in science instruction, access to materials and equipment, time for teachers to plan for hands-on instruction, and a school climate that encourages teachers to try less-traditional approaches to science instruction are needed if positive effects on students are desirable.

Therefore, the data for this study support the concept that when elementary teachers receive intensive inservice
training in hands-on science instruction, they use more hands-on activities in their classrooms during science instruction, and their students like science better than do students whose teachers have not received the training.

Recommendations for Further Research

In light of the results of this study, further research in the following areas is recommended:

1. The time frame for the inservice model used in this study consisted of 3 days of training in the summer. Future studies should use variations of this time frame. Perhaps, the 3 days of training could be incorporated at varying times during the school year. This would enable teacher participants to immediately share the hands-on science lab activities they experience during training with their students.

2. For this study no follow-up was completed on the teachers involved in the study. Perhaps, follow-up research a year or more after training would determine if the teachers in the treatment group continued to use hands-on science lab activities in their classrooms, and if each succeeding class of their students liked science.

3. This research was focused on the effects of science on students' perceptions after their teacher received inservice training in hands-on science instruction. Future
research should include studies focused on the effects of this kind of training on students' achievement in science.

4. The reliability study for the Student Science Questionnaire was completed at the beginning of the school year. While the other 13 items were found to be acceptably reliable (coefficients above .50), item 11 related to the number of times per week science lessons were taught was found to be less reliable (coefficient below .50). It is recommended that future reliability studies for item 11 be conducted near the end of the school year, when science instruction patterns have been established.
Dear Student: You have been selected to be part of a research study. We are trying to learn how elementary students feel about science. Your answers to the following questions are extremely important and could have an effect on how science is taught to other elementary students in the future. There are no right or wrong answers. The way you feel about each question is the correct answer for you.

Please circle your answer to the following questions.

Thank you,
Dawn Haynes, Assistant Principal
Lively Elementary Irving, Texas

1. Is studying science in 5th grade usually fun? Yes No

2. Is studying science in 5th grade usually problems to be solved? Yes No

3. Is studying science in 5th grade usually interesting? Yes No

4. Do you usually enjoy trying to solve science problems when you are studying science in 5th grade? Yes No

5. Do you wish you had more time for studying science in 5th grade? Yes No

6. Does your 5th grade teacher like for you to ask questions about science? Yes No

7. Does studying science in 5th grade usually make you feel curious? Yes No

8. Does studying science in 5th grade usually make you feel comfortable? Yes No

9. Is studying science in 5th grade usually easy for you? Yes No

10. Does your 5th grade teacher like for you to give your own answers to science problems when you are studying science? Yes No
11. How many **times in a week** do you get to study science in 5th grade?  
0 1 2 3 4 5

12. In how many science lessons **per week** do you get to **work with**  
science materials to complete a science lab activity in 5th grade?  
0 1 2 3 4 5

13. Which one of the following describes **most** of the science lessons you have in 5th grade:  
A. **Reading** about science  
B. **Doing** science lab activities yourself  
C. **Listening to your teacher talk** about science

14. Circle the number that best tells how you **feel** about the subjects below from 1 _least liked_ to 7 _most liked_:  

A. math  
1........2........3........4........5........6........7  
least liked ..............................................most liked

B. reading  
1........2........3........4........5........6........7  
least liked ..............................................most liked

C. English  
1........2........3........4........5........6........7  
least liked ..............................................most liked

D. science  
1........2........3........4........5........6........7  
least liked ..............................................most liked

E. social studies  
1........2........3........4........5........6........7  
least liked ..............................................most liked
APPENDIX B

TEACHER INSERVICE TRAINING SESSIONS
Teacher Inservice Training

Day 1—August 3, 1992

Preparations for Presenter

Group 1 (a.m.): Activities 1 - 14
Group 2 (p.m.): Activities 1 - 14

Special Problem Activities*

Group 2 (a.m.): Activities 18,19,21,36,40,49,52,55,56
Group 1 (p.m.): Activities 18,19,21,36,40,49,52,55,56

ON-HAND ITEMS FOR ALL THREE DAYS:

- balance scale with weights
- scissors
- glue
- paper towels
- string
- pitcher of water
- masking tape
- extension cord
- microscope/slides/covers

SPECIAL ITEMS NEEDED FOR SPECIFIC ACTIVITIES (Day 1)

Activity

- balance scale: 1
- thermometer: none
- meter stick: 4, 9
- magnifier: 18, 40, 49
- microscope: 40 (optional)

*Take more than one day to complete
Things to Do (Day 1)

1. Write group activities assignments on board.


3. Activity 18: Add (2) slices of bread, (2) pieces of orange and (2) pieces of banana

4. Activity 19/21: Add (4) potted plants

5. Activity 36: Add aquatic plant

6. Activity 49: Add hot water

7. Activity 55: Add (2) loaves of bread

8. Pick up microscope from high school.

9. Set up overhead projector with (2) transparencies:
   (1) Instructions: The White Object and (2) Instructions

10. Set out packets with annotated descriptions of activities/peripheral materials for participants to place in notebook.

11. Arrange furniture for whole group and small group
Agenda for First Day

I. 8:30 - 9:30 Whole group activities
   A. Sign-in/Introduction
      1. Welcome
      2. Pre-test
      Say: "I am requesting that you complete a pre-test that will be helpful in the data analysis for this study. The information you write down has important implications, so please take it seriously and respond to each question to the best of your ability."
   B. Introduction

   Science education is important! Recognizing its importance, in 1990, President Bush and the Governors of the States adopted a set of national goals for education that include a goal for science and mathematics. It states: "By the year 2000, U.S. students will be first in the world in science and mathematics achievement." The National Center for Improving Science Education formulated its own set of goals in 1990. These goals are aimed at kindergarten through sixth grade because it is felt that the elementary level is where science learning needs enhancement.

   There is not complete agreement on precisely how to achieve increased student learning in science, but most experts do agree that a hands-on approach to science is better than the text-lecture method that dominates science instruction today. After studying the subjects students
liked, Goodlad found that regardless of the subject, students reported they liked to do activities that involved them actively or in which they worked with others. When ranking students' liking of school subjects, Goodlad found that students ranked science next to last.

It is important that teachers understand that the content of science is important, but that in order for meaningful learning to occur, teachers need to orchestrate concrete experiences with science phenomena for their students. Hands-on activities give students the opportunities to use their knowledge and skills to solve problems and to find out why things happen. I believe the hands-on activities should have connections to the science curriculum content and not be isolated "wow!" events.

The workshop I have designed for you will have these connections because my compilation of activities are keyed to the district's enabling objectives that are keyed to the state's essential elements, and for the most part taken from the new science curriculum guide, Scott Foresman Discover science teacher's edition, Optical Data materials, Full Option Science System, available at the media center and on display here, as well as other sources deemed appropriate. It was my intention to keep the activities simple and the materials easily accessible and inexpensive. I think I have succeeded; however, as you go through the activities, I
encourage you to interact with group members in discussing ways you think the activities can be improved. There are no magic formulas here, but if you use these activities in the classroom to get your students involved in learning about science phenomena, I believe the activities will change your students perceptions of science.

C. Tentativeness of Science Activity: OBSERVATION

Group members will have access to the following materials: eyedropper, vials of food coloring, vinegar, alcohol, iodine, water, a pencil, scissors, paperclips, and a sheet of paper. The objects to test are marshmallows that have been smashed and dried out. These instructions are on an overhead transparency:

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**Instructions: "The White Object"**

Choose a recorder for your group. The Recorder will write the following on the sheet of paper you see on your table:

**Scientists Make Observations and Inferences**

An observation is _______________________

An inference is _______________________

**OBSERVATIONS Made of an Object**

(Groups will each make 25 - 30 observations.)

When the Recorder has finished, wait for instructions.
Next, tell the groups that an observation is any piece of data in which the observer has used his senses to obtain. At that point, clap hands and say, "That is an observation. You used your senses of hearing and sight to determine that you saw me clap my hands and heard the sound of clapping. An inference is a guess based on the observation. An example is when I look out a window and observe that the sidewalk looks wet. That is an observation. But, if I think that the sprinkler must have been left on, or a truck came by and dumped water on it, or it has rained—then those are inferences. Suppose I look out and see the sidewalk is wet, but at the same time I see a bolt of lightning and then hear a clap of thunder. I look up and see big, dark clouds. Those observations have given me confidence in one of my inferences, that it must have rained. However, I still don't know for certain that I am correct. This is the problem scientists face every day. They can't consult Mother Nature, so they may never know for certain that their inferences are correct. This is why we say science is tentative, not static!

Then, these instructions are given: "Look on your table at the objects you see there. Ask your Recorder to fill in the information on the sheet of paper she prepared. Together with the members of your group, make at least 20 observations, not inferences about the white object you have been given. The groups that can make 30 observations will
get special recognition. When you have finished, the Reporter will tell us some of your observations."

At this point, allow approximately 5 minutes for group discussion. Then ask the Reporters to share their observations with the whole group. Ask the groups to make an inference as to what the white object is. Do not tell them if they are right or wrong.

Next, show a box with its open end turned toward the presenter. Tell the groups that you have a box of white objects that they cannot see, but they must make an inference about whether this white object is the same as theirs. They can make their inferences by asking the presenter questions and by requesting some of the same tests be performed on the white object in the box.

Perform the tests and report the outcomes. Last, poll the groups as to whether they think the white object is the same as theirs. NEVER tell them what your white objects are. Say: "Scientists make observations and inferences; they report their inferences as hypotheses. Other scientists then attempt to replicate their findings. If the findings of other scientists are the same, they can be fairly certain their inferences are valid."

II. 9:30 - 11:30 Small groups perform hands-on activities

Brief Explanation/Rationale

First, pass out the compilation of activities and support materials for participants to place in a three-ring
looseleaf notebook. Ask them to read the accompanying letter and preface to the activities.

Say: "For the next three days, you will perform 69 hands-on science activities that will serve as the core of your science curriculum for the coming school year. Each activity was carefully selected to address both the state's essential elements and the district's enabling objectives for fifth grade science for 1992-1993 school year. Most of the activities were taken from the district's science curriculum guide and Scott-Foresman's Discover science teacher's edition. All other activities came from different sources. A list of references is included in your packet of materials. Today's activities were taken out of sequence because there are some activities that require more time for observation. In your classrooms, I suggest that you maintain the suggested sequence.

Also included in the packet are a number of support materials designed to accompany the activities. I don't believe science should ever be primarily a pencil-paper, fill-in-the-blanks activity; however, I think students should be encouraged to formulate and write their own answers to problems they encounter in the hands-on science experiences in the classroom. I believe students can keep logs or write in their personal journals about what they learned and how it applies in the real world. Samples of
this kind of writing would be very appropriate for student portfolios. I would like for every teacher to issue a challenge to students at the end of each activity to do more experimentation on their own in an attempt to answer additional questions they had about the activity and share their findings with their classmates. Don't forget to celebrate when they do!

This workshop has been carefully designed and planned to enable you to become familiar with your science curriculum, to help you better utilize the resources available to you, and to give you the confidence you need in preparing and carrying out hands-on science activities, but most of all, to create an atmosphere in your classroom in which your students think SCIENCE IS FUN! Are there any questions or comments to this point?

Then, tell the teachers that for the rest of the day they will be working in small groups. Divide the groups into four members each by handing out cards to each participant with the numbers 1 or 2 on them. Tell them that the numbers determine in which group they will work. On the other side of the card is the role they will accept for the first activity. They may change roles with each activity they perform, but the groups will remain the same throughout the day. On the two succeeding days, the groups will be rearranged in the same manner each morning. This arrangement will give each member an opportunity to work
with different people and have different roles for each hands-on activity. Set the climate as a relaxed learning environment in which they are free to interact with each other and to ask questions about the activities.

Show these instructions on an overhead transparency:

There are twenty-three activities for you to complete today. There are a number of activities to perform in one room, and some in the other room. The materials you will need to perform each activity are in bags with the numbers of the activities on them. Your morning schedule of activities is listed on the board. You should complete all the activities in the morning in one room, and all the activities in the other room in the afternoon. To get an idea about time, you will have approximately 13 minutes for each activity. However, you may find you need less time for some activities and more time for others. Remember, your students will spend a class period or more on one activity.

The Reader will find each activity in the notebook and read it to the group. The Runner will get each bag from the shelf and return it when the group is finished. You may divide other responsibilities by assigning the other jobs—Recorder and Reporter—to the other members of the group.

Please perform the activity just as your students will, noting any changes you feel would improve the activity in your notebook. When you are finished with an activity, your
group will dismantle the materials, replace them in the bag, put the bag back on the shelf, and get the next bag. Continue until all activities are completed.

At 10:30, there will be a ten minute break. You will find cold drinks and snacks in the room on the left just beyond the outside door. At 10:40, please be ready to begin the next activity.

At 11:30, we will break for lunch. Please be back at 12:30. We will work until 3:30 when the day's activities will end.

REMEMBER, SCIENCE IS FUN!
Teacher Inservice Training

Day 2--August 4, 1992

Preparations for Presenter

Group 1 (a.m.): Activities 15-17, 20, 22-29
Group 2 (p.m.): Activities 15-17, 20, 22-29
Group 2 (a.m.): Activities 30-32, 34, 35, 39, 41-44, 46
Group 1 (p.m.): Activities 30-32, 34, 35, 39, 41-44, 46

SPECIAL ITEMS NEEDED FOR SPECIFIC ACTIVITIES (Day 2)

Activity

balance scale: 32
thermometer: 24, 42, 44, 46
meter stick: 30
magnifier: 34
microscope: none
lamp: 44, 46

Things to Do (Day 2)

1. Set up VCR/video-game of "Hex"
2. Activity 17: Add (2) mushrooms
3. Activity 20: Add (2) leaves of lettuce
4. Activity 22: Add earthworms
5. Activity 23: Add crickets
6. Activity 24: Add (2) frogs, crushed ice
7. Activity 42: Add hot water
Tell this story:

Once upon a time Sir Isaac Newton sat under an apple tree and an apple fell and hit him. He got as mad as hops and threw the apple up and the apple came down. He thought for a minute and he picked up a rock and threw it up, and it came down. Then he said, "I've got it! One of the rules by which Mother Nature operates is that what goes up must come down". So he wrote to some of his friends and Newton said, "Here's one of the rules: What goes up must come down". So they all starting throwing things up. One of them shot an arrow into the air and it came down.

So, what scientists like Newton do is make observations. Based on those observations, they make up the rules by which they think nature is operating. We accept those rules as okay until an observation's made that contradicts them. A few years after Isaac was under the apple tree, Einstein said, "Wait a minute. What Isaac didn't do was throw things up hard enough. If he had thrown them up hard enough, they wouldn't have come down." And we've now made observations that tell us, yes, if we throw something up hard enough it won't come down. Now, we have spaceships going up and out of our solar system.
Isaac's rule is no longer true. What scientists do when they make an observation that contradicts their rules is change the rule. Rules are just made up. The scientists then changed Isaac's rule to say, "What goes up must come down, unless you throw it up with enough initial velocity to escape Earth's gravitational pull." With that little addition, Isaac's rule still applies. Rules must be consistent with ALL observations.

That is, if you make an observation with which a rule is not consistent, you change the rule. Rules are not made forever; and remember, rules are based on observations.

(The game of Hex will give the teachers some experience with rule making and revising to match their observations.)

How to Play Hex

The participants will observe the game as it is played while they watch the video. Based on their observations, they have to decide the rules by which the game is being played.

Turn on the video-taped game of Hex. Let them watch the first game. Turn the monitor off and ask each participant to write the rules. Then say, "Okay, here's game two. Watch this." Turn it on again and let them see game two. Turn it off and have the participants write new rules or revise the original ones. Then say, "Okay, the game went by so fast that some of us observed some things
that others didn't. I will write the rules on the board upon which you all agree." Write the rules.

Tell participants that nature always plays by the rules. Nature does not change the rules in mid-stream. She doesn't say, "Today I'm going to let things come down that you throw up, but tomorrow I won't." We assume their consistency. You, too, can assume that the people playing the game of Hex will always play by the rules in every game.

Rewind the tape and start over. Tell the participants to focus on the game again, and to look especially at those places where there was some disagreement. Tell them that the tape can be stopped at any time. The presenter should note the specific rules on which there is disagreement so those can be pointed out throughout the rerun of the tape. As the participants watch the tape again, they may want to revise or add new rules. Write these rules on the chalkboard.

Continue to rerun through each of the first three games. Stop at the end of each game to talk about the rules. (The participants will note that the players always start in the right hand corner of the board through the first five or six games. So that will be a rule, until the participants note the change. Then they will probably want to change the rule to **Make the first marks on the player's side** as this is consistent with all observations. (Saying
The first mark can be anywhere on the board would also be consistent.)

Show the fourth through the ? games so that the participants can gain confidence in their set of rules. When participants ask if there is a set of rules by which to check theirs, reply, "There is no filing cabinet that contains the rules to check yours by. The scientist has no filing cabinet for Mother Nature that he can check either. What you have done is made up some rules that can't be checked. You now have the feeling that scientists have. This is like the scientist who doesn't know, for example, what will be found in the next galaxy. It's okay not to know. The scientist can only make rules for what he knows at a point in time.

The chemist observes the reactions of chemicals in a test tube, and he then makes the rules by what he observes; he doesn't go to a textbook to get the rules! He is making them up. His rules will always be consistent with his observations, but those may change in time.

There are rules in science books today that are probably wrong. A good example is the planet farthest from the sun. Ask them to jot down on paper the name of the planet farthest from the sun. Say, "Most of the time it is Pluto, but because Neptune's orbital path around the sun is elliptical, it is sometimes farther from the sun than Pluto. At the time some textbooks were written, it had been a long
time since Pluto had made a complete orbit around the sun
and for many of those Earth years, Pluto was farthest away."

9:30 - 11:30 and 12:30 - 3:30 Small group activities
Group the participants using the number cards and display
the "Instructions" transparency as before.
Teacher Inservice Training
Day 3--August 5, 1992

Preparations for Presenter

Group 1 (a.m.): Activities 33, 37, 38, 45, 47, 48, 50, 51, 53, 54, 57
Group 2 (p.m.): Activities 33, 37, 38, 45, 47, 48, 50, 51, 53, 54, 57
Group 2 (a.m.): Activities 58 - 69
Group 1 (p.m.): Activities 58 - 69

SPECIAL ITEMS NEEDED FOR SPECIFIC ACTIVITIES (Day 3)

balance scale: 53, 61
thermometer: 46, 61
meter stick: 60, 69
magnifier: 53, 54
microscope: 33
lamp: 46

Things to Do (Day 3)

1. Activity 37: Add baking soda, milk solutions, pH paper
2. Activity 38: Add bean seedlings/pH paper
3. Activity 45: Add calcium chloride
4. Activity 51: Add pitcher of water
5. Activity 53: Add mock rocks
Agenda for Third Day

8:30 - 9:30 Whole group activities

The investigator will conduct a discussion on the "how-to's" of hands-on science instruction. Topics to be covered include (a) structuring the lesson, (b) gathering and managing materials, (c) room arrangement, (d) grouping students, (e) assessing students, (f) scheduling hands-on science lab activities, (g) student roles, (h) failure?, (i) integrating science with other subjects, etc.

1. Structuring the lesson

A model for instruction may include the following:

(a) Focus of the science lesson begins with a story/conflict, the purpose of which is to pique the interest/curiosity of the students.

(b) Students are provided the materials for the hands-on science activity in which they observe and make up the rules.

It was easier for me to write out fully what I planned to do and say. I made up the stories on the students' experience level. For example, here is the story I made up to accompany a battery and bulb activity for second graders: "My nephew Bubba asked what we'd be learning about next in science and when I told him 'heat and light,' he asked if we could help him solve a problem he and his family had one day while trying to find a sweater for him to wear. It seems the weather had gotten cooler and he needed to wear
something to keep warm. His mother told him to look in the hall closet and find his dark gray sweater. When Bubba turned on the light in the closet, he heard a 'pop!' and the light went out. Bubba told his mom it was too dark to see in the closet, so she suggested a flashlight, but all Bubba could find were the batteries and the bulb! Someone had taken the case and left them there on the shelf where the flashlight was stored. What was he to do? Can we help him? Could Bubba make a light with only a battery and a bulb? You try it. Is there something Bubba might have at home that he could add to the battery and bulb that might help him light the closet enough to find his sweater?

Ask teacher participants, "How do you structure your lessons?"

2. Gathering and managing the materials

Make a list of needed materials far enough in advance of the lesson that they can be obtained in time. Some materials, like the owl pellets, need to be ordered at least two to three weeks in advance. Students can help bring in materials if you let their parents know what you need and when you need them. I know some teachers who send home a letter requesting materials 6 weeks in advance. You have the materials list separate from the other pages in your packet so that you can see at a glance all the materials you will need for each activity for each 6 weeks.
Once I had a plan, it took me the first year to gather most of the materials as I needed them. Once I had the non-consumable materials, I placed them in trays, clearly labeled, under the cabinets for the succeeding years.

A word of caution: Don't make material requests unless you know where they will be stored when they arrive.

Ask teacher participants, "How do you manage materials?"

3. Room arrangement

Flat-topped desks/tables are a must for hands-on science activities. I arranged four flat-topped desks in a rectangle with two of the desks facing the other two. This worked well for groups of four, but it also worked well for pairs, as the two sitting next to one another could become partners. There were as many groups of four as the number of students allowed. When odd numbers were involved, these students would be in a group by themselves or they would become the fifth member in a group of four, depending on the lesson. The groups were situated within the room in such a way that there was easy access to the materials and the teacher could easily circulate.

Ask teacher participants, "How do you arrange furniture?"

4. Grouping the students

I used the Johnson and Johnson model of cooperative learning throughout the curriculum. This model has groups
comprised of a high achiever, low achiever, and two average achievers, with a mix of gender, ethnics, etc. However, for science I liked to use a random grouping, so that kids learn to work with all other kids. I used the card system I am using with you. I handed a card with a group number on it to each student as they entered the room. They could then sit in any available desk in that group. Some of the time, I would add the role on the back of the card as I have done for you.

Ask the teacher participants, "How do you group students?"

5. Assessing the students

We are required to assess students by giving them letter grades in science. I believe all students can be successful in science, and their grades should be evidence of that success. Students should always know exactly what they must do to earn the letter grades. For the most part, I gave participation grades to each student for every hands-on lesson based on the criteria on this chart:

95 - Shows exceptional interest in subject through sharing ideas and materials

85 - Shows interest in subject matter through sharing stories and listening

75 - Shows lack of interest in subject matter as demonstrated by not listening, following directions, or cooperating
I recommend you give group grades for group data sheets, being careful not to expect "right" answers but accepting any answer that is reasonable. Sometimes, groups can assess themselves.

There are an infinite number of ways to assess. I encourage you to omit the fill-in-the-blank-with-the-right-word assessments and instead use journal writing, data sheet analysis on which students have written their own answers, or other assessments of the process involved.

Ask teacher participants, "How do you grade students?"

6. Scheduling two hands-on science lessons per week

The state recommends 120 minutes of science per week. Each lesson in the series you've performed is designed for 1 hour, with some lessons taking several days to complete.

I always scheduled science after p.e. so that I had time to get the materials set up and ready for the lesson to begin when the students returned. There was always an aura of excitement about what they were going to find when they came back into the room. Before going back inside, I would often caution them about what they might find and what I expected of them. They were then handed the cards with numbers on them so that when they entered the room, they knew in which group they would sit.

Scheduling should also include follow-up activities. The data sheet that accompanies most lessons is considered follow-up. There are a variety of other types of follow-up.
These include journal writing, of course, but also films/videos, field trips, creative writing, oral/written reports, and class discussions. One way to enhance class discussions is to ask pairs to tell each other one at a time all they know about a given topic (this can be done before or after the lesson) in a specified amount of time. Each student may write down what the other says and report the results to the class. At any rate, I initiated lots of discussions. Students' personal experiences with the science phenomena presented in the lesson extended and enhanced every lesson. Be sure to ask higher order thinking questions, such as "Why?" "What do you think?" "How would you do that?" "How would you do that another way?" etc.

Ask teacher participants, "How do you schedule science?"

7. Student roles

Group member roles are important. Each student needs to feel responsible for some aspect of the activity. Sometimes, I would assign the group member roles, and some of the time, the groups would make that determination. Member roles can be anything appropriate to the activity, but the role "Leader" should be avoided because that is the role everyone desires. With titles like Reader, Recorder, Runner, Reporter, each student has an equally important job.
The teacher can remind the students that each role is important for the group to function well.

Ask teacher participants, "How do you assign roles?"

8. Failure?

I used "failure" as a learning experience and never regarded it as a failure. In the beginning, have students predict what they think will happen. If that doesn't occur, ask, "What happened?" "Why do you think that happened?" "What could we have done differently?" It may sometimes be appropriate to repeat the activity. Some of the best lessons come from apparent "failures," so do not become dismayed when you think something has gone wrong.

Ask teacher participants, "What do you do when the lesson fails?"

9. Integrating science with other subjects

Science topics incorporate children's natural curiosity and can be a springboard to integration. When students are involved in science activities, they use their classroom experiences and their own experiences with the science phenomena presented in the science lesson to think, write, and act in other subject areas.

For example, children who blow through a soda-straw kazoo and feel the vibrations on their lips and fingers can easily relate those vibrations to pitch in music, even composing their own tunes with straws of varying lengths. Or children who observe and measure creepy crawlers will
enjoy reading How to Eat Fried Worms by Thomas Rockwell. Identifying the star outlines in the constellations of the Big Dipper, Draco the Dragon, and Cepheus the King can lead to great art and creative writing projects in which children create their own imaginary constellations and make up their own myths.

Are experiences such as these solely science? Can they also be art, music, language arts, social studies, and mathematics? Yes, they can incorporate all of them. For all of my science lessons, I included books from the library on the topic of the lesson and shared these books in some way with the students. I purposefully chose fiction as well as non-fiction in every collection. Whenever possible, I made students aware of connections with other lessons we had shared. There are many ways to plan integration with other subjects, but much of it will happen spontaneously.

Ask teacher participants, "How do you integrate science?"

The remainder of the hour will be devoted to any questions, concerns, or comments participants have about conducting hands-on science activities in their classrooms.

9:30 - 11:30 and 12:30 - 3:30 Small group activities Discuss with participants their role in administering the Student Science Questionnaire to their students both at the beginning of school and at year's end.
APPENDIX C

ANNOTATED LIST OF SCIENCE LAB ACTIVITIES
Annotated List of Science Lab Activities

First Six Weeks

Activities 1 Through 13

Topic of Study:

Scientific Method/Technology/Measurement/Equipment

Activity

1. **Observing:** Participants note 30 observations of an unknown object and make inferences about another unseen white object.

2. **Estimating:** Participants may use any technique for sampling and estimating the contents of three jars.

3. **Measuring:** Participants estimate the volume of several small objects, using a graduated cylinder to determine the actual volume of each.

4. **Collecting data:** Participants drop a ball from various heights and record distances bounced.

5. **Classifying:** Participants sort several different beans in several ways according to different properties.

6. **Inferring:** Participants are given a shoebox with numbered holes in its cover. They slide a straw into the holes to observe how far down the straw goes, infer what the elevation inside the box looks like, and draw a diagram.

7. **Predicting:** Participants toss a die 60 times and record the numbers they see on top. They predict the numbers that will occur when they roll the die 30 more times.
8. **Making Models:** Participants are given nuts and bolts and challenged to make a model of a molecule, using scientific symbols for each.

9. **Making Graphs:** Participants use an eyedropper to drop water from various heights on to a sheet of absorbent paper. A participant draws around the wet spot, measures it at the widest point, and labels it as to the distance from which it fell. Results are graphed.

10. **Hypothesizing:** Participants are given a straw and are instructed to cut off the end in some way so they can make a sound. They must answer the question, "How does the length of the straw affect the pitch of the sound produced?"

11. **Controlling Variables:** Participants tape a pencil to a table from which a rubber band is suspended. A paperclip is opened on one end and hung from the rubber band. Washers are placed one at a time on the open paperclip; the length of the rubber band is measured with each added weight.

12. **Defining Operationally:** Participants attempt to light a flashlight bulb using insulated wire and a battery. They write a definition of the word **circuit** from their experience and then compare their definition with those in a dictionary and their science text.

13. **Investigating:** Participants determine which rubber bands of equal lengths but different widths will stretch the most when a weight is added to them.
Second Six Weeks

Activities 14 Through 24

Topic of Study: Living Systems

14. **Classifying Living Things by Characteristics:**
Participants classify imaginary flowers by stated characteristics.

15. **Classifying Seashells:** Participants group seashells according to common characteristics.

16. **Kingdoms:** Participants list 5 kingdoms of living organisms, draw pictures to represent each, and write at least two distinguishing characteristics of each.

17. **Fungus Kingdom—Mushroom Spores:** Participants remove the stem of a fresh mushroom and set the mushroom cap gill surface down on white paper. A cup is placed over the mushroom. The next day they observe the spores print on the paper.

18. **Growing and Comparing Fungi:** Participants sprinkle water on a slice of bread and place it with an orange and a banana in a plastic bag. After the bag has been undisturbed for a few days, participants examine what is seen growing there.

19. **Photosynthesis:** Participants cover some leaves on a healthy potted plant with black paper. The potted plant is left in the sunlight for a few days so that participants can observe changes in the leaves.
20. **Taking Color from Leaves**: Participants' task is to remove the chlorophyll from a lettuce leaf. One way is to put crushed green leaves in a jar with alcohol. A piece of paper towel is draped over a pencil so that it touches the liquid inside the jar. Participants observe what they see on the paper after a few minutes.

21. **Respiration**: Participants observe what happens when a healthy potted plant and a stick in a pot of soil are wrapped in clear plastic wrap.

22. **Invertebrates-Earthworm**: Participants measure a live worm on different surfaces, count its segments, locate parts of its body, describe it, and tell how it moves.

23. **Invertebrates-Arthropods-Cricket**: Participants observe the physical characteristics of live crickets and their behaviors when touched and given food and water.

24. **Vertebrates-Amphibians-Frog**: Participants' task is to simulate the conditions that force a frog into hibernation. A live frog and a thermometer are placed in a jar with a lid. The closed jar is placed into a large container of ice. The temperatures are recorded periodically as participants observe the appearance and behavior of the frog as the temperature drops.
Third Six Weeks
Activities 25 Through 36

Topic of Study: Environment

25. **Estimating Organisms**: Participants are given a data sheet with a picture of ants arranged in partitioned squares. They are asked to estimate how many ants are in the picture. Then they estimate by counting the number of ants in any 2 squares, dividing that number by 2 and multiplying by the number of total squares to determine how many ants may be in the picture. Those estimations are compared with the actual number of ants.

26. **Nature Walk**: Pairs of participants walk around the school locating living and non-living things. One of the pair records what they observe; the other collects sticks, grasses, and the like for a shelter needed in a later activity.

27. **What's for Dinner?**: Participants analyze where the food they eat comes from by making food chains ending with them. They make generalizations about what they discovered.

28. **Animal Habitat Musical Chairs**: Participants brainstorm about what all animals need to grow and be healthy. The items are classified as one of the following components: **food, water, shelter, space**. Four different chairs marked with these components are placed in a circle of chairs. When a participant lands in a marked chair, he
is out of the game. A follow-up discussion includes how an animal may be unable to find a needed component.

29. **My Kingdom for a Shelter**: A pair of participants research an animal's habitat and then attempt to reconstruct its habitat by using the natural materials collected on the Nature Walk earlier.

30. **Making a Model of Predator-Prey Relationships**: Index cards labeled **mouse** (prey) are arranged in a one meter square. **Owl** (predator) cards are tossed inside the square. Rules are given for life and death. Results are graphed.

31. **Food Pyramid**: Participants become one of several producers, one of a few consumers, one of two secondary consumers, and one tertiary consumer in a game that involves jelly beans as food.

32. **Owl Pellets**: Participants weigh, measure and dissect an owl pellet to identify animals the owl had eaten.

33. **Observing Changes in Population**: Participants stir dry yeast into water, use an eyedropper to place a sample population on a microscope slide, and count the yeast cells. They repeat this procedure after adding sugar to the yeast mixture. Results are recorded after increments of 3 minutes.

34. **No Water Off a Duck's Back**: Participants examine and sketch a dry feather, a wet feather, and an oily
feather. Attempts are made to clean the oily feather without damaging it.

35. **Here Today, Gone Tomorrow Research:** Participants write letters to environmental agencies and organizations to gather information about animals that are considered endangered, critically endangered, threatened, rare, peripheral, or recently extinct. They make the information they receive available to others in some format.

36. **Forest in a Jar:** Participants use soil, water, aquatic plants, birdseeds, and a large glass jug to create an ecosystem and observe succession over time.

**Fourth Six Weeks**

**Activities 37 Through 47**

**Topic of Study: Environment**

37. **Testing for pH:** Participants test several solutions with litmus paper and graph their acidity or alkalinity. Changes in climate that may be caused by people are discussed.

38. **Deadly Skies:** Participants plant two bean seeds. When the seeds become seedlings, they spray one with tap water, the other with vinegar. Wetting the soil is done in the same manner. Participants observe changes in the plants and draw conclusions.

39. **Pollution—Now You See It, Now You Don't:** Participants stir a drop of red food coloring into a cup of
clear water. They are asked to imagine the food coloring as a harmful chemical. Participants dilute the mixture several times to determine if the harmful chemical is still present.

40. **Pollution Trap:** Participants' task is to determine how polluted the air is in various locations. They glue a 100cm grid to a sheet of poster board, then cover it with wax paper, and smear petroleum jelly over the wax paper. The traps are put in their locations and after several days, participants check for attached particles. They determine the average number of particles per square centimeter.

41. **Getting Rid of Garbage Through Innovations:** Participants are given one of several common household objects. They are asked to list new uses, draw models, and make a prototype of the best innovation for demonstrating its new use to others.

42. **Organisms Adapt to Climates:** Participants decide how animals adapt in cold weather. They use two tin cans of equal size, a roll of cotton, thermometers, and other materials to design an experiment to prove fur keeps animals warm in old climates.

43. **Discovering Direct and Indirect Light Rays:** Participants use a flashlight to project light directly and indirectly on sheets of graph paper. Each time, a participant outlines the circle of light on the graph paper so that comparisons can be made as to how sunlight is affected by the tilt of the earth in summer and in winter.
44. **Changing Temperatures:** Participants are given 2 glass jars with lids and small thermometers. They fill one jar with water. They record the temperature inside both jars to ensure they are the same. Both jars are placed in a refrigerator. Changes in temperature are noted in 3 minute increments. The question to think about is "Do you think the ocean changes temperature at the same rate as the air around it?".

45. **Observing How Mountains Affect Climate:** Participants rub calcium chloride evenly over one side of a sheet of construction paper that has been folded lengthwise to form a peak. The paper is placed peak-side-up inside an aquarium with a cup of hot water on one end. A sheet of clear plastic wrap is secured over the top of the aquarium. Participants observe what happens.

46. **Greenhouse Effect:** Participants' task is to set up materials to simulate what happens when carbon dioxide absorbs the light energy from the sun. They set up one glass jar with water and a thermometer, another with seltzer water and a thermometer. A bright light is directed to the top level of the liquids. Participants observe changes in temperature every five minutes.

47. **Smog Production:** Participants simulate smog by lighting a match and placing it at the mouth of a clear plastic bottle that has been rinsed with water. They blow out the match and collect the smoke in the bottle. They
insert a straw through modeling clay that seals the top of the bottle and blow into the straw. They ponder, "When smog is no longer visible, is the air clean?"

Fifth Six Weeks

Activities 48 Through 61

Topic of Study: Earth Systems/Matter and Energy

48. Making a Stream Model: Participants construct a model of a stream by placing sand and pebbles in a cake pan. They elevate the pan and pour water onto the sand at the raised end. They empty the water, and repeat using a steeper slant. Changes are observed and discussed.

49. Drop by Drop: Participants simulate the formation of stalactites and stalagmites in caves. They fill 2 jars with hot water to which they add several tablespoons of baking soda. The two jars are set in a place with a plate between them. A string with a paperclip as a weight on each end is stretched from jar to jar. Participants observe what forms on the string and on the plate.

50. Dissolving Rock: Participants determine how much of a solid mineral can be dissolved in a gallon of water. A clear gallon milk container is filled 3/4 full of water. A felt-tipped marker is used to mark the water level. Participants add salt a spoonful at a time until the salt stays on the bottom even after shaking the container.
51. **Save Those Seeds:** Participants place corn kernels in one pan of soil with straight rows and another pan with arched rows. Both pans are elevated on one end and water is poured through a sieve into the pans at the higher ends. A comparison between results and erosion is made.

52. **Frost Wedging:** Participants simulate frost wedging by observing what happens to a one liter plastic bottle filled with water and left in a freezer overnight.

53. **Mock Rock Geology:** Participants are given mock rocks that they measure, observe through a magnifier, and separate with a nail to identify different ingredients.

54. **Scratch Test:** Participants scratch the surface of calcite, fluorite, quartz, and gypsum with a penny, paperclip, and fingernail to determine which are softest/hardest.

55. **Pressure of Layering:** Participants divide a loaf of bread in half. On top of one stack of bread, they place several books; the other stack is left as is. They continue to add a book a day for several days to the stack with books. After several days, they make observations.

56. **Making a Fossil Imprint:** Participants imprint a leaf or some other small object in plaster of Paris. Connections are made to what we find out from fossilized remains of plants and animals.

57. **Core Sampling:** Participants simulate drilling to obtain a core sample like others do when they are seeking
oil or coal deposits. Three different colors of modeling clay are placed one on top of the other and a straw is pushed through the layers and pulled out.

58. Atom 'n Eat 'Um: Participants used colored marshmallows and pretzel sticks to construct a model of a carbon atom.

59. Static Electricity—Balloons and Puffed Rice: Participants are given a balloon and asked to find ways to show static electricity exists. They deflate balloons, put puffed rice inside and rub the balloons briskly on a surface they have found effective in charging their balloons.

60. Making a Device that Changes Energy: Participants use a string to tie a metal nut to a rubber band that is stretched inside an oatmeal box from end to end. When the oatmeal box is rolled forward, it will roll backward.

61. Comparing Stored Heat from Solar Energy: Participants' task is to determine the rate of stored heat in water, oil, and sand, and to compare their results to see which medium stores solar heat best or worst. They use tin cans covered with black paper to which 100 grams of each medium is added. The cans are placed in sunlight for 3 minutes and the temperature is recorded. When the cans are placed in shade, the drops in temperature are also recorded.
Sixth Six Weeks
Activities 62 Through 69

Topic of Study: Space Systems

62. Making Models of Computer Pictures: Participants' task is to draw a simple picture on a grid. Each box must be either shaded or all white. They write 1 in all the white boxes and a 0 in all the shaded boxes. They number a clean grid with the numbers they used and give it to another group to shade in and discover their picture.

63. Studying Sunspots: Participants punch a hole with a nail in the middle of a piece of cardboard. One participant holds up the cardboard with his back to the sun while the other holds the poster paper so that the sun's image falls on it. Black spots in the image are sunspots.

64. Making a Model of How Scientists Compare Star Distances: Three participants tape a blue, yellow, or red circle to the ends of three meter sticks. One participant stands across the room, one in the middle of the room, and the third, one meter away from the observer. When the observer closes his right eye, only the first circle should be visible. When he closes his left eye, he can measure the distances by holding the end of a ruler so the first circle seems to be touching the 1 on the ruler.

65. Constructing an Astrolabe: Participants cut out a pattern of an Astrolabe, glue it to a sheet of cardboard,
and cut out the Astrolabe. They are given instructions on how to use it.

66. **Using the Astrolabe to Measure the Motion of the Sun:** Participants measure the altitude of the sun, without looking at the sun, with their Astrolabes at 12:00 noon each day for several weeks (or months) to observe how the altitude of the sun changes.

67. **How Do Stars Move?:** Participants construct a model of how stars seem to move. They cut out identical size black and white circles. They draw dots representing major constellations on the black circle and punch them out. They place a paper fastener through the middles of the black and white circles. Looking at the black circle, they spin it and observe what happens.

68. **Making a Galaxy Model:** Participants construct a galaxy model by cutting a file folder into a circle and arranging dots in a spiral pattern on it. A paper fastener is placed in the middle of the circle and labeled Starcraft I; another is placed closer to the edge and labeled Starcraft II. A straight line labelled X on one end and Y on the other end passes through both space probes. Participants count the stars each probe would see when looking at X and again at Y.

69. **What Things Affect Brightness?:** Participants' task is to compare the brightness of light sources that are different distances from the viewer. They cut three circles
of tag large enough to cover the ends of the identical flashlights labeled X, Y, Z. A participant with a flashlight stands 1 meter away from the observers, the other 2, 10 and 20 meters away. The room is darkened and the flashlights are turned on. Observers describe the brightness of each flashlight.
REFERENCES


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