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Effects of hands-on, activity-based science and a supportive instructional environment on at-risk sixth-grade students' attitude toward science, achievement in science, goal orientation, and cognitive engagement in science

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EFFECTS OF HANDS-ON, ACTIVITY-BASED SCIENCE AND A SUPPORTIVE INSTRUCTIONAL ENVIRONMENT ON AT-RISK SIXTH-GRADE STUDENTS' ATTITUDE TOWARD SCIENCE, ACHIEVEMENT IN SCIENCE, GOAL ORIENTATION, AND COGNITIVE ENGAGEMENT IN SCIENCE

by

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The purpose of this investigation was to examine the effects of hands-on, activity-based science instruction in a supportive instructional environment on at-risk, sixth-grade students' attitude toward science, achievement in science, goal orientation, and cognitive engagement in science. The sample was comprised of 204 sixth-grade students of whom 60 were identified as being at-risk. The students were in eight science classes taught by four teachers at one middle school. Each science class had both at-risk and not at-risk students in the class. Since no comparison group was available, and in order to establish differences between at-risk and not at-risk students, and in order to show that this approach would not be detrimental to the not at-risk students, data on all students in the classes were included. A pretest-posttest design was used with each student serving as his or her own control. The study lasted for the second nine-week quarter of the school year. Staff development services were provided to the teachers who participated in the study, in order to provide materials, strategies, and training in the use of hands-on, activity-based science and in developing supportive instructional environments in the science classroom. No significant differences in the students' attitude toward science were found. A significant difference was found in all students' grades in science, with a decrease in grades during the study. A significant effect was found on both task mastery goal orientation and cognitive

engagement of the at-risk students, with both having significant increases during the study. An additional element of the study was the description of the instructional environment of the classroom as it related to cognitive engagement of all students in the class. The classes that had a more supportive instructional environment had higher student cognitive engagement than classes that had a less supportive instructional environment.

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I dedicate this study to my children, Robert and Courtney, who have been extremely supportive and encouraging throughout this long process.

TABLE OF CONTENTS

CHAPTER Page

APPENDICES

LIST OF TABLES

CHAPTER I

INTRODUCTION

Science instruction in the schools should help each student become scientifically literate (Harms & Yager, 1981). Scientific literacy includes the preparation of students to participate as citizens in making decisions about technology-related societal issues and to use science in everyday life. Despite the emphasis placed on science education in the schools in the post-Sputnik era of the 1960s, and the increased availability of funds and of new curricula during the next decade, evidence suggests that the goal of scientific literacy has not been met (Yager, 1984). Several large studies including those supported by the National Science Foundation (NSF) and the National Science Teachers Association (NSTA)identified new goals for school science. The results of the National Assessment of Educational Progress (NAEP) third Science Assessment (Weiss, 1978) further emphasized the need to improve science education in the schools.

During the 1980s educators became increasingly concerned with the segment of the student population that was not succeeding in school. These unsuccessful students, known as at-risk students, are increasing in numbers each year (Smith & Lincoln, 1988). Students who are characterized as being at-risk, potential dropouts, or marginal students often share common traits or characteristics. Common characteristics of these at-risk students include low socioeconomic background, residing in the urban or rural South, minority group status, or single-parent family (Wehlage & Rutter, 1986). Sinclair and Ghoury (1987) characterize the at-risk or marginal student as one who feels disconnected from school. These potential dropouts are usually low-achieving students who are frequently absent from school, are often "in trouble," and have been retained in grade level. "They have come to be called youth 'at risk' because they are at risk of emerging from school unprepared for further education or the kind of work there is to do" (Smith & Lincoln, 1988, p. 2). One focus of the educational reform movement of the 1980s was to identify and implement programs to help at-risk students become successful.

Roy (1985) stated that in order to meet the goal of scientific literacy for all students new curricula strategies must be tried. Linn (1987) stated that "the different perspectives of cultural and population groups require special attention. Instruction must respond to this diversity" (p. 198).

The concern for students identified as at-risk has increasingly focused on ways and methods of helping these students succeed in school. According to Wehlage, Rutter, and Turnbaugh (1987) the students who are identified as "at-risk" "demonstrate low self-esteem and a sense of having lost control of their futures" (p. 71). To respond to the needs of these students schools "must construct new programs that will have positive effects on at-risk students" (p. 71).

Students who have difficulty reading, decoding, and comprehending information lack skills that are essential for successful performance in many classes. These students withdraw, fell angry, and come to see school "as a social event" (Hare, 1987, p. 35). These at-risk students, who often lack the skills necessary to perform successfully on paper-and-pencil tests, can experience and achieve success in hands-on science activities where physical actions, senses, and oral skills can be utilized. Hare stated, "As Ruth Wellman (1978) and Ted Bredderman (1985), among others, have argued, evidence clearly suggests that for a number of reasons children's success in hands-on science experiences often leads to academic and social improvements in general" (p. 36). Additional evidence suggests (Bredderman, 1984; Saunders & Shepardson, 1987) that students who are concrete operational learners, as many sixth-grade students are, make greater gains in achievement and in cognitive development when they receive concrete rather than formal instruction. Saunders and Shepardson (1987) state that "for learners who are reasoning at a concrete level, science laboratory activities, or more generally 'hands-on' activities, may play an important role in at least two major educational outcomes: (1) science achievement and (2) cognitive development" (pp. 39, 40).

Student learning takes place in the context of the classroom. Students are involved in activities or tasks that are organized or structured by the teacher. Students approach classroom tasks with different degrees of motivation and different cognitive interpretations of these tasks. Student learning takes place in the environment of the classroom and is shaped not only by the student's motivation but also by the student's cognitive engagement. The relationships between student cognitive engagement and learning and teacher behaviors can be best understood when viewed in the instructional context of the classroom. The instructional environment encompasses the elements of student, teacher, content, and context. The instructional environment provides the framework through which to view student learning. Student learning takes place in the classroom and is influenced by the instructional environment of the classroom. Therefore, facets of the instructional environment should be included in studies of student learning.

Statement of the Problem

The purpose of this investigation was to examine the effects of hands-on, activity-based science instruction in a selected school setting on at-risk sixth-grade students regarding their attitudes toward science, achievement in science, goal orientation, and cognitive engagement in science, and to investigate how elements of the instructional environment were related to high cognitive engagement.

Nationally, educators are concerned with the growing numbers of students identified as being at-risk, and are looking for ways and methods of intervention to reduce the number of drop-outs and to reach and to retain at-risk students (Pellicano, 1987). The national cumulative dropout rate is approximately 25%. In North Carolina the dropout rate is higher than the national average. The annual dropout rate for North Carolina in 1985-86 was 6.9%. Reidsville City School System had an annual dropout rate for that year of 9.4%. The growing numbers of at-risk students represent a major problem for educators.

While there are a number of programs nationally and locally that are designed to meet the needs of at-risk students, no one approach appears to be the most effective. These at-risk students drop out during the high school years, but often the decision to drop out is made during the middle school years (Casebolt, 1987). Programs or strategies aimed at students during the middle school years might be effective in preventing these at-risk students from becoming dropouts. It is necessary to design programs that would meet the needs of these students.

The marginal or at-risk student often feels disconnected from school (Strahan, 1988) and is usually academically unsuccessful or is a low-achiever. These students do not view themselves as being successful on academic tasks. Brophy (1987) suggested that one way to motivate students to learn is by structuring activities so that students can be successful and can learn to expect success. Science can provide the content through which activities and tasks can be structured in small steps that can provide students with successful learning experiences. The results of many studies (Bredderman, 1985; Shymansky, Kyle, & Alport, 1983) provide evidence to support the effectiveness of hands-on, activity-based science instruction on student attitudes, achievement, and related skills. Additionally, these studies provide evidence that this approach is effective for elementary and middle school students.

Hands-on, activity-based science instruction could be structured and designed to provide the at-risk student with successful learning experiences and enhance student attitudes toward science and student learning. Additional evidence, however, suggests that particular instructional strategies are effective when used with low-achieving students (Cosden, 1988; Jones & Friedman, 1988). According to Jones and Friedman (1988) the connections between teacher behavior and student learning can be properly understood only in the instructional context. Research from Jones and Friedman (1988) and from other studies (Natriello, McDill, & Pallas, 1985; Tobin, 1984; Wang, Rubenstein, & Reynolds, 1985) suggested that providing the at-risk students with hands-on, activity-based science would not be effective unless it was provided in the context of a supportive instructional environment. Elements of a supportive or effective instructional environment were identified in studies by Tobin (1984), Blumenfeld and Meece (1988), and Meece, Blumenfeld, and Puro (in press).

Evidence about the effectiveness of hands-on, activity-based science used with at-risk sixth-grade students is not conclusive. The purpose of this study was to examine the effectiveness of this approach when used in a supportive instructional environment.

The Reidsville City Schools had a high dropout rate, and administrators and staff in the system were interested not only in ways of identifying these at-risk students, but also in implementing new programs to reach these students. This school system was chosen for this study because of its high dropout rate and because all the middle-school students in the system were located in one school. Additionally, the sixth-grade science teachers at this school had expressed an interest in learning hands-on activities, strategies, and techniques that encouraged at-risk students' interests, motivations, and learning. Due to the nature of this study, and the fact that the participation of all the sixth-grade science teachers at this school was encouraged, it was not possible to identify a comparison group. All sixth-grade science teachers were encouraged to participate, and it would not have been possible to deny staff development services to any of these teachers. However, since no comparison group of at-risk students was available, and since the treatment took place in the science classes that were composed of both at-risk and not at-risk students it was considered essential to include the data of the not at-risk students. Additionally, the data on the not at-risk students in the participating science classes are provided to illustrate the differences between the two groups of students, and to provide evidence that the experimental approach used in this study was not detrimental to the learning or achievement of the not at-risk students. Because it was not possible to identify a comparison group, a pretest-posttest design was used with each student serving as his/her own control. The appropriate statistical analysis to compare group means is a t test. The t test was used in the statistical analyses.

Hypotheses

The study will address the following hypotheses:

1. At-risk sixth-grade students who receive hands-on science instruction will demonstrate a more positive attitude toward science as measured by the Children's Attitude Toward Science Survey (CATSS) than they did prior to receiving hands-on science instruction.
2. At-risk sixth-grade students who receive hands-on science instruction will demonstrate higher achievement in science, as measured by numerical grade average in science, than they did prior to receiving hands-on science instruction.
3. At-risk sixth-grade students who receive hands-on science instruction will demonstrate a higher task-mastery goal orientation, as measured by the Goal Orientation scale of the Science Activity Questionnaire (SAQ), than they did prior to receiving hands-on science instruction.
4. At-risk sixth-grade students who receive hands-on science instruction will demonstrate more active cognitive engagement in science, as measured by the Cognitive Engagement scale of the SAQ than they did prior to receiving hands-on science instruction.
5. Teachers whose science classes have higher ratings on the Instructional Environment Scale will have higher student cognitive engagement as measured by the Cognitive

Engagement scale of the <u>SAQ</u> than teachers whose classes have lower ratings on the <u>Instructional Environment Scale</u>.

Assumptions and Limitations

The basic assumptions of the study were as follows:

1. Teachers can improve the quality of their science teaching.
2. Teachers who choose to learn new instructional techniques and methods can implement them successfully in their science classroom when provided with support services.
3. Teachers are the instructional leaders in the classroom and can effect positive changes in the instructional environment.
4. Teachers want to teach and motivate all students in their classrooms.

The following limitations were made:

1. This study was limited to sixth-grade students at Reidsville Middle School and to the sixth-grade science teachers who voluntarily chose to participate in the study.
2. This study was limited to the science classes of four of the five sixth-grade science teachers at this school.

Definition of Terms

Active cognitive engagement is determined by the student's reported use of meta-cognitive and self-regulated strategies such as regulating attention and effort, relating new information to existing knowledge, and actively monitoring comprehension.

At-risk students are students who are identified through a combination of three factors including number of absences from school (previous year), age of student, and fifth-grade teachers' at-risk referral forms (O'Sullivan, 1989).

Attitudes toward science includes those affective objectives such as interest in science and science class, feelings about science, enjoyment of science lessons, and attitude toward scientific inquiry.

Goal orientations are a "set of behavioral intentions that determine how students approach and engage in learning activities" (Meece, Blumenfeld, & Hoyle, 1988, p. 514). These goal orientations can be used to explain differences in students' achievement behavior. Goals differ primarily, according to these authors, in terms of whether learning is perceived and valued as an end in itself or as a means to a goal external to the task. The three goal orientations defined by these authors are task mastery, ego/social, and work-avoidant. Students who operate from an ego-social orientation seek to impress the teacher or show high ability. Those students who have a work-avoidant goal orientation attempt to get work done with minimal effort.

The task mastery goal orientation is one in which students seek to master and understand their work.

Hands-on science consists of science instructions or activities that include the manipulation or use of concrete materials or objects. For the purposes of this study, for a science class to be considered "hands on," the students were involved in direct manipulation or interactions with materials or objects for 20% of the time.

Instructional environment is composed of classroom factors that include the teacher, students, content, and context. This would include teaching strategies, student groupings, teacher questioning, and classroom climate factors.

Learning as defined by Meece et al. (1988) "involves the active process of integrating and organizing new information, constructing meaning, and monitoring comprehension in order to develop a sound understanding of a subject matter" (p. 514).

Success according to Trowbridge and Bybee (1986) ". . . is felt when one has a challenging goal and meets it" (p. 52). These authors state that in terms of science teaching, success is felt "where students will have to expend an effort in an uncertain situation" (p. 52).

Superficial cognitive engagement includes student use of strategies that maximize short-term retention of information.

Tasks as defined by Doyle and Carter (1984) "designates situational structures that organize and direct thought and action" (p. 130). These authors further state that the curricular content of classrooms are the academic tasks that students encounter. Tasks may have content, may differ in form, may involve different activities, procedures or properties and can vary in complexity.

Significance of the Study

The North Carolina Department of Public Instruction identified the competency goals for science in the Teacher Handbook, Science K-12 (1985). These competencies which, at the time of this study, were not coordinated with the state approved textbooks in science, are specified for each grade level. Each classroom teacher may develop or use techniques, methods, or strategies of his/her own choice in teaching these competencies. Many elementary classroom teachers have limited background in science, but have the desire to use more "hands-on" activities with their students.

Classroom teachers are often interested in new ways and methods of reaching different segments of the student population, especially low achieving and at-risk students. The Reidsville City School System had a high dropout rate and a high at-risk population (Strahan & O'Sullivan, 1989). Because of the high at-risk population at Reidsville Middle School, the teachers were interested in new curricula and methods for their classes. The sixth-grade science teachers were particularly interested in learning new techniques and strategies. Research studies suggest that hands-on activities can be structured to provide successful learning experiences for students. Successful academic experiences can lead to improved student motivation and learning (Jones & Friedman, 1988). It appears likely that a supportive classroom environment is necessary to enhance student learning. Little published data exist about the effects of hands-on science instruction used with at-risk students. As a result of this study, valuable information concerning the effects of hands-on science on at-risk sixth-grade students' attitudes toward science, achievement, goal orientation, and cognitive engagement in science will be provided. Additionally, the instructional environment of the classroom will be rated on the Instructional Environment Scale. This information can provide direction for instructional methodology and techniques for science teachers.

Summary

Science instruction that is activity-based and hands-on has been shown to be effective when used with elementary and middle-school students. Different programs have been tried with differing populations of at-risk students. Several studies suggest that a supportive instructional environment would facilitate or enhance student learning, especially that of at-risk or low-achieving students. However, the use of hands-on, activity-based science instruction with at-risk students in a supportive instructional environment has not been adequately researched. In this study, the effects on sixth-grade students' attitude toward science, achievement in science, goal orientation, and cognitive engagement in science of hands-on, activity-based science provided in a supportive instructional environment are examined. A pretest-posttest design was used with nine weeks in between test sessions. Teachers involved in the study were provided staff development in the form of materials, supplies, activities, and training in the use of instructional strategies and techniques. The next chapter presents the literature reviewed for this study. Chapter III presents the method of the study, and Chapter IV the results and analyses. The summary, conclusions, discussion, implications, and recommendations are presented in Chapter V.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

"There are only two problems in science education: what is taught and how. Educators get into trouble when they forget that the best way for students to learn science is to have them do science" (Begley, Springen, Hager, Barrett, & Joseph, 1990).

This chapter reviews the literature related to the various topics and variables of this study. While this study deals specifically with the effects of hands-on science instruction on at-risk students, the literature review is organized in terms of several broad categories. The categories of literature reviewed in this chapter are the following: goals of science education; at-risk students; affective domain and science instruction; classroom tasks; student goal orientation and cognitive engagement; student involvement, achievement, and motivation; the instructional environment; and staff development.

Goals of Science Education

The demand for scientific and technological literacy attracted increasing attention during the 1980s. The results of several major studies and conferences, as well as reports, and reviews of research including: Project Synthesis (Harms & Yager, 1981); "Establishing a Research Base for Science Education: Challenges, Trends, and Recommendations" (Linn, 1987); A Nation at Risk: The Imperative for Education Reform (National Commission on Excellence in Education, 1983); and Phase I of Project 2061 (Staff, 1990), indicated a need for reform in science education as well as a need to increase the scientific and technological literacy of students.

Despite the exemplary programs of the last 30 years, such as the Science Curriculum Improvement Study (SCIS), Science - A Process Approach (SAPA), and the Elementary Science Study (ESS) which made extensive use of laboratory and hands-on activities, in most schools science is still taught in the traditional methods using textbooks, lectures, and demonstrations. The turmoil of the 1970s created a need for assessment of the state of science education and the identification of new goals. The new goal clusters were identified in Project Synthesis as being: personal needs, academic preparation, societal issues, and career education. Evidence from these programs showed that students' attitudes toward science, critical thinking, and process skills were enhanced by these programs (Shymansky, Kyle, & Alport, 1982). Holdzkum and Lutz (1984) suggested that teachers should be recognized and provided with support and encouragement to use hands-on and activity-oriented programs. Other studies described the need for establishing goals of scientific and technological literacy for all students (Kormondy, 1985; Pogge & Yager, 1987; Shamos, 1983/84).

Some science educators (Jarcho, 1985; Roy, 1985; Yager, 1985) proposed and described science courses which emphasized the interactions of science, technology, and society (STS) as a way of meeting these goals. The need for scientific and technological literacy in our society will not decline, making scientific and technological literacy a goal for all people (Penick & Yager, 1986). Hurd (1983/84) stated that the current form of science education should undergo a basic restructuring prior to implementing new goals for science in the schools. According to Hurd (1983/84), science education should be brought into the real life of the student and should emphasize inquiry processes and decision-making.

A meta-analysis to study the effects of the science curricula projects of the 1960s and 1970s, that is curricula that were process-oriented, hands-on, or activity-based, was conducted by Shymansky et al. (1983). They reported that across all the curricula included in the study, students in the "new" curricula performed better than students in traditional courses in achievement, analytic skills, process skills, and related skills in areas such as reading, mathematics, and communication. The students in these programs also developed a more positive attitude toward science. Saunders and Shepardson (1987) examined the effects of concrete and formal instruction on the reasoning ability and science achievement of sixth-grade students. The concrete instruction was organized as a hands-on, activity-based format. Results of this nine-month study showed that students in the concrete instruction group scored higher on cognitive development and science achievement than did the students in the formal instruction group. These and other studies (Bredderman, 1985; Griffitts, 1987; Shymansky et al., 1982) add evidence to support the use of hands-on science with elementary and middle grades students.

As our society becomes more technological, science educators are concerned with ways and methods of improving the scientific and technological literacy of students. Linn (1987) recommended that science educators consider the different subcultures of our population, as well as the learning styles and characteristics of individuals, in designing new programs, materials, or strategies. The late 1980s brought an increasing awareness of the numbers of at-risk youth in the nation's schools, and the need to develop and identify programs which would meet the needs of these students. Motz and Anderson (1990) reported on a National Science Teachers Association lead paper on Science and Technology Education for the 21st century in which the NSTA adopted as one of two major goals, that of scientific literacy. This goal emphasized the importance of preparing the citizens of our nation for living in a technological society. Using hands-on, activity-based science is clearly established as being effective when used with elementary and middle-school students.

At-Risk Students

As the numbers of school dropouts and at-risk youth increase, educators have looked for ways and methods of intervention to reduce the number of dropouts and to retain and educate at-risk students. Many studies (Jones & Friedman, 1988; Natriello et al., 1985; Pellicano, 1987) suggested that educators are concerned with the growing numbers of at-risk students, and are trying to explore and identify strategies and programs to use with these students (Cardenas & First, 1985; Hare, 1987; Horne, 1988; Jones, 1986; Mann, 1985; Wang, Rubenstein, & Reynolds, 1985; Wehlage, Rutter, & Turnbaugh, 1987). According to Wehlage and Rutter (1986) characteristics common to at-risk students who become dropouts include low socioeconomic background, residing in the urban or rural South, minority group status, or single-parent family. Sinclair and Ghory (1987) described at-risk or marginal students as those who feel ". . . disconnected from conditions that were intended to foster academic skills and competencies" (p. 13). Efforts to identify the characteristics of potential dropouts or at-risk students have focused on several areas such as retention in grade level, number of absences from school, disciplinary problems, home environment, and minority group status.

Educators recognize the need to identify and develop programs that respond to the needs of these at-risk students. Several studies have identified or examined instructional strategies for these low-achieving students (Cosden, 1988; Jones & Friedman, 1988). These studies suggest that active instruction is an important goal for teachers of at-risk students. Jones and Friedman (1988) examined instruction as a ". . . complex interaction of four complex and interacting sets of variables: student, teacher, content, and context"

(p. 302). These researchers examined these four interactions in the context of the classroom from the cognitive perspective. Several instructional strategies suggested by this study (Jones & Friedman, 1988) include: content area instruction that focuses on activities, especially those that involve critical thinking, application, or analysis; sequencing of skills from simple to complex; and strategies that shift the responsibility for learning to the student.

Each year almost one million students drop out of school (Smith & Lincoln, 1988, p. 3). These students contribute to the national cumulative dropout rate of approximately 25% (Horne, 1988). In 1986 North Carolina ranked 37th in the nation in the high school graduation rate. The North Carolina Public High School Dropout Study (North Carolina Department of Public Instruction, Division of Support Services, 1985) found that approximately 72% to 74% of the public school ninth-graders in North Carolina graduate or receive attendance certificates within five years.

North Carolina has dropout programs that focus on different aspects of the dropout problem. Some programs focus on specific age groups, such as high school or middle school, others are preventative, remedial, or work-oriented. In many counties in North Carolina the drop-out rate was higher than the national rate. On an annual basis, for comparison, the dropout rate for the Reidsville City Schools is greater than the annual rate for the state of North Carolina. The annual dropout rate for the Reidsville City Schools for 1985-86 was 8.9%, while the annual rate for the state was 6.9%. In 1986-87, Reidsville's annual rate was 9.4%, compared with 6.7% for the state. In 1987-88, it was 7.9% compared with 6.7% for the state (North Carolina Department of Public Instruction, 1985). The state of North Carolina has had funds available for dropout prevention programs since 1985. Several studies in North Carolina have focused on at-risk middle-school students (Casebolt, 1987; O'Sullivan, 1988a, 1988b; Strahan, 1988). These studies suggest strategies and instructional methods that can improve success of middle-school at-risk students.

The data on at-risk students revealed that these students had low self-esteem, had low expectations of getting good grades, and had discipline problems, the most frequent of which was truancy (Wehlage et al., 1987). These students felt alienated, and often "perceive little interest or caring from teachers . . . ." (p. 71). One study (Van Hoose, 1989) reported on the effects of changing the attitudes and behaviors of the teachers who were working with the at-risk students. The program used in that study, the TOPS (Teaching Our Pupils Success) program, generated positive results in terms of changing at-risk students' attitudes and behaviors. One important component of this program was that the TOPS teachers ". . . came to believe that the students could do well, developed a special relationship with most students, and related to them in a different manner" (p. 6). New programs and strategies need to respond to the characteristics and needs of at-risk students in order to have positive effects.

Casebolt (1987) reported that the decision to drop out of school is often made by students during the middle-school years. In reporting on marginal middle-school students, Strahan (1988) stated that these academically at-risk students feel disconnected from school and were trying to "survive" in school. This study suggests that one possible way of improving these students' perception of themselves is to ". . . incorporate more peer interaction into academic activities" (p. 373).

In reporting on strategies for motivating students to learn, Brophy (1987) stated that individuals who believe they can succeed on a task will demonstrate more effort and persistence than those who do not think they will succeed. He further maintained that one way "to insure that students expect success is to make sure that they achieve it consistently" (p. 42). Instruction should begin at the student's level and move in small steps. Teachers should prepare the instruction in such a way that confusion and frustration are minimized. Research from several studies (Cosden, 1988; Jones & Friedman, 1988; Rohrkemper & Corno, 1988) suggests that science instruction which was based on hands-on activities and methods could be structured to provide successful experiences for these at-risk students. Children are naturally curious, and this curiosity could lead these at-risk students into involvement with science activities.

Affective Domain and Science Instruction

Several researchers have clarified and identified the affective domain as it relates to science education (Aiken & Aiken, 1969; Gardner, 1975; Klopfer, 1976; Laforgia, 1988; Shrigley, Koballa, & Simpson, 1988). In a study of elementary school children, Harty, Beall, and Scharmann (1985) reported a significant positive relationship between attitude toward science and achievement in science. Bloom (1976) found that student interest and attitudes were closely tied to the amount of learning in science classrooms. According to Bloom (1976) the relationship is cumulative, and achievement increases as attitudes become more positive.

Several researchers have studied the affective domain as it relates to middle- and junior-high school students. Several studies report a decline in student attitude toward science during these middle-school years (Haladyna & Shaughnessy, 1982; James & Smith, 1985; Simpson & Oliver, 1985). Simpson and Oliver reported on a study in a large school system in central North Carolina. That study examined attitude toward science and achievement motivation scale of middle- and high-school students at the beginning, in the middle, and at the end of the school year. Results of this study showed that both student attitude toward science and achievement motivation declined steadily across the six grades examined in this study. An additional report of this study showed that attitude toward science declined sharply from the beginning to the middle of the year within each grade. A more gradual decline was noted from the middle to the end of the year. Simpson and Oliver (1985) suggest that changes should be made in the way science is taught to adolescent students. In a study involving students in grades four through twelve, James and Smith (1985) reported that the greatest decline in attitude toward science was between the sixth and seventh grade. Germann (1988) studied the relationship between attitude toward science and science achievement. Germann reported a relationship between classroom environment and student attitude; students of teachers with better instructional environments had significantly better attitudes toward science than students of teachers with poorer environments.

Evidence suggests that teachers should include the affective domain in designing curricula and materials for students (Hamrick & Harty, 1987; Harty et al., 1985; Harty, Smauel, & Beall, 1986; Simpson & Oliver, 1985). Efforts should be made to identify science teaching practices that foster improved student attitude toward science and increase student learning. In science, the use of hands-on or concrete materials can foster the development of a more positive attitude toward science (Johnson, Ryan, & Schroeder, 1974) and can lead to more active student learning.

Classroom Tasks

According to Doyle (1983) tasks are the basic treatment units of the classroom. Tasks can be used to examine "the link between curriculum, teachers, and student learning and motivation" (Blumenfeld & Meece, 1988, p. 236). Several researchers (Blumenfeld, Mergendoller, & Swarthout, 1987; Marx & Walsh, 1988; Mergendoller, Marchman, Mittman, & Packer, 1988) have investigated student learning and motivation by examining classroom tasks. "Teacher behavior and student cognitive processes are associated with learning outcomes through the tasks students complete" (Blumenfeld & Meece, 1988, p. 236).

Elements of tasks include content and form. Task content includes both subject matter and cognitive learning objectives (Blumenfeld et al., 1987). The form of the task is composed of the activities, products, and social organization of the classroom. Academic tasks can be used to examine the interrelationships of time, space, organization, and classroom events in relation to student learning (Doyle & Carter, 1984). Classroom work can be viewed as an intricate system of tasks (Marx & Walsh, 1988). Tasks can provide one way of examining student learning in the classroom.

Teachers direct and organize the tasks in the classroom. Teachers must structure and match task levels in order to meet the needs and learning styles of students in the classroom (Anderson, Stevens, Prawat, & Nickerson, 1988; Bennett & Desforges, 1988). In matching classroom tasks to students' cognitive level, teachers use pupil performance on task to assess student progress.

Several researchers have used science classroom tasks to examine student involvement, student learning, teacher behaviors, and classroom management (Blumenfeld & Meece, 1988; Mergendoller et al., 1988; Sanford, 1984). These researchers suggest that the nature of a particular task influences the type of thinking in which students engage. Sanford (1984) identified teaching behaviors and classroom management techniques that were related to high levels of student task engagement in science classroom activities. In extensive studies and analyses, Tobin (1984) identified and described teaching behaviors that were associated with high levels of student task engagement in middle-school science classes.

Student Goal Orientation and Cognitive Engagement

According to Meece et al. (1988) a student's goal orientation "is an important mediator of students' engagement patterns in the classroom" (p. 515). The goal orientation can be task-mastery, social-ego, or work-avoidant. In a comprehensive analysis of fifth-grade and sixth-grade students' goal orientations in science, Meece et al. (1988) generated a structural model that described the relationship among the critical variables related to active cognitive engagement in science. The structural model developed by these authors revealed the strongest correlation between task mastery goal orientation and active cognitive engagement. Both individual and situational variables can influence cognitive engagement and goal orientation, according to these authors. Other investigators have examined the role of cognitive engagement in student learning (Corno & Mandinach, 1983). The results of this study indicated that active cognitive engagement is determined primarily by student's goal orientation. Students who placed a stronger emphasis on task-mastery goals reported more active cognitive engagement in learning activities.

Students in a classroom are involved in a wide range of activities or tasks. Students approach these tasks with different backgrounds, motivation, viewpoints, and cognitive interpretations of the tasks. The form of cognitive engagement with which students approach classroom tasks may be superficial or active cognitive engagement (Corno & Mandinach, 1983). According to Corno and Mandinach, one form of cognitive engagement is self-regulated learning. Self-regulated learning, according to these researchers, is composed of specific cognitive activities such as deliberate planning and monitoring and connecting new information with prior knowledge. Teachers in the classroom can use instructional strategies that encourage and promote the use of self-regulated student learning. Teaching strategies that promote self-regulated learning include teacher modeling the cognitive strategy students should use, and asking questions of students about how an answer was obtained. These strategies can help students learn how to learn. According to Corno and Mandinach, instruction that encourages self-regulated learning appears to be especially beneficial to low achieving students. Particular teaching strategies to encourage self-regulated learning are described by Thomas, Strage, and Curley (1988).

These investigations suggest that cognitive engagement is a strong determinant of classroom learning, and that students' perceptions of academic tasks and their goal orientation toward them determine the degree to which they are cognitively engaged in academic tasks. In science, students who have positive attitudes toward science are most likely to demonstrate active cognitive engagement if they also have a mastery orientation toward the task, while students whose orientations are toward pleasing others or avoiding work are less likely to demonstrate cognitive engagement and thus less likely to learn (Meece et al., 1988). According to Brophy (1988) "high task-engagement rates attained through successful classroom management methods are among the most frequent and powerful correlates of student achievement" (p. 241).

Student Learning, Achievement, and Motivation

Educators have been concerned with ways of improving student learning and achievement in various academic areas. Fisher, Filby, Marliave, Cahen, Dishaw, Moore, and Berliner (1978) defined "academic learning time" as the amount of time a student performs relevant academic tasks with a high level of success" (p. 35). These researchers found that cognitive engagement was a useful measure of performance and that students who learned the most were those who were most actively involved in activities they perceived as productive. Active cognitive engagement, according to Blumenfeld and Meece (1988), is defined by the number of self-regulated, high-level learning strategies a student reports using. Self-directed or self-regulated learning activities are those that are "wholly or partly under the control of the learner" (Thomas, Strage, & Curley, 1988,

p. 314); in contrast, superficial cognitive engagement is determined by the number of work-avoidant and help-seeking strategies students report using.

Student motivation to learn as defined by Brophy (1983b) is a state in which the student values learning for its own sake. Students who try to master concepts and skills involved in classroom tasks are engaged in a state of motivation to learn. According to Brophy, conditioning and learning experiences affect student motivation. The value a student places on a particular goal will influence the amount of effort put forth to reach that goal. The student's expectation of success also will influence the amount of effort expended. Classroom motivation, as seen by Brophy, is the motivation to learn. Since learning occurs in the classroom, the environment of the classroom will influence student learning. Most academic tasks in the classroom require cognitive engagement and learning on the part of the student. Student motivation to learn can be influenced by various behaviors and strategies used by the teacher. By structuring classroom environments in which students feel free from anxiety and free from fear of failure, and where tasks are appropriately structured for difficulty, student motivation to learn is enhanced (Brophy, 1987; Uguroglu & Walberg, 1986).

In a motivational analysis of the learning environment in elementary science classrooms, Meece, Blumenfeld, and Puro (in press) reported several features of the learning environment that could promote high task-mastery motivation. The descriptive analysis by these authors of two elementary science classrooms contrasted the learning environments of a teacher whose students exhibited high motivation with that of a teacher whose students exhibited low motivation. The teacher of the high-motivation students used instructional strategies that emphasized understanding and mastery of material, used small and large group instruction, and encouraged and promoted the use of self-directed learning. This teacher provided feedback to the students and modeled cognitive strategies for the students.

Instructional Environment

This section of the literature review describes the framework of the instructional environment and examines various elements of that environment. Classrooms are complex spaces where a variety of activities occur (Good & Brophy, 1987). According to Jones and Friedman (1988), the connections between teacher behavior and student achievement can be appropriately understood only when viewed in the instructional context. They further suggest that instruction is a complex interaction of student, teacher, content, and context. The instructional environment provides the framework through which to view the complex linkages among students, teachers, content, and context.

Students in a classroom are "assumed to be engaged in learning" (Gagne & Driscoll, 1988, p. 1). Teachers provide instruction designed to promote student learning. Students' learning is facilitated and enhanced when instruction and the learning context are compatible with student learning styles (Dunn & Dunn, 1987). Student learning can be enhanced by strategies and techniques used by the classroom teacher (Anderson et al., 1988). Classroom instruction involves interactions among students, teacher, resources, and the environment of the classroom. It is the teacher who is responsible for arranging the instructional environment in such a way that learning is promoted (Anderson, 1981; Gagne & Driscoll, 1988; Thomas et al., 1988). The teacher's management of classroom behavior is an important and necessary factor in the learning environment. Student learning increases when active participation in the learning activity is demanded by the teacher (Anderson, 1981).

Brophy (1988) stated that ". . . it is more important that teachers create a supportive learning environment and be patient and encouraging throughout their interactions with their students than that they praise a high percentage of the correct answers that these students supply during classroom recitation" (p. 249). A supportive instructional environment can facilitate student learning (Brophy, 1988; Jones & Friedman, 1988).

Researchers have recognized that classroom climate is an important factor in educational research (Benninga, Guskey, & Thornburg, 1981; Berliner, 1983; Brophy, 1983a; Brophy & Good, 1986; Nummela & Rosengren, 1986). Additional researchers have described and explored elements of the classroom climate (Anderson et al., 1988; Beyer, 1987; Fraser & Fisher, 1983; Good & Brophy, 1987; Good &

Weinstein, 1986; Hart, 1983; Weinstein, 1983). Several researchers have identified and described elements of science classroom environments (Blumenfeld & Meece, 1988; Gallagher & Tobin, 1987; Meece et al., in press; Sanford, 1984; Tobin, 1986a, 1986b; Tobin & Capie, 1982; Tobin & Fraser, 1986, 1987; Tobin & Gallagher, 1987).

One researcher in particular, Tobin, has extensively studied and described science classroom environments. Tobin (1984) described the relationship between teacher behavior and student engagement in activity-oriented science. In an additional report on this same study, Tobin (1986b) described the validation of these 14 aspects of teacher performance measures with student engagement and achievement in middle-school science classes. The purpose of that study, which used 25 indicators from the TPAI (Teacher Performance Assessment Instrument [Capie, Anderson, Johnson, & Ellett, 1979]) was to extend the concurrent and predictive validity of the TPAI in middle-school science classrooms. In that study the validity criteria were student engagement and process skill achievement. The indicators from the TPAI that were used by Tobin were designed to assess aspects of the teacher's performance on classroom procedures and interpersonal skills. The results of that study indicated that 11 of the teacher performance variables were significantly correlated with student engagement rates; seven of these variables were managerial and four were instructional.

Two teacher managerial variables (#12 - Uses instructional time effectively and #14 - Manages disruptive behavior among learners.)

were not significantly correlated with student engagement. One instructional variable (#10 - Helps learners recognize the importance of activities.) was not significantly correlated with student engagement. According to Tobin (1984), teachers who want to influence student achievement need to provide a classroom environment that encourages student learning and ensures student engagement in productive, relevant learning tasks. According to Tobin (1984) and other researchers (Anderson et al., 1988) in order to promote student achievement, teacher instructional behaviors must be effectively combined with teacher managerial behaviors.

Factors of the instructional environment in science classes have been examined and identified in studies by other researchers. Blumenfeld and Meece (1988) described teacher behaviors and students' cognitive engagement and involvement in a study of eight science classes composed of fourth-grade through sixth-grade students. The teaching behaviors identified in this study which were linked to higher student cognitive engagement and learning were the following: demand for wide student participation; press for student mastery of material; prompt students to think at a fairly high cognitive level; and probe for student comprehension and understanding.

In describing the role of a teacher in relation to the classroom environment, several researchers have used observational data and classroom narratives in order to describe qualitatively the instructional environments in science classrooms. In a study that examined classroom variables that promoted high levels of cognitive engagement in elementary science classes, Meece et al. (in press) reported several features of the classroom learning environment that promoted a high task mastery orientation. Classes which encouraged high levels of student motivation and cognitive engagement were those in which the intrinsic value of learning was emphasized, peer relations and student autonomy were supported, active teaching was used, and challenging learning activities were used. The items used on the Instructional Environment Scale were adapted from Tobin (1984) and from factors identified in studies of science classes by Blumenfeld and Meece (1988) and Meece et al. (in press).

The Instructional Environment Scale replaced three factors that were not highly correlated with student learning and cognitive engagement with three factors that were identified as being strongly related to student learning and cognitive engagement. These factors identified as critical in a study of task factors, teacher behaviors, and student involvement in science and were further explored in a study by Meece et al. (in press). The critical factors accoring to these authors were the press for wide student participation in activities and the press for student mastery of material in which students were asked to justify or explain answers so that student learning went beyond mere memorization. The third factor identified during these and other studies appeared to be especially important when working with low-achieving students (Jones & Friedman, 1988; Meece et al., in press). This factor was the teacher's modeling of cognitive strategies for the students. These items were field tested during the pilot study.

In a meta-analysis of hands-on, activity-based elementary science programs, Bredderman (1985) identified hands-on science as an effective method of science instruction that improved students' achievement in science and attitude toward science. Several studies suggested that when using hands-on, activity-based science with at-risk students, a supportive instructional environment was essential. This supportive instructional environment should encourage and facilitate student learning. To provide new curricular experiences without the positive classroom environment would probably not help the at-risk student (Jones, 1986; Natriello et al., 1985; Tobin, 1984; Wang et al., 1985).

Characteristics of students and teachers are studied in the ecological setting of the classroom. Berliner (1983) argued that it was necessary to understand and identify the classroom environmental factors that influenced behavior. Skinner (1981) and Resnick (1981) also identified the need to explore classroom environment factors that affect student behavior. According to Champagne and Hornig (1986) teachers should be encouraged and supported in the use of activity-based or hands-on science. Hands-on, activity-based science instruction that occurs in a supportive instructional environment could provide successful academic experiences for these students, foster the development of a positive attitude toward science, and encourage a task-mastery goal orientation and active cognitive engagement in learning.

Staff Development

Many teachers search for ways and methods of improving student learning in the classroom. Different approaches have been tried to change, effect, or improve teaching and student learning. These approaches have included staff development, in-service training, university and school collaboration, consultant services, mentor services, and various other approaches. In a meta-analysis of 91 well-documented studies on in-service teacher education, Wade (1984/85) reported that no one approach appeared to be the most effective. According to Wade, in-service programs that use observation, microteaching, audio and visual feedback, and practice appear to be more effective than programs which do not use these methods. These methods were effective when used individually or in some combination.

Several researchers have examined the relationship between staff development and student learning (Bredderman, 1984; Joyce, Showers, & Rolheiser-Bennett, 1987). The use of hands-on, activity-based science instruction that is facilitated through staff development, has been shown to increase student learning (Bredderman, 1985). Joyce et al. (1987) reported several specific teaching practices which facilitated student achievement or learning. These practices included the teacher's use of wait-time (Rowe, 1974; Tobin, 1986b), and the teacher's calling on all students for participation, especially poor learners who are frequently called on less often by the teacher. In a study on improving elementary science and mathematics teaching, Tobin and Jakubowski (1989) identified several assertions as being important when facilitating changes in teachers and teaching strategies. These assertions included the availability of the basic materials and supplies necessary to implement hands-on curriculum, on-site workshops for teacher enhancement, and the availability and use of a facilitator. In that and other studies (Tobin, 1989; Tobin & Ulerick, 1989) Tobin examined the teacher's role through the use of metaphors. Helping teachers view their teaching roles through the use of metaphors, enables some teachers to effect changes in those roles.

The staff development or in-service training which was provided to the four sixth-grade science teachers at Reidsville Middle School was designed to be responsive to the needs of those teachers and to the needs of their students, both at-risk and not at-risk. The researcher was seen as a facilitator who provided materials and supplies for hands-on activities, instructional support for science teaching and classroom strategies, in-service workshops, and feedback to the teachers involved in this project.

The staff development component of this study provided the teachers with the materials, supplies, strategies, and techniques necessary to implement hands-on science instruction. Additionally, the staff development workshops and informal meetings and sessions encouraged, supported, and enhanced the development of a positive instructional environment within the science classroom.

Summary

The review of the literature in this chapter was structured to include the goals of science education, at-risk students, the affective domain and science instruction, classroom tasks, goal orientation and cognitive engagement, student learning, achievement, and motivation, and staff development. The literature chosen for review in this chapter was that which was relevant to the variables and characteristics of this study. The instructional environment of classrooms provides the framework through which student learning, teacher behavior, content, and context may be examined. Chapter III presents and discusses the method of this study. The analyses of the data are presented in Chapter IV. The summary, conclusion, discussion, implications, and recommendations are found in Chapter V.

CHAPTER III
METHOD OF THE STUDY

Overview

The purpose of this chapter is to describe the research methodology used in this study. Based on the literature review, the following hypotheses are the focus of this study.

Hypotheses

Hypothesis 1

At-risk sixth-grade students who receive hands-on science instruction will demonstrate a more positive attitude toward science as measured by the Children's Attitude Toward Science Survey (CATSS), than they did prior to receiving hands-on science instruction.

Hypothesis 2

At-risk sixth-grade students who receive hands-on science instruction will demonstrate higher achievement in science, as measured by numerical grade average in science, than they did prior to receiving hands-on science instruction.

Hypothesis 3

At-risk sixth-grade students who receive hands-on science instruction will demonstrate a higher task-mastery goal orientation, as measured by the Goal Orientation scale of the SAQ, than they did prior to receiving hands-on science instruction.

Hypothesis 4

At-risk sixth-grade students who receive hands-on science instruction will demonstrate more active cognitive engagement in science, as measured by the Cognitive Engagement scale of the SAQ, than they did prior to receiving hands-on science instruction.

Hypothesis 5

Teachers whose science classes have higher ratings on the Instructional Environment Scale will have higher student cognitive engagement, as measured by the Cognitive Engagement scale of the SAQ, than teachers whose classes have lower ratings on the Instructional Environment Scale.

Design of the Study

In order to test the research hypotheses, it was necessary to find a school or school system that had a large at-risk population of elementary or middle-school students. In addition, it was desirable to have an established procedure by which to identify these students. An additional necessary element was that several science teachers of a particular grade level would be willing to participate in this study.

Reidsville City School System had the eighth highest dropout rate in North Carolina (O'Sullivan, 1989). For instance, in 1985-86 the rate was 9.4% which was higher than the state average for that year of 6.9%. Reidsville School System was interested in identifying potential dropouts or at-risk students and in providing programs for these students.

As part of a model dropout prevention program that was implemented at Reidsville Middle School during the 1988-89 academic year, and which was funded by the Mary Reynolds Babcock Foundation, O'Sullivan (1989) developed procedures to identify potential dropouts. The study by O'Sullivan identified the three predictor variables of number of absences from school during the preceding year, age of student, and fifth-grade teachers' at-risk referral forms as being consistent significant predictors of at-risk students. The availability of this information that predicted at-risk students and the expressed desire of the middle-school teachers to address the problem of at-risk students satisfied two of the requirements for a location for this study. In addition, all middle-school students in this school system were located in one school, Reidsville Middle School. The combination of a relatively large number, about 80 students in each grade level, of at-risk students, with procedures in place by which to identify these students, and teachers who desired to affect changes in student learning and achievement provided the necessary ingredients for this study.

As part of a model dropout prevention program during the 1988-89 academic year, selected at-risk sixth-grade students spent part of the academic day with a resource teacher. The resource teacher taught science and math to these identified at-risk students. In the spring semester of 1989, pilot work was conducted in the science class of the resource teacher. The pilot study examined the effects of hands-on, activity-based science instruction on the attitudes toward science, goal orientation, and cognitive engagement of the at-risk sixth-grade students. In addition, elements of the instructional environment that supported and enhanced student cognitive engagement were identified. Based on the results of the pilot study, and the desire of the other sixth-grade science teachers at Reidsville Middle School to implement new curricula and strategies for their students, both at-risk and not at-risk, a staff development program was offered to the sixth-grade science teachers.

At the beginning of the 1989-90 school year, a staff development program was offered to all sixth-grade science teachers at Reidsville Middle School. This program included hands-on materials, supplies, and activities, as well as training and practice in using these activities and training in strategies and techniques that appeared to be especially beneficial to at-risk students. These instructional strategies and techniques were ones identified on the Instructional Environment Scale. Because hands-on, activity-based science has been shown to be effective with not at-risk student populations, the sixth-grade science teachers were interested in participating in the staff development program, which the teachers felt should benefit both the at-risk and not at-risk students. For this reason, data on the not at-risk students were included in this study. The participation of all sixth-grade science teachers was encouraged. One sixth-grade science teacher, however, chose not to participate. With four of the five sixth-grade science teachers and their classes participating in the study, it was not possible to identify a comparison group.

The overall design of this study was that through staff development workshops and services, the sixth-grade science teachers would be provided with supplies, materials, and activities necessary to implement hands-on, activity-based science. The staff development workshops and individual sessions provided teachers with the opportunity to observe the use of these materials, and allowed the teachers the chance to practice and use micro-teaching techniques. During the workshops and individual sessions, the teachers received training and practice in instructional techniques and strategies that appeared to be effective in enhancing student learning, motivation, and engagement and in ways of providing a supportive instructional environment. As part of the staff development program, four observations were made of each science class for each teacher during the first nine weeks of school, that is, prior to the start of the study. Four observations of each science class for each of the four science teachers were made during the nine weeks of the study in order to obtain ratings on the Instructional Environment Scale.

In order to test hypotheses one through four of the study, a pretest-posttest design was used in which students acted as their own controls. Since hypothesis five involved rating the instructional environment of the entire classroom, cognitive engagement of all students in the classroom was determined.

Subjects

The population of this study was the sixth-grade students ($\underline{n}$ = 204) enrolled in the classes of four sixth-grade science teachers at Reidsville Middle School in Reidsville, North Carolina for the 1989-90 school year. From this population of 204 students, a subpopulation of at-risk students ($\underline{n}$ = 64) was identified. Since all students, both at-risk and not at-risk, were in the science classes and received the activity-based science instruction, data on both groups of students are included. Since it would not be desirable to use programs or activities that would benefit one group of students at the expense of another group of students, data on the not at-risk students are provided. Additionally, the data on the cognitive engagement of the not at-risk students were needed for the analysis of hypothesis five, which related the instructional environment of the classroom to the cognitive engagement of all students in that classroom.

Reidsville Middle School is located in a small city in central North Carolina and serves sixth-grade and seventh-grade students. Sixth-grade students were assigned to teaching teams consisting of two teachers (Student Placement Memo, Reidsville Middle School). One teacher on each team taught science. There were five sixth-grade teams. There were 84 students identified as being at-risk and approximately 16 at-risk students were assigned to each of the five teams. One sixth-grade science teacher chose not to participate in the study, therefore, data on the 17 at-risk students in that teacher's classes were not included.

The population (n = 204) for this study, then, was all the students in the science classes of four sixth-grade science teachers. The subpopulation (n = 64) was the identified at-risk students in these same science classes; there were then 140 not at-risk students in these classes. Since one characteristic of at-risk students is numerous absences from school, it was not possible to obtain complete data on each at-risk student. Since some at-risk students are often "in trouble," these students are placed on Out-of-School Suspension (OSS) for periods of time ranging from 1 to 14 days. It was not possible to obtain data on some students due to time spent in Out-of-School Suspension. Data were included only when the pretest and posttest for the measure had been completed. For this reason the number of cases reported for the subpopulation of at-risk students will show a slight variation on different hypotheses.

The students identified as at-risk were determined by a combination of three factors (O'Sullivan, 1989). Students were identified by number of absences from school in the previous year, by age, and by fifth-grade teachers' at-risk referral forms. During the 1989-90 school year, the teachers were not aware of the identity of the at-risk students.

Procedure

The design for this study was a pretest-posttest design in which students acted as their own controls. The appropriate statistical test to use in this case was the nonindependent t test. The t test can be used to test statistical significance on the same group before and after an experimental treatment. Alpha level of .05 was used for the t test. This design also controlled for teacher effects, since the students were taught by the same science teacher both before and during the study. Since it was not possible to identify a comparison group of at-risk students, the pretest-posttest design was the best possible experimental design to use. The data on the not at-risk students (n = 140) are included for reference and to provide a way of establishing differences between at-risk and not at-risk students.

The pretest was given in each sixth-grade science class by the regular science teacher. Each teacher read the directions, read each question, and possible answer choices. Additionally, teachers were asked to make notes on any unusual circumstances or happenings. The students were told that answering the questions was voluntary. In some cases students did not complete the questionnaires. The methods for treating incomplete data are addressed under each measure.

The pretest was given at the end of the first nine-week grading period. Students had not received report cards for the first nine weeks at the time the pretest was given. The posttest was given in the same manner as the pretest. It was given to the students at the end of the second nine-week grading period. Teachers read the directions, the questions, and the answer choices for each question. No problems were reported in administering either the pretest or the posttest.

The instructional environment of the classroom was measured by determining the mean of four ratings made for each teacher for each science class. Since each science teacher taught two science classes during the day, each teacher had two mean ratings. These are identified as rating for class 1, the morning class, and a rating for class 2, the afternoon class. Since student ability groupings had been used by the school in placing students in classes, instructional environment ratings were made on each of a teacher's two classes. The teacher's mean rating on the Instructional Environment Scale was compared with the mean cognitive engagement of all students in that class.

There were five different measures used in this study. The measures used included the Children's Attitude Toward Science Survey (CATSS), end-of-quarter numerical grade average in science, two scales of the Science Activity Questionnaire (SAQ), the Task Mastery Goal Orientation (TM) scale, and the Cognitive Engagement (CE) scale, and ratings of classroom environmental factors on the Instructional Environment Scale (IES).

Measures

Attitude Toward Science

Children's Attitude Toward Science Survey (CATSS) was used to measure student attitude toward science. This instrument was developed by Harty, Andersen, and Enochs (1984) and was adapted from the "Attitude Survey for Junior High Science" (Fisher, 1973). These authors assured a readability level for fifth-grade and sixth-grade students.

The instrument consists of 20 Likert-type items with five possible choices of answers: strongly disagree (1), disagree (2), undecided (3), agree (4), and strongly agree (5). Five of the items have reversed scoring. Scores may range from 20 to 100. Higher scores indicate a more positive attitude toward science.

The validity of the original instrument (Fisher, 1973) was established using six science curriculum specialists who participated in the generation and refinement of the items. Fisher reported a split-half reliability of 0.83 and test-retest reliability of 0.79.

The instrument adapted by Harty et al. (1984) was field tested by these researchers using 171 fifth-grade students. Alpha internal consistency was found to be 0.78. Utilizing split-half method, internal consistency reliability was found to be 0.76. Test-retest reliability with a three-week interval between test sittings was found to be 0.55 ($p < 0.05$). Internal consistency for the sample in the study of 91 fifth-grade students was alpha (0.67) and split-half (0.65).

For the purposes of this study the original format of checking or circling the response under each question was reinstated, rather than using smiling/frowning faces due to the ages of the students. Also, an open-ended question that was contained on the original instrument was reinstated in order to obtain student responses that could be analyzed qualitatively. Responses to the open-ended question were coded as being negative, neutral, or positive in their attitude toward science or science class. If the student did not respond to the question, or if the response was not legible or was incomplete, a neutral coding was assigned. Examples of responses coded as negative were as follows: "is boring," "is stupid," "is a waste of time," "is dull," "is dum (sic)." Examples of responses coded as expressing a neutral attitude were" "is OK," "is interesting," "is dull but important," "so-so," and responses which included both positive and negative attitudes, such as "is fun at times (sic) when we be messy (sic) with stuff but other times it is boring." The following responses were coded as indicating a positive attitude toward science or science class: "is very fun," "is good, I like it," "I like it and it's cool," and "is fun because we do experiments."

Student Achievement in Science

Student achievement in science was measured by end-of-quarter numerical grade averages in science class as determined by the individual classroom teachers. During the study, the classroom teachers were not aware that grades would be used as a measure of student achievement. The teachers used teacher-made test and end-of-chapter test from the science textbook. Teachers reported using consistent grading criteria throughout the school year. Teachers occasionally included test items on process skills. Grades in science were based on a combination of factors including homework, reports, classroom participation, and tests.

Student Goal Orientation

Student goal orientation in science was measured by a scale of the Science Activity Questionnaire (SAQ) for intermediate (fourth through sixth grade) students which was developed by Meece et al. (1988) by adapting items from several questionnaires (Ames, 1984; Nicholls, Patashnick, & Nolen, 1985) and from pilot work (Nolen, Meece, & Blumenfeld, 1986). Questionnaire items for the cognitive engagement scale were adapted from measures developed by Nolen et al. (1986), Peterson, Swing, Stark, and Waas (1984), Pintrich (1985), and Weinstein, Schulte, and Palmer (1987). Methodology for the cognitive engagement scale was adapted from that of Ames (1984).

The SAQ contains three scales to measure students goal orientation: task mastery, ego-social, and work avoidant. Table 1 lists the three types of goal orientations, the number of items on the scale for that orientation, and the reliability coefficient alpha.

Students rated each item on a four-point Likert scale of not at all true (1), a little true (2), somewhat true (3), and very true (4). This scale contained nine items; the mean score on this Task Mastery Scale was calculated for each student.

Table 1

Goal Orientation Scale (SAQ)

Scale	Number of Items	Coefficient Alpha
Task Mastery	9	0.94
Ego/Social	3	0.85
Work Avoidant	3	0.77

Student Cognitive Engagement in Science

Students' cognitive engagement in science was measured using the Cognitive Engagement (CE) scale of the Science Activity Questionnaire (SAQ). The SAQ measured engagement in science by 15 additional items on two scales, active cognitive engagement and superficial cognitive engagement. The Active Cognitive Engagement (CE) scale was used in this study. This scale is measured on a three-part Likert scale that included not at all like me (1), a little like me (2), and a lot like me (3). A mean score for the CE scale was used to measure student cognitive engagement. Table 2 describes the type of engagement, the number of items on the scale for that type of engagement, and the coefficient alpha.

Classroom Instructional Environment

The degree of supportive instructional environment of a science classroom was measured by the Instructional Environment Scale (IES) adapted from Tobin (1984). This scale consisted of 14 items which

Table 2

Cognitive Engagement Scale (SAQ)

Type of Engagement	Number of Items	Coefficient Alpha
Active cognitive	8	0.87
Superficial cognitive	5	0.79

were rated on a scale of 1 to 5, with 1 being the lowest rating and 5 the highest. Descriptors or indicators for each of the 14 items are part of the IES and provide the rating basis for each item. A mean rating on the Instructional Environment Scale can be calculated from this. Each class was observed during one entire class period, descriptors and/or indicators for each of the 14 items were recorded during the observation, and a mean rating determined. Since the range of the mean ratings for the IES was 1 through 5, a rating of 3.0 or higher was set as being indicative of a supportive instructional environment. All observations and ratings on the IES were made by one observer.

Three items on the original scale which were not highly correlated with student engagement rates were replaced with three items identified in studies by Blumenfeld and Meece (1988) and Meece et al. (in press) as being especially important in enhancing student cognitive engagement, particularly with low-achieving students. The three items on the original scale which were not highly correlated with student cognitive engagement were the following: teacher helps learners recognize the importance of activities (item #10), teacher uses instructional time effectively (item #12), and teacher manages disruptive behavior among learners (item #14).

The instrument developed by Tobin (1984) identified instructional and managerial teacher behaviors which facilitated student achievement in science. Based on results from previous studies (Capie, Anderson, Johnson, & Ellett, 1979; Capie & Ellett, 1982; Tobin & Capie, 1982) Tobin investigated the relationship between student engagement and teacher performance on various tasks during a two-week science module that emphasized process skills. Using 25 variables from the Teacher Performance Appraisal Instrument (TPAI) (Capie et al., 1979) and ratings from 1 to 5, 13 middle-school science classes were observed eight times each. Ratings were pooled over all observations, and results indicated that 11 of the performance variables were significantly correlated with student engagement rates. The correlations between ratings on the teacher performance variables and the rates of student engagement as reported by Tobin are given in Table 3.

The Instructional Environment Scale is experimental, but based on extensive studies by Tobin 11 of the 14 items on the original scale established high levels of correlation between teacher performance variables and student cognitive engagement. The Instructional Environment Scale used in this study is composed of the 11 items that showed high correlations, and three other items which replaced the three low-correlation items. The three items on the original scale

Table 3

Correlations Between Performance Variables on the IES and Student Cognitive Engagement

Variable	Correlation
1	.72
2	.63
3	.56
4	.62
5	.57
6	.58
7	.76[a]
8	.54
9	.65[a]
10[b]	.24
11	.57
12[b]	.17
13	.57
14[b]	.44

[a] $p < .01$, all others $p < .05$

[b] Items replaced with factors identified from other studies.

that were not highly correlated with student cognitive engagement were the following: teacher helps learners recognize the importance of activities (item #10), teacher uses instructional time effectively (item #12), and teacher manages disruptive behavior among learners (item #14). These three items were replaced with ones identified in studies by Blumenfeld and Meece (1988), Meece et al. (in press). The three items that were added were the following: teacher models cognitive strategy, teacher presses for wide student participation, and teacher presses for the student mastery of materials.

Pilot Study

With the support of the researchers involved in the overall model program for at-risk students, and the support of the teacher in the "Academic Enrichment" class, a hands-on, activity-based science program was implemented in the science "Academic Enrichment" class. In January 1989, prior to the implementation of hands-on activities, the 23 students in the model program completed the Children's Attitude Toward Science Survey and the SAQ. A hands-on, activity-based science instructional program was then implemented during the remainder of the school year in the science class which the at-risk students attended as the "Academic Enrichment." The content, pacing, sequencing, and activities were planned and coordinated with the model program teacher and the Teacher Handbook, Science K-12 (North Carolina Department of Public Instruction, 1985).

The model program teacher received science materials, supplies, and activities, assistance, demonstration teaching, and consultant support services in science during this semester. Additionally, the model program teacher implemented and used instructional environment factors that supported active cognitive engagement.

Beginning in March 1989, six student interns from the University of North Carolina at Greensboro (UNCG) were recruited to assist in this project. The interns attended three training sessions and served as classroom observers and interviewers. Six students in the model classes were identified as a sample to be observed and individually interviewed following specific hands-on science lessons. These six students included four males and two females of whom three were black and three were white students. The purpose for observing and documenting the behavior, attention, and answers of these six students was to validate the use of the SAQ with at-risk, sixth-grade students. A high level of agreement was obtained between observer documentation of the student's engagement during class, and the student's reported engagement during the interview in response to the questions on the SAQ. As a result of the pilot study the slightly altered Children's Attitude Toward Science Survey was judged to be valid for use with at-risk students.

The UNCG interns also helped identify instructional environmental factors that encouraged active cognitive engagement and task mastery orientation in science activities. Each intern observed the assigned student during class making detailed notes on that student's participation, responses, attention, and interactions with the teacher and with other students. At the end of the science class, the intern then privately interviewed the observed student, orally administered the SAQ, asked questions about concepts covered during the lesson, and asked questions about the student's actions and responses during class. Through analysis of these notes, observations, and documented interviews, instructional environment factors that support active cognitive engagement were identified. All interviews were audio recorded, and responses were recorded on paper.

The means and standard deviations for the Children's Attitude Toward Science Survey are described in Table 4. Student attitude toward science was more positive after hands-on science instruction. Due to excessive absences and suspension, 11 of the students were not both pretested and posttested on the Children's Attitude Toward Science Survey.

Table 4

Children's Attitude Toward Science Survey (CATSS) (Pilot Study)

Condition	Mean	SD	*t*
Initial[a]	65.07	14.37	2.358
Final	73.29	12.36	

[a]*n* = 14 for both conditions

Note: Maximum score = 100.

Results of the *t* test for nonindependent samples showed that the means were significantly different at the 0.05 probability level. This means that hands-on, activity-based science appeared to foster a more positive attitude toward science on the part of the student. The qualitative responses to the open-ended question about students' attitudes toward science and science class were analyzed and subjected to content analysis using three categories for responses: (1) positive, (2) neutral, and (3) negative. Results of this analysis are indicated in Table 5. The qualitative responses indicated a more positive attitude toward science after hands-on science instruction.

Table 5

Content Analysis of Open-Ended Question on *CATSS* (Pilot Study)

Response	Initial	Final
Positive	9	12
Neutral	4	5
Negative	5	1

Note: *CATSS* is the *Children's Attitude Toward Science Survey*.

A summary of results for the pilot study using the *SAQ* is presented in Tables 6 and 7. Table 6 presents the results of the Goal Orientation Scale. The Task Mastery Goal Orientation of students increased from a mean of 3.15 to a mean of 3.26 during the period of

Table 6

Goal Orientation Scale (SAQ) (Pilot Study)

Orientation	Initial[a]	Final	Initial[b]	Final
Task Mastery	3.15	3.26	3.24	3.42
Ego/Social	2.56	2.71	2.28	1.89
Work Avoidant	2.45	2.60	1.94	2.16

[a] *n* = 16

[b] *n* = 6

the pilot study. The mean Task Mastery score was higher than that of the Ego/Social or Work Avoidant Scale. Table 7 presents the results of the Cognitive Engagement Scale of the SAQ. Both Active Cognitive Engagement (CE) and Superficial Cognitive Engagement decreased during the period of the study. Attempts were made to have all 23 students in the model program complete a pretest and posttest SAQ. However, many at-risk students are frequently absent from school, are often in "trouble" and in ISS or OSS. Complete data were obtained on only 16 students. The results from the sample of six students who were individually interviewed by the UNCG interns are also reported.

Meece et al. (1988) reported that students who had a high task mastery goal orientation had higher active cognitive engagement. Pilot study results supported this finding. The mean for Task

Table 7

Cognitive Engagement Scale (SAQ) (Pilot Study)

Type of Engagement	Initial[a]	Final	Initial[b]	Final
Active Cognitive	2.39	2.30	2.22	2.15
Superficial	1.69	1.61	1.33	1.27

[a]n = 16

[b]n = 6

Mastery Orientation increased during the period of the pilot study. One explanation for the lack of increase in active cognitive engagement could be the way in which the students in the model program were grouped. Each of the students in the model program was an identified at-risk student. These students have social and behavioral problems that could have contributed to the results obtained. By late spring of the school year, friction among students in the "Academic Enrichment" classes increased, and necessitated one student changing from the morning to the afternoon class. Student behavioral problems became more pronounced. In addition, as the year progressed students in the model program class began to perceive a more negative image of that class as being for students who were less able. Other students in the school also perceived the "Academic Enrichment" classes as being for low-achievers. This negative image could have contributed to the lack of increase in active cognitive engagement.

Based on the results of the pilot study, hands-on, activity-based science appeared to be effective when used with at-risk sixth-grade students. Student attitude toward science was more positive as determined by the Children's Attitude Toward Science Survey. Answers to the open-ended qualitative question at the end of this scale provided additional evidence to support the improved student attitudes toward science. The students in the model program class reported an initial task mastery orientation that was higher than expected. This could have been due to the structure of the model program. Results obtained from the Science Activity Questionnaire suggested that hands-on, activity-based science encouraged task mastery orientation. Results of the pilot study also indicated the necessity for using identified factors in the instructional environment that would encourage the student's active cognitive engagement.

Summary of the Pilot Study

Research suggests that hands-on, activity-based science instruction can be structured to provide successful learning experiences for at-risk students. By providing a supportive environment in which to conduct this instruction, student learning can be enhanced. The pilot study involved approximately 25 identified at-risk sixth-grade students. The instruments used in this study were validated during the pilot study. Instructional strategies and techniques, and instructional environment factors that supported and enhanced student learning, were tested and identified. Results of the pilot study suggested that hands-on, activity-based science instruction, when used with at-risk sixth-grade students, can effect changes in student attitude toward science and student goal orientation and cognitive engagement. Elements of a supportive instructional environment appear to enhance student learning and engagement.

Treatment of the Total Population

The population of this study was the sixth-grade students (n = 204) enrolled in the classes of four sixth-grade science teachers at Reidsville Middle School during the 1989-90 school year. This population had a subpopulation of 64 identified at-risk students, leaving 140 not at-risk students in these classes. One teacher in each team taught science to all the students on that team. Each of the four science teachers taught two classes of science each day. Because student groupings were used to place students in classes, the at-risk students were not evenly distributed between a teacher's two science classes. Each teacher, however, taught approximately the same total number of at-risk students. During the school year, the teachers were not aware of the identity of the at-risk students.

Prior to the start of the 1989-90 academic year, all sixth-grade science teachers at Reidsville Middle School were invited to attend a meeting during a teacher work day. The purpose of that meeting was to explain a proposed staff development program to be offered to the sixth-grade science teachers. The proposed staff development program would include providing the teachers with materials, supplies, and activities for teaching hands-on, activity-based science. Additionally, teaching behaviors and strategies that enhanced student learning and that facilitated the development of a supportive instructional environment, would be identified, described, and practiced. Furthermore, through staff development activities and individual sessions, the teachers who participated would receive training and practice in the methods and techniques. All sixth-grade science teachers were invited to participate in this program. Four of the sixth-grade science teachers volunteered to receive training and assistance in hands-on, activity-based science and participate in this study; one science teacher chose not to participate.

The five sixth-grade teaching teams were assigned students as shown in Table 8. The students were assigned to teams according to federal, state, and local guidelines (Student Placement Memo, Reidsville Middle School, 1989).

The teachers were assigned to the teams as indicated in Table 8. The science teacher on each team taught two classes of science each day. There were approximately 22-29 students in each class. Each teacher taught one class of science in the morning and one class of science after lunch period. Teacher A had approximately 20 years of teaching experience, and at the start of the study stated that she/he never used any hands-on activities. Teacher B had 30 years of teaching experience. Teacher C had two years of teaching experience, but had the strongest background in science, and used some hands-on activities and methods prior to the start of the study. Teacher D had

Table 8

Sixth-Grade Team Assignments

Team	Teacher	Class Grouping
1	C	1 AG[a]/ 1 Chapter I[b]
2	B	1 Regular[c]/ 1 LD and EMH[d]
3	A	2 Regular
4	D	1 Regular (some LD & EMH)/ 1 Chapter I
5[e]	E	1 AG/ 1 Chapter I

[a]AG = academically gifted

[b]Chapter I = students identified by federal guidelines

[c]Regular class includes academically high, medium and low students

[d]LD & EMH = learning disabled and emotionally handicapped students

[e]This team did not participate in the study.

been teaching for eight years but had very limited background in science.

In order to test the research hypothesis and to control for teacher effects, the students' first nine-weeks science grades were compared with the students' second nine-weeks science grades. In this way, students could each serve as their own control.

In the first nine weeks of school each of the participating teacher's science classes was observed a total of four times, and teachers were requested to keep a daily log of content covered, instructional format, and activities in science. Teachers were encouraged to use their "normal" teaching style. At the end of the first nine weeks, all sixth-grade students completed the Children's Attitude Toward Science Survey and the Science Activity Questionnaire. Student grades in science for the first nine weeks were also collected from the Student Information Management System (SIMS) director.

At the beginning of the school year the teachers participating in the study identified the content areas to be taught during each nine-week period. The participating teachers agreed to teach the same topics or chapters throughout the first two grading periods. During a teacher work day at the end of the first quarter, the teachers in the study participated in the staff development workshop on using hands-on methods and activities and in developing a supportive instructional environment. Additionally, during the second nine weeks of school the teachers participating in this study received science activities, materials and training weekly, consultant services, and demonstration teaching in their science classes, if requested. At the end of the second nine-week grading period all sixth-grade students were post-tested on the Children's Attitude Toward Science Survey and on the SAQ. Students' grades in science for the quarter were obtained from the SIMS director and were recorded.

Each teacher participating in the study was observed four times during the second nine-week period in order to determine ratings on the Instructional Environment Scale. The Instructional Environment Scale was used to compute a mean rating for each teacher by class.

Additionally, each teacher maintained a log of classroom activities in order to document that at least 20% of the weekly instructional time in science was used in hands-on, activity-based science.

In order to control for teacher effects within a teachers' classes, students were used as their own controls. Students were pretested and posttested using the Children's Attitude Toward Science Survey and the SAQ in order to test hypotheses 1-4 that hands-on, activity-based science would foster a more positive attitude toward science, would improve science achievement, and would encourage the development of a task mastery orientation and active cognitive engagement. Four separate dependent *t* tests by teacher were used with alpha set at 0.05 to test hypotheses 1-4.

Hypotheses

Hypothesis 1

At-risk sixth-grade students who receive hands-on science instruction will demonstrate a more positive attitude toward science as measured by the Children's Attitude Toward Science Survey, than they did prior to receiving hands-on science instruction.

Hypothesis 2

At-risk sixth-grade students who receive hands-on science instruction will demonstrate higher achievement in science, as measured by numerical grade average in science, than they did prior to receiving hands-on science instruction.

Hypothesis 3

At-risk sixth-grade students who receive hands-on science instruction will demonstrate a higher task-mastery goal orientation, as measured by the Goal Orientation Scale of the SAQ, than they did prior to receiving hands-on science instruction.

Hypothesis 4

At-risk sixth-grade students who receive hands-on science instruction will demonstrate more active cognitive engagement in science, as measured by the Cognitive Engagement scale of the SAQ, than they did prior to receiving hands-on science instruction.

To describe the impact of hands-on, activity-based science instruction provided with a supportive instructional environment on at-risk sixth-grade students, a series of factorial analyses of variance was conducted. These analyses compare differences between at-risk students and those students not at-risk. For these analyses of variance a simple, random sample by class of not at-risk students was drawn with numbers the size equivalent to the at-risk population.

Hypothesis 5

Teachers whose science classes have higher ratings on the Instructional Environment Scale will have higher student cognitive engagement in that class as measured by the Cognitive Engagement scale of the SAQ than teachers whose classes have lower ratings on the SAQ.

A descriptive analysis of the degree of supportive instructional environment, as measured by the mean score on the IES for that particular class, and the mean cognitive engagement of the students in the class was used. The degree to which a supportive instructional environment contributes to cognitive engagement of the class was tested tabulating the mean teacher rating by class on the Instructional Environment Scale with the class scores on the Cognitive Engagement Scale of the SAQ.

Summary

This chapter describes the method that was used in this study on the effects of hands-on, activity-based science instruction, provided in a supportive instructional environment, on the attitudes toward science, achievement in science, goal orientation, and cognitive engagement in science of at-risk sixth-grade students. An additional element of this study was a descriptive analysis comparing the degree of a supportive instructional environment of a classroom with the cognitive engagement of the students in the class. Because the experimental method involved intact classes in a middle school, data on all students in those classes, both at-risk and not at-risk, are included in this study.

The four sixth-grade science teachers who participated in this study also participated in staff development activities, which were designed to facilitate the implementation of hands-on, activity-based science. The staff development services included training in techniques and strategies identified as being components of a supportive instructional environment. Teachers in the study were provided with the materials, supplies, and activities needed to implement a hands-on, activity-based science program.

The design of the study was a pretest-posttest design with students acting as their own controls. The treatment lasted for nine weeks, the second quarter of the school year. The measures used in this study were the Children's Attitude Toward Science Survey (CATSS), the Task Mastery Goal Orientation Scale (TM) and the Active Cognitive Engagement Scale (CE) of the Science Activity Questionnaire (SAQ). An experimental scale that measured the instructional environment of the classroom, the Instructional Environment Scale (IES), was also used; a descriptive analysis of the degree of supportive instructional environment and the students' cognitive engagement will be found in Chapter IV. The CATSS contained one open-ended question that was completed by the students. Students' answers were analyzed qualitatively. The appropriate statistical test to use in this study was a *t* test to compare group means. The results of the analyses are described in the next chapter. Chapter V describes the summary, conclusions, discussion, implications, and recommendations for further research.

CHAPTER IV

ANALYSIS OF DATA AND RESULTS

Overview

The purpose of this chapter is to present the results of the study and to describe the analysis of the data. The five measures examined were (1) Children's Attitude Toward Science Survey, (2) the students' science grades, two scales of the Science Activity Questionnaire, (3) the Task Mastery scale and (4) Cognitive Engagement scale, and (5) the Instructional Environment Scale.

For the purposes of analysis, the resources of the Academic Computer Center at the University of North Carolina at Greensboro were used to calculate descriptive and summary statistics. The Statistical Consulting Center of UNCG and Dr. Grace Kissling of the Mathematics Department provided statistical assistance. The Statistical Package for the Social Sciences, Version X (SSPSX) was used for data analysis.

The identity of the at-risk students was obtained from computer files of a larger study which was identifying at-risk middle-school students in Reidsville City Schools (Strahan & O'Sullivan, 1989).

Table 9 summarizes the frequency of responses for the teachers, class periods, numbers of at-risk and not at-risk students, and class

Table 9

Student Risk Type by Teacher and Science Period

Teacher	Science Period	Group	Risk Type: Not At-Risk	Risk Type: At-Risk	Total
A	1	Regular	17	11	28
	2	Regular	21	4	25
B	1	LD & EMH	21	7	28
	2	Regular	20	6	26
C	1	AG	25	2	27
	2	Chapter I	8	16	24
D	1	Regular[a]	10	10	20
	2	Chapter I	18	8	26
Total				64	204

[a]This class had some LD and EMH students.

ability groupings. The science class period 1 was a morning science class for each teacher, and science class period 2 was after lunch for each teacher.

Each science class was composed of both at-risk and not at-risk students; however, the at-risk students were not evenly distributed among the classes. Teacher A taught two regular science classes, the morning class was composed of 28 students, 11 of whom were at-risk; this teacher's afternoon class had 25 students, four of whom were at-risk. Teacher B had seven at-risk students in class 1 and six at-risk students in class 2. Science class 1 of teacher C had the fewest number, two, of at-risk students. This class was a designated academically gifted (AG) class and contained 25 not at-risk students. The highest number of at-risk students was found in science class 2 of this same teacher, which was a Chapter I class. Science class 1 of teacher D was a regular grouped class composed of 10 at-risk and 10 not at-risk students. Science class 2 of teacher D was a designated Chapter I class and had eight at-risk and 18 not at-risk students.

The Children's Attitude Toward Science Survey (CATSS)

The CATSS was hand scored and tabulated and the results were checked. The responses to the open-ended question were tabulated and analyzed qualitatively.

For scoring purposes, if a student omitted one question on the CATSS, the response was scored as neutral, a numerical value of three. If a student did not complete the CATSS or omitted more than one response, that survey was not included in the data.

In order to analyze the open-ended question on the CATSS, responses were coded as positive, neutral, or negative, with classifications established from the results of the pilot study. If the open-ended question was not answered, a coding of neutral was assigned. The mean posttest scores from the CATSS are given in Table 10.

Table 10

Mean Posttest Scores of Student Attitude Toward Science by Teacher, Science Period, and Student Risk

Teacher	Science Period	Risk Type: Not At-Risk	Risk Type: At-Risk	Class Mean	Teacher Mean
A	1	72.3	69.0	71.0	70.6
	2	70.0	70.8	70.1	
B	1	67.9	62.1	66.5	69.8
	2	73.3	74.3	73.6	
C	1	70.4	77.5	71.0	73.9
	2	80.2	75.2	77.0	
D	1	73.4	77.5	75.5	71.5
	2	71.3	61.8	68.1	
Mean		71.5	71.0		71.4

The mean score for the not at-risk students was 71.5, while the mean score for the at-risk students was 71.0. Within classes, however, there was more variation of scores between the two groups. The highest mean scores for at-risk students were found in teacher C's morning class (only two at-risk students) and in class 1 of teacher D (10 at-risk students). Teacher means were as follows: teacher A, 70.6; teacher B, 69.8; teacher C, 73.9; and teacher D, 71.5.

The highest mean score for not at-risk students was in class 2 of teacher C; the mean for these students was 80.2. The lowest mean score for not at-risk students was class 1 of teacher B, with a mean of 67.9.

The posttest scores on the Children's Attitude Toward Science Survey were subjected to an analysis of covariance using the pretest attitude scores as the covariate. A significant two-way interaction was found between science teacher and science class period ($F(3,181) = 8.419$, $p < .001$); no other effects were significant. Since students were grouped in science classes, as described in Table 9, and the numbers of at-risk students were not evenly distributed among classes, interactions between science teacher and science class period are described. To describe this interaction of science teacher and science class period, Table 11 provides the means of all students' posttest attitude scores for each science teacher and class. For teacher A, the means were approximately the same for both science periods. For teachers B and C, the means were about six points higher for period 2, and for teacher D, the mean was about seven points lower for period 2 than for period 1.

The Children's Attitude Toward Science Survey contained one open-ended question. The answers to this question were subjected to content analysis. The responses were coded as negative, neutral, or positive. The results of the content analysis of this attitude toward science statement are indicated in Table 12. Student pretest attitude is coded with student posttest attitude in order to indicate attitudinal changes for each student. For teacher A, the attitudes of six not at-risk students changed from negative on the

Table 11

Mean Student Attitude Toward Science by Teacher and Science Period

	Science Period			
	1		2	
Teacher	n	Mean	n	Mean
A	27	71.0	25	70.1
B	27	66.5	23	73.6
C	25	71.0	22	77.0
D	20	75.4	25	68.1
Mean		70.6		72.1

Note: The number of students for whom pretest and posttest scores were obtained is indicated by n.

pretest to positive on the posttest, and 20 not at-risk students were positive on both pretest and posttest. Twelve of the at-risk students for teacher A had positive attitudes on both the pretest and posttest, one at-risk student changed from a negative pretest attitude to a positive posttest attitude.

Twenty-one not at-risk students in teacher B's classes indicated positive attitudes on both pretest and posttest, seven not at-risk students showed a change from a neutral to a positive attitude, and one not at-risk student changed from negative to positive attitude. Seven at-risk students in teacher B's classes indicated positive pretest and posttest attitudes, while one student changed from a positive to a negative attitude, and one student remained negative on both pretest and posttest.

Table 12

Content Analysis of Open-Ended Question on Children's Attitude Toward Science Survey (CATSS) by Teacher and Risk Type

		Not At-Risk Students				At-Risk Students		
		Posttest Attitude				Posttest Attitude		
		Negative	Neutral	Positive		Negative	Neutral	Positive
Teacher A								
Pretest Attitude	Neg	2	2	6	Neg	0	0	1
	Neu	1	1	4	Neu	0	1	0
	Pos	0	2	20	Pos	0	1	12
				n = 38				n = 15
Teacher B								
	Neg	1	0	1	Neg	1	1	0
	Neu	2	1	7	Neu	0	1	2
	Pos	1	6	21	Pos	1	0	7
				n = 40				n = 13
Teacher C								
	Neg	1	2	0	Neg	0	1	0
	Neu	3	1	5	Neu	1	2	0
	Pos	1	0	18	Pos	0	1	13
				n = 31				n = 18
Teacher D								
	Neg	1	1	3	Neg	0	1	1
	Neu	0	1	4	Neu	2	1	5
	Pos	1	3	12	Pos	0	2	6
				n = 26				n = 18

Eighteen of the not at-risk students in the science classes of teacher C indicated positive pretest and posttest attitudes, five not at-risk students changed from neutral to positive attitudes, and the attitudes of three students changed from neutral to negative, and one student changed from positive to negative. Thirteen at-risk students in teacher C's classes indicated positive pretest and posttest attitudes, and only two at-risk students' attitudes moved in a negative direction.

Twelve not at-risk students in the classes of teacher D indicated positive attitudes on both pretest and posttest, the attitudes of four students changed from neutral to positive, and the attitudes of three students changed from negative to positive. Six at-risk students in teacher D's classes remained positive in attitudes toward science, five at-risk students changed from a neutral to a positive attitude, and one at-risk student moved from a negative to a positive attitude. Overall, most at-risk and not at-risk students indicated a positive attitude toward science based on the content analysis of the open-ended question.

The result of the paired *t* test for the variable attitude toward science is given in Table 13. There was no significant difference in attitude toward science. Hypothesis one was not supported by the data.

Student Achievement in Science

Student grades in science were obtained from the SIMS office of Reidsville Middle School as a computer printout. Student grades were included only for students who attended Reidsville Middle School for the first two quarters of the 1989-90 school year. Mean second quarter grades in science are given in Table 14.

Table 13

Results of the Paired t Tests Comparing Pretest and Posttest Means for At-Risk Students' Attitude Toward Science

Variable[a]	Mean	SD	Paired t Value	Degrees Freedom	p Value
Pretest					
Attitude	69.6	9.6			
Posttest			1.03	62	.305
Attitude	71.0	10.4			

[a]n = 63

The means by teacher for science grades, ranged from a low of 79.1 for teacher B, to a high of 84.9 for teacher A. For teacher A, the mean for not at-risk students in class 1 was 85.1, while that of the at-risk students was 76.1; for class 2, the not at-risk mean was 89.0, and the at-risk mean was 87.5. The mean scores for class 1 of teacher B were 78.4 for the not at-risk students, and 75.4 for the at-risk students. Class 2 for teacher B had a mean not at-risk score of 82.0, and an at-risk mean of 76.7. For teacher C, the not at-risk mean for class 1 was 88.8, and the at-risk mean was 92.5. Class 2 for teacher C had means of 86.6 for the not at-risk and 71.8 for the at-risk students. In science teacher D's class 1, the mean not at-risk grade was 78.9, while the mean at-risk grade was 79.2. The not at-risk students in class 2 for this teacher had a mean of 87.4, and the at-risk students had a mean of 76.9.

Table 14

Mean Second Quarter Science Grades by Teacher, Science Period, and Student Risk Type

Teacher	Science Period	Risk Type Not At-Risk	At-Risk	Class Mean	Teacher Mean
A	1	85.1	76.1	81.6	
	2	89.0	87.5	88.7	84.9
B	1	78.4	75.4	77.6	
	2	82.0	76.7	80.7	79.1
C	1	88.8	92.5	89.1	
	2	86.6	71.8	76.8	83.3
D	1	78.9	79.2	79.1	
	2	87.4	76.9	84.2	82.0
Mean		84.8	76.8		82.3

In six of the eight science classes the mean grade for the at-risk students was lower than the mean grade for the not at-risk students.

The results of the paired *t* test for the variable science grades are given in Table 15. The paired *t* test value on the students' science grades was significant ($t(63) = -2.77$, $p < .007$) but in the opposite direction of that expected. Students' science grades decreased during the second quarter of the school year.

An analysis of covariance on the students' grades in science, with the first quarter science grade being used as the covariate,

Table 15

Results of the Paired t Test for At-Risk Students' Science Achievement

Variable[a]	Mean	SD	Paired t Value	Degrees of Freedom	p Value
1st Quarter					
Grade	79.9	8.6	-2.77	63	.007
2nd Quarter					
Grade	76.8	11.0			

[a]n = 64

revealed main effects of teacher and risk as listed in Table 16. All other effects were not significant. There was a significant difference in the mean science grade across teachers ($F(3,187) = 3.013$, $p = .031$). The mean for all students for each teacher was as follows: teacher A (84.9), teacher B (79.1), teacher C (83.3), and teacher D (82.0). The mean for teacher B was significantly lower than that of the other three teachers. The two risk groups were significantly different on mean science grades at the end of the second quarter ($F(1,187) = 7.301$, $p = .008$), with the mean grade for all at-risk students being lower (76.8) than the mean grade for all the not at-risk students (84.8). Hypothesis two was not supported by the data.

Table 16

ANCOVA of At-Risk Students' Second Quarter Grades in Science

Main Effects	Degrees of Freedom	F	p
Teacher	3, 187	3.013	.031
Risk	1, 187	7.301	.008

Student Goal Orientation

The mean posttest scores for student task mastery orientation are given in Table 17. These scores were obtained from the Task Mastery Scale of the SAQ. For teachers A, C, and D, the mean posttest Task Mastery scores were higher for the not at-risk students than for the at-risk students. The at-risk students in the classes of science teacher B had higher TM means than those of the not at-risk students. Teacher B had the lowest teacher mean at 3.05, while teacher means for teachers A, C, and D were 3.08, 3.45, and 3.34, respectively. The mean for not at-risk students was 3.23, while the mean for at-risk students was 3.21. However, the means for teachers C and D were significantly higher than the means for teachers A and B.

The result of the paired t test for the variable task mastery orientation (TM) is given in Table 18. Students' task mastery orientation increased significantly after hands-on science instruction ($t(60) = 3.57$, $p = .001$). Hypothesis three was supported by the data.

Table 17

Mean Posttest Task Mastery Scores by Teacher, Science Period, and Student Risk

Teacher	Science Class	Risk Type: Not At-Risk	At-Risk	Class Mean	Teacher Mean
A	1	3.22	3.09	3.17	
	2	3.04	2.72	2.99	3.08
B	1	2.94	3.12	2.98	
	2	3.02	3.57	3.13	3.05
C	1	3.46	2.99	3.42	
	2	3.75	3.35	3.49	3.45
D	1	3.41	3.40	3.40	
	2	3.40	3.04	3.28	3.34
Mean		3.23	3.21		3.22

The result of the analysis of covariance on the posttest Task Mastery (TM) scores using the pretest Task Mastery scores as covariate revealed two significant two-way interactions; all other effects were not significant. The interaction of teacher and class was $F(3,180) = 3.347$, $p = .020$ and the interaction of teacher and risk was $F(3,180) = 3.587$, $p = 0.15$. The results of this analysis are given in Table 19.

Table 18

Results of the Paired *t* Test for Task Mastery (TM) Orientation for At-Risk Students

Variable[a]	Mean	SD	*t* Value	Degrees of Freedom	*p* Value
Pretest TM	2.98	.54	3.57	60	.001
Posttest TM	3.21	.46			

[a]*n* = 61

Table 19

ANCOVA of Task Mastery Scores for At-Risk Students

Two-Way Interactions	Degrees of Freedom	*F*	Significance
Teacher X Science Period	3	3.347	.020
Teacher X Student Risk[a]	3	3.000	.015

[a]Student risk type was either not at-risk or at-risk.

To describe these interactions, the means for the interactions of teacher and class period are given in Table 20, and the means for teacher and risk groups are given in Table 21.

Table 20

Task Mastery Means by Teacher and Science Period

	Science Period			
	1		2	
Teacher	n	Mean	n	Mean
A	28	3.17	25	2.99
B	28	2.98	24	3.13
C	25	3.42	22	3.49
D	20	3.40	25	3.28
Total	101	3.23	96	3.22

The means for teacher and class period given in Table 20 show a decline in task mastery means from the morning to the afternoon for both teachers A and D, while for teacher C the means were approximately the same for both classes, and the class means for teacher B were higher in the afternoon class. The task mastery means for the interaction of teacher and risk group, as given in Table 21, were higher for the not at-risk group in the classes of teachers A, C, and D; in contrast, the at-risk students in teacher B's classes had a higher task mastery orientation.

Table 21

Task Mastery Means by Teacher and Student Risk

	Student Risk			
	Not At-Risk		At-Risk	
Teacher	n	Mean	n	Mean
A	38	3.12	15	2.99
B	40	2.97	12	3.31
C	31	3.53	16	3.30
D	27	3.40	18	3.24
Total	136	3.23	61	3.21

Student Cognitive Engagement

The mean cognitive engagement scores by teacher are given in Table 22. These scores were obtained from the Cognitive Engagement scale of the SAQ. The mean cognitive engagement (CE) score for not at-risk students was 2.45, while the mean CE score for the at-risk students was 2.37. Teacher means ranged from a low of 2.36 for teachers A and B, to a high of 2.53 for teacher C. Teacher D had a mean of 2.47.

The result of the paired *t* test for cognitive engagement is given in table 23. Mean cognitive engagement of the students increased significantly after hands-on science instruction ($t(59) = 2.45$, $p = .017$). Hypothesis four was supported by the data.

Table 22

Mean Posttest Cognitive Engagement Scores by Teacher, Science Period, and Student Risk

Teacher	Science Period	Student Risk Type: Not At-Risk	At-Risk	Class Mean	Teacher Mean
A	1	2.45	2.32	2.41	
	2	2.32	2.21	2.30	2.36
B	1	2.36	2.34	2.35	
	2	2.31	2.52	2.36	2.36
C	1	2.62	2.56	2.61	
	2	2.69	2.29	2.44	2.53
D	1	2.50	2.47	2.49	
	2	2.48	2.42	2.46	2.47
	Mean	2.45	2.37		2.42

An analysis of covariance on the posttest cognitive engagement scores using the pretest cognitive engagement scores as the covariate yielded two significant main effects for teacher and class; no other effect was significant. The $\underline{F}$ statistic for main effect for teacher was $F(3,177) = 3.244$, $\underline{p} < .023$ and the main effect for class was $F(1,177) = 5.022$, $p < .026$. The means for teachers were as follows: teacher A (2.36), teacher B (2.36), teacher C (2.53), and teacher D

Table 23

Results of the Paired _t_ Test for Student Cognitive Engagement (CE) Scores for At-Risk Students

Variable[a]	Mean	SD	Paired _t_	Degrees of Freedom	_p_
Pretest CE	2.24	.48			
			2.45	59	.017
Posttest CE	2.37	.42			

[a] _n_ = 60

(2.47). The cognitive engagement score for the morning science classes was 2.46 and for the afternoon science classes was 2.39.

Summary of Hypotheses One Through Four

The results of the paired _t_ tests for all four variables are given in Table 24. Results of the study did not support hypothesis one that hands-on activity based science instruction would improve at-risk students' attitudes toward science. Hypothesis two that at-risk students' achievement in science as measured by grades would improve after hands-on, activity-based science instruction was rejected. Student grades in science decreased during the period of the study. Hypothesis three, that at-risk students' task mastery goal orientation would improve during hands-on, activity-based science instruction was supported by the results of the study. Hypothesis

Table 24

Summary of the Paired *t* Tests Comparing Pretest and Posttest Means for Four Variables for At-Risk Students

Variable	Mean	SD	Paired *t*	Degrees of Freedom	*p*
Pretest Attitude[a]	69.6	9.6			
Posttest Attitude	71.0	10.4	1.03	62	.305
1st Quarter Science Grade[b]	79.9	8.6			
2nd Quarter Science Grade	76.8	11.0	-2.77	63	.007
Pretest Task Mastery[c]	2.98	.54			
Posttest Task Mastery	3.21	.46	3.57	60	.001
Pretest CE[d]	2.24	.48			
Posttest CE	2.37	.42	2.45	59	.017

[a] $n = 63$

[b] $n = 64$

[c] $n = 61$

[d] $n = 60$

Note: CE stands for cognitive engagement.

four, that at-risk students' cognitive engagement in science would increase after hands-on, activity-based science instruction was supported by the data.

Instructional Environment

The instructional environment for teacher and science class was calculated from the mean rating on the Instructional Environment Scale (IES). Each teacher's class was rated four times using IES, a mean score determined for each of the two science periods, and an overall mean for the teacher. The highest possible mean rating was 5.0, and scores on items ranged from one to five. The mean ratings for the IES by teacher and class period are given in Table 25. Two teachers, C and D, had a class rating of more than three, which was taken to indicate a positive classroom environment. One teacher, B, had a rating below two for one class period.

The instructional environment in the classrooms of teachers C and D as determined by the mean score on the IES was more supportive than that of teachers A and B.

Descriptive Analyses of Science Classes

A descriptive analysis of each teacher's classroom climate follows. Each of the two science classes taught by the four teachers was observed four times prior to the treatment and at least four times during the study. Descriptive narratives and observations were made of the classes. The following descriptions are compiled from these narratives and observations.

Table 25

Mean Ratings on the Instructional Environment Scale (IES) by Teacher and Science Period

Teacher	Science Period	Rating	Teacher Mean
A	1	2.77	
	2	2.16	2.47
B	1	2.18	
	2	1.86	2.02
C	1	3.34	
	2	2.80	3.07
D	1	3.05	
	2	2.69	2.87

Teacher A

This teacher was a black male in his 40s with 20 years of teaching experience. He was well-respected by the students and teachers and maintained good control of student behavior in his classes. In statements made prior to the start of this study, the teacher acknowledged that he never used hands-on activities in his science classes, with the exception of occasionally using microscopes. He expressed concern about the at-risk students in his classes, and his desire to be able to teach them more effectively. His method of teaching was to follow the textbook using silent and oral readings.

He was quite adept at questioning students. This teacher had a quiet manner, and rarely raised his voice. His classroom was relatively bare and did not contain charts, pictures, or objects relating to science.

This teacher was the slowest in implementing the hands-on teaching strategies and activities, since his teaching style had been quite different. However, at the conclusion of the study, this teacher was the most enthusiastic and the most positive about the effects of using the hands-on approach with his students. After using the hands-on approach for four weeks, this teacher stated that he was observing differences in his students from using the hands-on science. This teacher exhibited the greatest change in teaching style and strategies during the period of the study. He continued to use the hands-on activities through the remainder of the school year. His classroom changed from bare walls and boards, to one that contained many charts, objects, and science-related items.

Teacher B

This teacher was a black female, approximately 60 years old, with 30 years of teaching experience. She used a variety of teaching strategies in her science classes, including reports, charts, pictures, and oral reports. Her room was very colorful and contained many science charts, objects, an aquarium, books, and microscopes. She was willing to try new approaches but had very poor control of her class, and as the school year progressed, student behavior in her classes deteriorated and became a severe problem that interfered with teaching.

This teacher displayed willingness to try the new approaches and activities, but did not organize the materials and students in a manner that allowed her to implement these activities successfully in her classroom. She requested frequent demonstration teaching from this researcher. She would often try to implement activities or lessons without being adequately prepared. The student behavior in her classes became such a problem during the second nine weeks that she and her team partner and the assistant principal implemented a strict discipline procedure. This strict procedure did not result in improved behavior in her classes. The teacher with whom she teamed taught the same students, but reported few behavior problems with these same students. This teacher, while willing to try new approaches, was not able to manage the classroom or student behavior, and was rarely successful in implementing an activity with success.

Teacher C

This teacher was a white female in her second year of teaching. She was about 40 years old. She had a strong interest in science, and at the beginning of the study reported that she used some hands-on science activities in her classes. This teacher's classroom was filled with a variety of charts, graphs, posters, and science-related objects. The student ability groupings for her team included one academically gifted (AG) class and one Chapter I class. This teacher reported some difficulty with student behavior in her Chapter I class. She was eager to learn more hands-on activities and techniques.

During the nine-week period of the study, this teacher easily implemented many of the new techniques and strategies into her science classes. This approach was one with which she was familiar and felt comfortable. She improved her control of student behavior in her classes, and consistently maintained the best control of her classes. She did not rely exclusively on the book. Immediately after this study began, this teacher decided to obtain certification for teaching gifted students and began taking other courses leading toward that AG certification. Her interest in AG students and techniques increased, and she lost interest in learning and practicing techniques particularly geared toward reaching the at-risk or lower-ability student. She successfully implemented the changes in her AG class, and with somwhat less success in the Chapter I class.

Teacher D

This teacher, a white female about 45 years old, had eight years of teaching experience. She had the weakest science background, but had the most experience in working with at-risk students. The previous year she had been the model program teacher for two classes of at-risk students. During the first nine weeks of school, she did not use any hands-on activities in her science classes. She was well-respected and well-liked by students and staff. Her room contained a variety of posters, charts, graphs, and pictures relating to science, student behavior, math, and other topics. She had some problems with student behavior, usually limited to three or four students in each of her classes. She was enthusiastic, varied her teaching styles and strategies, and was interested in working with at-risk students.

During the period of the study, this teacher successfully implemented many hands-on activities in her classes. She requested occasional demonstration teaching, especially on topics with which she felt least comfortable. During the period of this study, student behavior of about four students became a significant problem in her afternoon science class. Teacher D asked for help from the assistant principal and implemented new discipline procedures in her classroom which helped to alleviate some of the problem. Overall, she quite successfully implemented the procedures and techniques and at the end of the study stated that she felt there were positive benefits towards using this approach. She identified several students in whom she noticed positive changes in attitude and attention during the course of using the hands-on science activities.

Hypothesis Five

Teacher ratings on the IES and the students' posttest cognitive engagement means are given in Table 26. For teachers A, C, and D the mean cognitive engagement score for all students was higher in the classes which had a higher IES rating. For teacher B, the total class' cognitive engagement score was about the same for both classes, and this teacher had the lowest mean IES rating.

When the risk groups were analyzed separately, for teachers A, C, and D, the at-risk students had a higher mean cognitive engagement score in the class in which the IES score was higher. In contrast, for teacher B the mean cognitive engagement score was higher in the class which had the lower IES rating.

The not at-risk students had a higher mean cognitive engagement in the class which had the higher IES rating for teachers A, B, and D. For teacher C, the not at-risk students had a higher cognitive engagement mean in the class which had the lower IES rating. The mean cognitive engagement for the morning classes across teachers was higher (2.46) than the mean for the afternoon classes (2.39).

The criterion for a supportive instructional environment was a rating of 3.0 or higher on the IES scale. Two science classes were found to have a supportive instructional environment, teacher C, period 1 and teacher D, period 1. The students in those two classes had the highest mean cognitive engagement scores. The CE for period 1 of teacher C was 2.61, with the IES rating of 3.34 and the CE mean for period 1 of Teacher D was 2.49, and the IES rating was 3.05. In general, a trend could be identified that the higher ratings on the Instructional Environment Scale corresponded with higher ratings of student cognitive engagement; lower ratings on the IES corresponded with lower student cognitive engagement scores. Teachers whose science classes have higher ratings on the IES have higher mean student cognitive engagement as measured by the CE scale, than teachers whose science classes have lower ratings on the IES. Hypothesis five was supported by the data.

Table 26

Means of the Instructional Environment Scale (IES) Rating and Student Cognitive Engagement (CE) by Teacher and Student Risk

		CE Student Risk Type					
		Not At-Risk		At-Risk			
IES Mean	CE Class	n	Mean	n	Mean	Teacher	Science Period
3.34	2.61	23	2.62	2	2.56	C	1
3.05	2.49	10	2.50	10	2.47	D	1
2.80	2.44	8	2.69	14	2.29	C	2
2.77	2.41	17	2.45	10	2.32	A	1
2.69	2.46	17	2.48	8	2.42	D	2
2.18	2.35	20	2.36	7	2.34	B	1
2.16	2.30	21	2.32	4	2.21	A	2
1.86	2.36	18	2.31	5	2.52	B	2

Summary of Analysis of Data

Based on the evidence presented in this study, hands-on, activity-based science instruction does not appear to have any significant effect on at-risk students' attitude toward science. This evidence would suggest that hands-on, activity-based science instruction does not have a positive effect on at-risk students' grades in science, since there was a significant decrease in students' science grades during the second quarter.

Hands-on, activity-based science instruction did have a significant effect on the task mastery orientation of at-risk students and on at-risk students' cognitive engagement in science, with both task mastery and cognitive engagement in science having statistically significant increases during the period of the study. Based on total student cognitive engagement means, both not at-risk and at-risk students, and the instructional environment of the classroom when rated on the IES, it appears that a more positive instructional environment in the classroom encourages higher student cognitive engagement as measured by the CE scale.

This chapter presented the data analyses for this study. Based on the information and analyses, hypothesis one and two were not supported, while hypothesis 3, 4, and 5 were supported by the data. The summary, conclusions, discussion, implications, and recommendations are found in Chapter V.

CHAPTER V

SUMMARY, CONCLUSIONS, DISCUSSION, IMPLICATIONS, RECOMMENDATIONS, AND FINAL SUMMARY

Summary of the Study

This study investigated the effects of hands-on, activity-based science used with sixth-grade students. The study examined the effects of this approach to science instruction on the at-risk students in the sixth-grade science classes at one middle school which had a high percentage of at-risk students. Since the study was conducted using intact science classes that contained both at-risk and not at-risk students, and since data from the not at-risk students were needed for hypothesis five, the data from all students in the intact classes are included. Four of the five sixth-grade science teachers and their students participated in the study. Data on students' attitudes toward science, achievement in science, task mastery orientation, and cognitive engagement in science were collected and analyzed.

An additional aspect of the study was that of rating the instructional environment of a science classroom. The instructional environment of the classroom and the cognitive engagement of the students in that classroom were compared.

Staff development services were supplied to the teachers who participated in the study in order to provide the materials, supplies, and activities needed to implement hands-on, activity-based science instruction. An additional purpose of the staff development was to provide the teachers with training in methods and techniques that would enhance the development of a supportive instructional environment.

The data collected and analyzed during this study indicated that the use of hands-on, activity-based science instruction did increase both the task mastery orientation and the cognitive engagement of at-risk students in science class. The data indicated no significant difference in students' attitude toward science. A decrease in students' science grades was observed during the period of the study. The comparison of the instructional environment of the classroom and student cognitive engagement indicated that in general, the higher the rating of the instructional environment of the classroom the higher the cognitive engagement of the students in that classroom.

Educators concerned with the high number of at-risk students in North Carolina and across the United States search for new programs, strategies, and methods of reaching these students. This study suggests that in science, the hands-on, activity-based approach can lead to improved student performance in the areas of task mastery orientation and cognitive engagement.

Conclusions

The following hypotheses were the focus of this study.

Hypothesis 1

At-risk sixth-grade students who receive hands-on science instruction will demonstrate a more positive attitude toward science as measured by the Children's Attitude Toward Science Survey than they did prior to receiving hands-on science instruction.

This hypothesis was not supported by the data. There was no statistically significant increase in students' attitudes toward science, although students' attitudes toward science did not decrease either. Teachers involved in the study reported several perceptions that might have explained some portion of these results. Each of the teachers expressed concerns regarding discipline. The teachers reported that they had been requested to handle discipline and behavior problems within the class setting rather than sending students to the office. The teachers reported that they felt a lack of support from the administration. Student behavior deteriorated and became a severe problem during the second quarter of the school year. Individual teachers attempted to handle disruptive behaviors within their classrooms in different ways. According to the teachers, the overall climate within the school became negative as problems continued to increase. It is possible that the negative school climate contributed to the lack of increase in students' attitudes toward science.

Hypothesis 2

At-risk sixth-grade students who receive hands-on science instruction will demonstrate higher achievement in science, as measured by numerical grade average in science, than they did prior to receiving hands-on science instruction.

This hypothesis was not supported by the data and was rejected. A decrease in student grades in science was documented during the time of the study. One factor which might have contributed to the decline in students' grades in science was that of the nature of the science content during the period of this study. During the first nine-week grading period, the content covered during science was familiar to most students. The first quarter, according to the teachers, was seen as a time for review and establishing classroom procedures, with less emphasis being placed on mastery of new material. The science content for the first quarter was the study of animals. This was familiar material not only to the students but also to the teachers. At the beginning of the school year, the teachers requested that the content for the second nine weeks deal with the topics of matter, physical and chemical changes, and energy. The teachers indicated that these topics were the ones with which they needed the most help, and felt the least confident about teaching. In addition, the teachers stated that the students were probably less familiar with this material than with the study of animals. The difficulty and newness of the material to the students could explain the decrease in grades during the second quarter. Furthermore, it had been noted that student grades declined from the first to the second grading period for sixth-grade students, according to the data collected from the previous year on sixth-grade students.

Hypothesis 3

At-risk sixth-grade students who receive hands-on science instruction will demonstrate a higher task mastery goal orientation as measured by the Goal Orientation scale of the Science Activity Questionnaire (SAQ), than they did prior to receiving hands-on science instruction.

This hypothesis was supported. The Task Mastery (TM) goal orientation of the at-risk students showed a statistically significant increase during the study.

Hypothesis 4

At-risk sixth-grade students who receive hands-on science instruction will demonstrate more active cognitive engagement in science, as measured by the Cognitive Engagement (CE) scale of the Science Activity Questionnaire (SAQ), than they did prior to receiving hands-on science instruction.

This hypothesis was supported by the data. Hands-on science instruction resulted in improved at-risk students' cognitive engagement scores as measured by the Cognitive Engagement scale of the SAQ.

Hypothesis 5

Teachers whose science classes have higher ratings on the Instructional Environment Scale (IES) will have higher student cognitive engagement (for all students in the class, at-risk and not at-risk) as measured by the Cognitive Engagement scale of the SAQ, than teachers whose classes have lower ratings on the Instructional Environment Scale.

This hypothesis was supported by the data. A descriptive analysis of the data revealed that the highest ratings on the Instructional Environment Scale corresponded with the highest mean cognitive engagement scores. The three classes with the lowest mean instructional environment ratings had the lowest mean student cognitive engagement scores. Based on this data, it appears that elements of a supportive instructional environment can enhance students' cognitive engagement. At the beginning of the school year and for the first nine-week period, three of the teachers used no hands-on methods or activities. One teacher used a few hands-on activities during that period. During the second nine weeks all four teachers in the study used hands-on, activity-based science instruction.

Discussion

This study was conducted during the first two quarters of the 1989-90 school year at Reidsville Middle School. The study was dependent upon the voluntary cooperation and level of commitment to the study of the participating science teachers. Several circumstances during the course of the study that might have affected the results included the following

1. A new superintendent for the school system was installed immediately prior to the start of the 1989-90 school year.

2. Each of the teachers involved in the study reported serious concerns regarding students' behavior and discipline. The teachers reported that this was an unusually unsettled time in the school. The teachers reported that a number of approaches were tried to alleviate students' discipline problems.

3. Immediately following the second quarter of the school year, the assistant principal at Reidsville Middle School was promoted to co-principal, and a new assistant principal was added. According to teachers, these changes were made by the administration of the school system in an attempt to improve discipline and alleviate other problems.

4. Teachers who participated in the study varied in their level of commitment to practicing and implementing the strategies, techniques, and methods of the hands-on, activity-based science and the elements of a supportive instructional environment. Additionally, individual teachers varied in the level of commitment to each of their two science classes. Student groupings were different for each science class, with one class being an identified Academically Gifted class, and two other classes being identified as Chapter I classes. The groupings of students or the teacher's response to students in a particular group could have influenced and affected various aspects of this study.

In order to test the research hypotheses in this study, it was necessary for the teachers to "teach in their normal manner" for the first nine weeks of the school year. No attempt was made to influence any teacher's style, strategies, or techniques. The teachers were asked to teach the same content area during that time. The students completed the pretest of the Children's Attitude Toward Science Survey and the SAQ at the end of the first nine weeks. All measures used in this study were given in the science class period by the regular science teacher. All teachers read the directions, the questions, and the answer choices to the class.

The teachers in the study varied in the length of time necessary to implement the hands-on, activity-based science in their classrooms. Teachers reported varying levels of difficulty in implementing these changes, especially in classes in which discipline was a problem. As the school year progressed, student behavior and discipline deteriorated, and both administrators and staff reported that the problems with behavior and discipline during the first half of this school year were greater than at any other time during the last few years.

One problem with the design of this study was that due to time constraints of the school calendar, the teachers involved in the study were able to attend only a brief workshop which introduced hands-on, activity-based science activities and strategies. During the initial workshop meeting, elements of a supportive instructional environment were identified and discussed. Teachers were given suggested techniques to use in implementing the elements of the supportive instructional environment in their science classes; these techniques and strategies were practiced and discussed throughout the time period of the study. The teachers were provided with weekly staff development services, weekly workshops, demonstration teaching when desired, and all equipment and supplies needed for the various activities. At the conclusion of the study, the teachers indicated that a more useful approach would have been daily workshops for three or four days prior to the start of implementing these changes. It was not possible to provide for this within the framework of the school calendar.

As teachers vary, so do the levels of control of the classroom and of student discipline. During observations of the science classes, it was noted that the classes in which the teacher had the poorest control of student discipline and behavior were the classes in which the hands-on, activity-based strategies were least successfully implemented. One teacher, in particular, increasingly lost control of classroom behavior and discipline as the study progressed. The students in the class of that teacher had the lowest mean score on attitude toward science and task mastery goal orientation. The mean science grade for students in that teacher's classes was lower than that of the other classes. In addition, the mean rating of the instructional environment for that teacher was significantly lower than that of the other three teachers in the study.

In examining the data obtained on the Children's Attitude Toward Science Survey, it was noted that while attitude did not improve during the time of the study, neither did the students' attitude toward science decrease. Several studies (James & Smith, 1985;

Simpson & Oliver, 1985) have documented sharp declines in students' attitude toward science from the beginning to the middle of a school year, and have documented that this decline is most marked between the sixth-grade and seventh-grade. Since this study involved sixth-grade students being tested on students' attitude during the first part of the school year, a decline in students' attitude toward science might possibly have been expected. However, since the attitude of the students in this study did not decrease, this might suggest that the hands-on, activity-based science instruction did have a positive effect on students' attitude toward science.

An alternative explanation for the lack of increase in student attitude toward science might be found by examining the disciplinary problems that became pronounced during the second quarter of the school year at this school. The climate of the school was affected by these problems, according to teachers and administrators. The teachers reported that these problems peaked during the second quarter of the school year, and as they attempted to "clamp down" and control the discipline and behavior of the students, the students' attitudes toward any facet of school life might have been affected. These two explanations either acting independently or together could explain the lack of improvement in the students' attitude toward science. Also, these discipline and behavior problems could have affected the instructional environment of the classroom. It is possible that without the unusual behavior and discipline problems the instructional environment in many of the science classes would have been more positive.

Measuring student achievement in science presented a challenging problem. North Carolina has a state-mandated competency-based curriculum for science. At the present time, the state-mandated test given in the sixth grade covers the competencies for grades four through six. There is no test available that covers only sixth-grade science curriculum. Since many of the competencies found in the state-mandated curriculum were not covered in the state adopted sixth-grade science books, a textbook test would not have been an appropriate choice to measure students' achievement in science. In addition, the teachers involved in the study reported that they were not willing to develop and use a common test for all students. An additional factor that contributed to the problem of identifying a measure for science achievement is that of measuring process skills. In considering these elements, it was felt that the "best" measure of student achievement in science would be the numerical science grade at the end of the quarter. That this was not a good measure of achievement is acknowledged, but was the best one available under the conditions of the study. Teachers involved in the study were not aware until the end of the 1989-90 school year that grades were being used to measure science achievement.

The teachers indicated that the tests given in science were primarily concerned with content. The teachers viewed the hands-on activities as a means of increasing students' interests and attitudes, and as a way of increasing students' understanding of the science content being taught. Science achievement, according to the teachers was based on a combination of factors including homework assignments, reports, class participation, and science tests. Teachers initially reported some initial difficulty in designing and structuring science tests during the time of the study, as the teachers attempted to include a few questions concerning science processes and activities. This difficulty could have resulted in tests that were not accurate measures of students' achievement in science. An additional factor that might have contributed to the decline in student grades was the nature of the material covered during the first two quarters. During the first quarter of the school year, all science teachers covered the study of animals. This topic was familiar to the students, and might have been "old" information and review rather than new material. The students were probably less familiar with the material covered during the second nine weeks and did not have the background and knowledge base in this material. The content covered during the second nine weeks included the topics matter, physical and chemical changes, and energy. To the students this material may have been much less familiar and perceived as "harder" than the material covered during the first nine weeks.

One of the problems that was observed during the course of this study was that the participating teachers varied in their level of commitment to the use of the instructional strategies and techniques that had been identified as being a part of a supportive instructional environment. Since participation in the staff development was voluntary, the teachers could only be encouraged to adopt and use the various strategies. Some teachers used a few of the strategies, but did not try to implement all of them. There could be several ways in which teachers could be encouraged in their use of these techniques and strategies. The teachers involved in this study did not receive credit toward recertification.

Implications

1. Hands-on teaching strategies and activities should be included in preservice and inservice courses. Teachers need experience and practice in using these methods and materials, in order to use them successfully with students.

2. Administrative support, recertification credit, or other incentives could be given to teachers who voluntarily choose to participate in research projects which may ultimately benefit the students; this support could be in the form of release time.

3. Principals and administration should provide staff development in science which includes school-based support services from a science consultant or science supervisor.

4. Administrators and principals should encourage and support a high level of teacher commitment to research projects, staff development, or the implementation of new programs and strategies, especially programs that meet the needs of different population groups.

5. Teachers of at-risk students should receive training in techniques and instructional strategies that improve student learning.

Recommendations for Further Research

1. A year-long study of the effects of hands-on, activity-based science program used with at-risk students at various grade levels should be tested with larger populations at more than one school.

2. Follow-up studies should be made on the students involved in this study to note trends or changes in achievement, attitude, task mastery orientation, and cognitive engagement in science.

3. Tests should be constructed to measure competencies of the sixth-grade (or other particular grade levels) science curriculum as specified by the North Carolina Teacher Handbook, Science K-12 (NCDPI, 1985).

4. Tests should be constructed to measure the process skills as specified in the North Carolina Teacher Handbook, Science K-12 (NCDPI, 1985) for particular grade levels.

5. Case studies of at-risk students who receive hands-on, activity-based instruction in science could provide useful information for educators.

6. Research on teachers' attitudes toward using hands-on science with at-risk students could be conducted.

7. Teachers' attitudes toward working with at-risk students should be investigated.

8. The effects of teacher age and experience in implementing new teaching strategies and techniques should be investigated.

9. The reactive effects of classroom management and the implementation of a new program, such as hands-on science, should be examined.

10. This study should be replicated in a school which has a stable administration.

11. Further research on the Instructional Environment Scale as it relates to student learning and cognitive engagement should be conducted.

Summary and Closing Statement

This study examined the effects of hands-on, activity-based science when used with at-risk sixth-grade students in a supportive instructional environment. The Task Mastery Orientation and the cognitive engagement of the at-risk students increased during the time of the study. The teachers who received the training, supplies, and techniques necessary to implement hands-on, activity-based science felt that this approach benefited both the at-risk and the not at-risk students in their classes.

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APPENDIX A

PERMISSION TO USE INSTRUMENTS

School of Education

THE UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

Department of Pedagogical Studies and Supervision

Curry Building, UNCG
Greensboro, NC 27412-5001
(919) 334-5100 FAX (919) 334-5060

August 28, 1989

Dr. Harold Harty
School of Education
Fort Valley State College
Fort Valley, Georgia 31030

Dear Dr. Harty;

I am writing to request permission to use the "Children's Attitudes toward Science Survey" (Harty, Anderson & Enochs, 1984). I talked with you by telephone in December of last year at which time you gave verbal permission for the use of this instrument.

I am currently a doctoral student at the University of North Carolina at Greensboro seeking an Ed. D. in Curriculum and Teaching. The research in which I am involved is part of a drop-out prevention program being conducted at Reidsville Middle School in Reidsville, North Carolina. This is the second year of the drop-out prevention program which is being funded by a grant from the Mary Reynolds Babcock Foundation. The project is being co-directed by Dr. David H. Strahan and Dr. Rita O'Sullivan.

As part of this project I will be working on a science component with the sixth grade science teachers and students. I would like to use the attitude survey in this study. I would appreciate a copy of the instrument as well as data concerning validity and reliability.

Thank you for your assistance in this matter.

Sincerely,

Anne-Courtney Miller

Anne-Courtney Miller
Research Associate

David Strahan

Dr. David H. Strahan
Department Chair (Interim)

Permission Granted
Harold Harty
9/5/89

FORT VALLEY STATE COLLEGE
School of Education/Graduate and Special Academic Programs

TRANSMITTAL SLIP

Date 9/5/89 *To* Anne

Re: ________ *Dept.* ________

- [x] *For your information*
- [ ] *For your approval*
- [x] *For your file*
- [ ] *For your comments*
- [ ] *For your signature*
- [ ] *For your action*
- [x] *In compliance with your request*

- [ ] **Please Return**

- [ ] *Please RUSH*
- [ ] *Please order*
- [ ] *Please handle*
- [ ] *Please check*
- [ ] *Please call me*
- [ ] *Please take up with me*
- [ ] *To Accompany* ________

Best wishes

From Bud Harty *Telephone* ________

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(919) 334 5100 FAX (919) 334-5060

THE UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

August 28, 1989

Dr. Judith L. Meece
Peabody Hall 037-A
CB #3500
University of North Carolina
Chapel Hill, North Carolina 27599-3500

Dear Dr. Meece;

Dr. David Strahan and Dr. Rita O'Sullivan of the Department of Education of the University of North Carolina at Greensboro are co-directing a drop-out prevention program at Reidsville Middle School in Reidsville, North Carolina. This is the second year of the project which is funded by a grant from the Mary Reynolds Babcock Foundation.

As part of this project I have been working as a research associate with the sixth grade science classes at this school. Dr. Sam Miller had recommended the Science Activity Questionnaire for use in this project. I would like permission to use this questionnaire with the sixth grade students. I would appreciate a copy of the questionnaire as well as any information concerning validity and reliability.

Thank you for your assistance in this matter.

Sincerely,

Dr. David H. Strahan
Department Chair (Interim)

Anne-Courtney Miller
Research Associate

THE UNIVERSITY OF NORTH CAROLINA
AT
CHAPEL HILL

School of Education

The University of North Carolina at Chapel Hill
CB# 3500, Peabody Hall
Chapel Hill, N.C. 27599-3500

September 6, 1989

Ms. Anne Courtney Miller
Dept. of Pedagogical Studies
and Supervision
Curry Bldg.
UNC-G
Greensboro, NC 27412-5001

Dear Ms. Courtney-Miller:

Thank you for your interest in my research on children's motivation to learn science. I am pleased to learn that you will be using the Student Activity Questionnaire in your dissertation study of high risk sixth grade students. Please keep me informed of how your study progresses.

The questionnaire you requested was developed as part of a collaborative research project with the University of Michigan. To use this questionnaire, you will also need to seek approval from Dr. Phyllis Blumenfeld in the School of Education at the University of Michigan.

I am looking forward to learning more about your study. If you should need additional information about the Student Activity Questionnaire, please contact me.

Sincerely,

Judith Meece

JLM:kt

cc: Dr. Phyllis Blumenfeld

School of Education

THE UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

Department of Pedagogical Studies and Supervision

Curry Building, UNCG
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September 7, 1989

Dr. Judith L. Meece
School of Education
CB # 3500, 107 Peabody Hall
University of North Carolina
Chapel Hill, North Carolina 27599-3500

Dear Dr. Meece;

I enjoyed talking with you last week, and look forward to meeting you on September 20. Dr. Strahan told me that the meeting you had scheduled with him and Dr. Miller had been changed from September 11 to September 20. I also talked with Dr. Blumenfeld this week. Dr. Blumenfeld stated that if you approved my using the Science Activity Questionnaire, then she would also approve it. She indicated that she felt comfortable leaving the decision to you.

I obtained the packet of information you sent Dr. Strahan, however, a copy of the teacher behavior instrument was not included. Perhaps I did not understand correctly in our phone conversation, but I thought a copy was included with the packet. I would like to have a copy of that instrument and permission to use it, if possible.

I am enclosing a stamped self-addressed envelope. If you have any questions or need additional information, I can be reached at 704-636-2959.

Thank you for your assistance and cooperation in this matter.

Sincerely,

Anne-Courtney Miller

Anne-Courtney Miller
Research Associate
237 Sudley Circle
Salisbury, NC 28144

THE UNIVERSITY OF NORTH CAROLINA
AT
CHAPEL HILL

School of Education

The University of North Carolina at Chapel Hill
CB# 3500, Peabody Hall
Chapel Hill, N.C. 27599-3500

September 14, 1989

Ms. Anne-Courtney Miller
237 Sudlev Circle
Salisbury, NC 28144

Dear Ms. Anne-Courtney Miller:

I apologize for not including the classroom perception scales in the packet I sent to Dr. Strahan. My understanding was that you wanted to talk about these scales on September 20. I have enclosed a copy of these scales, descriptions of their scale structure, and their correlations with the goal and engagement scales I sent you earlier. Please note that some of the items included in the Work in My Class Scale (classroom perceptions) were dropped from the analysis because they did not relate to other items contained in the scale. I have indicated the items that were dropped on the enclosed questionnaire. I am currently writing up these data, and I do not have any further information at this time.

You have my permission to use these scales along with the goal and engagement measures in your study of science classrooms. I would like to talk about the possibilities of some follow-up work on your sample at the meeting on September 20.

I hope this information is helpful. I am looking forward to meeting you.

Sincerely,

Judith Meece/kt

Judith Meece

JLM:kt
Enclosures

THE UNIVERSITY OF NORTH CAROLINA
AT GREENSBORO

School of Education

237 Sudley Circle
Salisbury, NC 28144
October 12, 1989

Dr. Kenneth Tobin
Department of Early Childhood
and Elementary Education
Florida State University
Tallahassee, Florida 32306

Dear Dr. Tobin,

Thank you for talking with me by telephone lastweek and giving me permission to use the variables identified in your study of "Student Task Involvement in Activity Oriented Science" (Journal of Research in Science Teaching, 1984, Volume 21, no. 5, pp. 469-482). As I mentioned in our conversation, I need to obtain written permission to use this information, and would appreciate your writing a statement to me to that effect.

I am a doctoral student at the University of North Carolina at Greensboro seeking an Ed.D. in Curriculum and Teaching with a speciality in science. I am conducting my research project at Reidsville Middle School in Reidsville, North Carolina.

The focus of my study is student goal orientation, and cognitive engagement of at-risk sixth grade students during hands-on science, with special attention to the role of the instructional environment and teacher behavior. I am also using an instrument developed by Dr. Judy Meece (and others) to measure goal orientation and cognitive engagement. Student attitudes toward science will be measured using an instrument adapted by Harty, Anderson, & Enochs (1984).

If you need any additional information, please let me know. Thank you again for your time and assistance in this matter.

Sincerely,

Anne Courtney Miller
Anne Courtney Miller
Doctoral Student

Ernest W. Lee
Ernest W. Lee
Dissertation Adviser

The Florida State University
Tallahassee, Florida 32306-3032

College of Education
Department of Curriculum
and Instruction

10/24/89

Ms. Anne Courtney Miller
237 Sudley Circle
Salisbury, NC 28144

Dear Anne:

In many respects your letter puzzles me. I cannot see why you need to be asking for my permission to be doing what you say you want to do. Ethically you are not bound to ask permission and as a courtesy it is not necessary either. However, I gladly give you permission to use the variables identified in my study of "Student Task Involvement in Activity Oriented Science" which was published in the Journal of Research in Science Teaching in Volume 21(5) of 1984 on pages 469-482. My purpose in publishing my research is to enable scholars such as yourself to have free access to my ideas and thoughts. I am flattered by your decision to use my research. Thank you.

You may not be aware that I changed my approach to research quite dramatically in 1984 and now adopt a distinctly different methodology and interpretive framework. I have enclosed several papers for your interest.

Best wishes with your research. I hope you are successful in finding answers to some of the priority questions that science educators need to address.

Sincerely,

Kenneth Tobin

Kenneth Tobin
Professor of Science Education and
Head of Curriculum and Instruction

APPENDIX B

RESEARCH PROJECT CONSENT FORM

RESEARCH PROJECT CONSENT FORM

I agree to participate in the present study being conducted under the supervision of Anne-Courtney Seigler Miller, a doctoral student in the School of Education at The University of North Carolina at Greensboro. I have been informed about the procedures to be followed and about any discomforts or risks which may be involved.

I understand that my name will not be used in any report of this investigation. I understand that on occasion, with my consent, my science class may be audiotaped. I also understand that on occasion I will be asked to furnish Mrs. Miller with copies of science tests given to students.

Mrs. Miller has agreed to answer any further questions that I may have about the procedures of this investigation. I understand that I am free to terminate my participation at any time without penalty or prejudice. I am aware that further information about the conduct and review of human research at The University of North Carolina at Greensboro can be obtained by calling UNCG and asking for the Office of Research Services, Beverly B. Maddox, Assistant Director.

Date: ______________________________

Participant's
Signature: ____

APPENDIX C

STUDENT PLACEMENT GUIDELINES

REIDSVILLE MIDDLE SCHOOL

Student Placement

In our effort to provide our children with the best possible education and in an effort to best utilize our resources and personnel, we find it necessary to place students in appropriate classroom settings. We do this in the following manner.

1. Identify children who qualify for Chapter I Reading services according to Federal Guidelines. Consideration for identification - (a) reading percentile on CAT scores, (b) reading below grade level, and (c) past and present teacher recommendations.

2. Serving exceptional students:

    (a) Considerations for identification - current placement or eligibility for EMH, LD, BEH, and AG classes according to Federal Guidelines and determine through the referral and testing process.

    (b) Placement of exceptional children is determined by:

        (1) AG clustering guidelines (attached) which limit us to two (2) AG classes per grade with a maximum of fifty-eight (58) students placed in these classes per grade.

        (2) Severity and type of handicap.

        (3) Identify students to bring AG classes up to regular class size. Considerations for identification (information from progress card).

            (a) Total battery percentile on CAT scores

            (b) Recent trends in CAT scores (over the last few years.

            (c) Previous teacher recommendations.

The remainder of our students are heterogeneously grouped according to race, sex, and ability. Teams in both the 6th and 7th grades include students of varying ability.

Team composition is designated in the following way:

1. 7th Grade - there are three (3) 7th grade teams. Each team is composed of four (4) teachers. Each teacher presents core curriculum area (language arts/reading, science, social studies, and math) and instructs students in the Enrichment and Advisor/Advisee programs.

7th Grade Teams:

Team A - AG, Regular, Chapter, LD/EMH

Team B - AG, Regular, Chapter, LD/EMH

Team C - Two (2) Regular, Chapter, LD/EMH

6th Grade Teams: Five teams of two teachers each

Team A - Two (2) Regular - academically high, medium and low students

Team B - AG, Chapter

Team C - Regular, LD/EMH

Team D - Regular (with some LD/EMH); Chapter

Team E - AG, Chapter

APPENDIX D

TESTING INSTRUMENTS

CHILDREN'S ATTITUDE TOWARD SCIENCE SURVEY

NAME ____________________ CLASS ____________________

TEACHER ____________________ DATE ____________________

Directions:

Following are some statements concerning how you feel about science and your science class this year. You will see that there are no correct (or right) answers or no incorrect (or wrong) answers. This is NOT a test or exam. We are only interested in your honest opinion.

Please indicate how you feel about each statement by drawing a circle around one of the five (5) answers underneath. Please tell us how you really feel. Your cooperation is appreciated greatly. Your response will remain confidential and your science teacher will not see your paper.

CIRCLE YOUR ANSWER

1. Reading about science is hard for me.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

2. I would like to spend more time doing science experiments.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

3. I am learning a lot about science in school this year.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

4. What we do in science class is what a real scientist would do.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

5. In science class we study "today's problems" related to science.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

6. I do not like coming to science class.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

7. I read more science materials than I did in the fifth grade.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

8. I enjoy doing the science activities.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

9. I can solve problems better now than before.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

---

10. My friends enjoy doing science experiments.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

---

11. What I am learning in science will be useful to me when I am playing and at home.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

---

12. I think about things we learn in science class when I'm not in school.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

---

13. I do not want to have to take any more science classes than I have to.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

---

14. Reading about science is more fun than it used to be.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

---

15. Science experiments or activities are hard to understand.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

---

16. Science is dull for most people.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

---

17. The things we do in science class are useless.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

---

18. I learn a lot from doing my science experiments.

Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree

---

19. Most people like science class.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

20. The kinds of experiments I do in class are important.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

21. Please complete this sentence. Write your answer on this paper.
I think science class____
____
____
____

SCIENCE ACTIVITY QUESTIONNAIRE

PART I

DIRECTIONS:
Students have a lot of different thoughts and feelings while they are doing their science work. We want to know how true each of these things below was for you. If the sentence describes you a lot, circle VERY TRUE. If the sentence is pretty close to how you felt but not exactly, circle SOMEWHAT TRUE. If the sentence describes you only a little, circle A LITTLE TRUE. Circle NOT AT ALL TRUE, if the sentence does not describe you. Remember, there are no right and wrong answers. Circle the answer that best describes your feelings. Be sure to circle only one answer for each sentence.

		VERY TRUE	SOMEWHAT TRUE	A LITTLE TRUE	NOT AT ALL TRUE	
1.	I put a lot of time and effort into my work.	4	3	2	1	(11)
2.	The work made me want to find out more about the topic.	4	3	2	1	(12)
3.	The directions were clear to me.	4	3	2	1	(13)
4.	I felt involved in my work.	4	3	2	1	(14)
5.	I liked what we did in science today.	4	3	2	1	(15)
6.	I understood what we were supposed to do.	4	3	2	1	(16)
7.	I wish we had more time to spend on science today.	4	3	2	1	(17)
8.	I can use what I learned today later on.	4	3	2	1	(18)
9.	The purpose of today's work was clear to me.	4	3	2	1	(19)
10.	I was daydreaming about other things during science.	4	3	2	1	(20)
11.	I would like to do another activity like this sometime.	4	3	2	1	(21)
12.	The work really made sense to me.	4	3	2	1	(22)

PART II

DIRECTIONS:
These sentences describe different reasons for doing schoolwork. Different kids have different reasons. We want to know how true each of these reasons was for why you did your science work. If the sentence describes you a lot, circle A LOT LIKE ME. If the sentence does not describe you at all, circle NOT AT ALL LIKE ME.

		A LOT LIKE ME	SOMEWHAT LIKE ME	A LITTLE LIKE ME	NOT AT ALL LIKE ME	
1	I wanted to learn as much as possible.	4	3	2	1	(23)
2.	I wanted to work with my friends.	4	3	2	1	(24)
3.	It was important to me that the teacher thought I did a good job.	4	3	2	1	(25)
4.	I wanted to do as little as possible.	4	3	2	1	(26)
5.	I wanted to find out something new.	4	3	2	1	(27)
6.	I wanted to talk with others about the work.	4	3	2	1	(28)
7.	It was important to me to do better than other students.	4	3	2	1	(29)
8.	I just wanted to do what I was supposed to and get it done.	4	3	2	1	(30)
9.	It was important to me that I really understood the work.	4	3	2	1	(31)
10.	I wanted to help others with their work.	4	3	2	1	(32)
11.	I wanted the others to think I was smart.	4	3	2	1	(33)
12.	I wanted to do things as easily as possible so I wouldn't have to work very hard.	4	3	2	1	(34)

PART III

DIRECTIONS:
There are many different ways students do their science work. We want to know how much each of these things are like what you did in science. Circle A LOT LIKE ME if the sentence is very much like what you did. If the sentence is sort of like what you did, circle A LITTLE LIKE ME. Circle NOT AT ALL LIKE ME if the sentence does not describe what you did.

		A LOT LIKE ME	A LITTLE LIKE ME	NOT AT ALL LIKE ME	
1.	I followed the directions.	3	2	1	(35)
2.	I tried to figure out how today's work fit with what I had learned before in science.	3	2	1	(36)
3.	I guessed a lot so I could finish quickly.	3	2	1	(37)
4.	I asked myself some questions as I went along to make sure the work made sense to me.	3	2	1	(38)
5.	I wrote some things down.	3	2	1	(39)
6.	I did my work without thinking too hard.	3	2	1	(40)
7.	I explained or wrote down some things in my own words.	3	2	1	(41)
8.	I checked to see what other kids were doing and did it too.	3	2	1	(42)
9.	I paid attention to things I thought I was supposed to remember.	3	2	1	(43)
10.	I skipped the hard parts.	3	2	1	(44)
11.	I checked my science book or used other materials like charts when I wasn't sure about something.	3	2	1	(45)
12.	I just did my work and hoped it was right.	3	2	1	(46)
13.	I tried to figure out the hard parts on my own.	3	2	1	(47)
14	I copied down someone else's answers.	3	2	1	(48)
15.	I went back over the things I didn't understand.	3	2	1	(49)

STOP HERE

Goal Scale Items
(Meece, Blumenfeld, & Hoyle, 1988)

Mastery Orientation (alpha = .94)	Factor Loadings
1. I wanted to find out something new.	.97
2. I wanted to learn as much as possible	.96
3. The work made me want to find out more about the topic.	.81
4. I felt involved in my work.	.75
5. I wish we had more time to spend on science today.	.72
7. It was important to me that I really understood the work.	.72
7. I liked what we did in science today.	.64
8. I would like to do another activity like this one.	.59
9. I put a lot of time and effort into my work.	.53

Ego/Social Orientation (alpha = .85)

1. I wanted others to think I was smart.	.89
2. It was important to me to do better than the other students.	.84
3. It was important to me that the teacher thought I did a good job.	.70

Work-Avoidant Orientation (alpha = .77)

1. I wanted to do things as easily as possible so I wouldn't have to work very hard.	.84
2. I just wanted to do what I was supposed to do and get it done.	.69
3. I wanted to do as little as possible.	.64

Affiliative Goals (alpha = .75)

1. I wanted to talk to others about the work.	.77
2. I wanted to work with my friends.	.72
3. I wanted to help others with their work.	.54

Cognitive Engagement Items
(Meece, Blumenfeld, & Hoyle, 1988)

Active Learning (alpha = .87)	Factor Loadings
1. I went back over things I didn't understand.	.79
2. I asked myself some questions as I went along to make sure the work made sense to me.	.77
3. I explained or wrote down some things in my own words.	.75
4. I tried to figure out how today's work fit with what I had learned before in science.	.68
5. I checked my science book or used other materials like charts when I wasn't sure about things.	.66
6. I wrote some things down.	.60
7. I tried to figure out the hard parts on my own.	.56
8. I paid attention to the things I was supposed to remember.	.54

Superficial Learning (alpha = .79)	
1. I copied down someone else's answers.	.84
2. I checked to see what other kids were doing and did it too.	.84
3. I guessed a lot so I could finish quickly.	.79
4. I skipped the hard parts.	.57
5. I just did my work and hoped it was right	.53

INSTRUCTIONAL ENVIRONMENT SCALE

TEACHER ______________________________ CLASS ______________________

OBSERVER ______________________________ DATE ______________________

MEAN RATING ______________________

This instrument is used to rate the instructional environmental factors of a classroom. The fourteen items are rated on a scale of 1 to 5. The ratings or descriptors are listed under each item. In the cases where descriptors are listed, the items are rated on a scale of 1 to 5, with 1 assigned when no descriptors of the item are evident to 5 when four of the descriptors are evident. For this scale, 1 is the lowest rating and 5 is the highest.

A mean score is obtained for each use of this scale.

Ratings:
1. None of the descriptors is evident.
2. One of the descriptors is evident.
3. Two of the descriptors are evident.
4. Three of the descriptors are evident.
5. Four of the descriptors are evident.

---

1. Teaching methods used are appropriate for the objectives, learners, and the environment.

1. <u>Descriptors</u>:
   a. Teaching methods are matched to objectives.
   b. Teaching methods are matched to learners.
   c. Activities are compatible with the learning environment.
   d. Lesson is well-coordinated.

---

2. Concrete materials, supplies, instructional equipment and/or instructional aids are used.

2. <u>Ratings</u>:
   1. Instructional equipment, concrete materials, objects, activities are not used.
   2. Instructional equipment, instructional aids, concrete materials and supplies are used, but has trouble which causes delays or materials do not fit planned lessons.
   3. Effectively uses equipment, concrete materials, activities at appropriate time in lessons.

4. Highly skillful use of instructional equipment, concrete supplies, activities, or aids at appropriate times.
5. In addition to items in 4, shows evidence of skillfully preparing original instructional materials and/or activities.

---

3. Instructional materials are used that provide learner with appropriate practice on objectives.

3. <u>Ratings</u>:
   1. Materials and activities chosen are irrelevant to the topic or objective or no materials or activities are used.
   2. Materials and/or activities chosen are related to the topic being studied but not to the objective.
   3. Most materials chosen provide for practice on specific objectives. Some of the practice may be insufficient in quantity to achieve the objective.
   4. Materials chosen are relevant to the objectives. Learners are given ample opportunity to practice and achieve the objective.
   5. In addition to the items in 4, formal or informal progress assessment techniques are used to determine whether the practice individual learners receive is sufficient.

---

4. Clear, frequent directions and explanations related to lesson content and purpose are given.

4. <u>Ratings</u>:
   1. Teacher fails to give any direction or explanations either written or oral when there is an obvious need to do so (i.e., demonstrating proper use of equipment).

      OR

      Directions and explanations are difficult to understand and no attempt is made to remedy the confusion.
   2. Directions or explanations are difficult to understand. Attempts to clarify confusion are largely ineffective.
   3. Although most learners appear to understand, the teacher works with the entire group to clarify misunderstandings.
   4. Only a few learners misunderstand. The teacher identifies specific learners who have difficulty with directions and explanations and helps them individually.
   5. No evidence of learner confusion about directions or explanations is evident.

---

5. Feedback is provided throughout the lesson to affirm correct answers and to correct mistakes.

5. Ratings:
   1. Accepts learner comments or performance without feedback about their adequacy.
   2. Responds to negative aspects of student work, but few comments are made about positive aspects.
   3. Informs students of the adequacy of their performance. Affirms correct responses. Few errors pass by without being addressed.
   4. Helps learners evaluate the adequacy of their own performances.
   5. In addition to 4, the teacher probes for the source of misunderstandings which arise.

---

6. Within a particular class period a variety of teaching methods are used.

6. Ratings:
   1. Within a class period no teaching method is used acceptably.
   2. One teaching method is used acceptably.
   3. Two teaching methods are used acceptably.
   4. Three teaching methods are used acceptably.
   5. Four teaching methods are used acceptably.

   Teaching methods may include: drill, inquiry, discussion, role-playing, demonstration, explanation, problem-solving, experimentation, hands-on activities, games.

---

7. Teacher provides opportunity for individual, small group, and large group work.

7. Descriptors:
   a. Group size for instruction is matched to the objectives.
   b. Teacher's role is appropriate to each group size being used.
   c. Transitions from one sized group to another are smooth.
   d. Different group sizes that are matched to the objectives are used.

---

8. Learners are provided with opportunities to participate.

8. Ratings:
   1. Class activities require passive commitment.
   2. The class is organized so that only a few learners participate actively.
   3. Most learners have opportunity for active participation at some time in the class (e.g., small group discussion, physical

manipulation of materials, physical movement, individual work with concrete objects, etc.)
4. All learners have opportunity for active participation in some type of activity (particularly physical manipulation of materials, supplies, equipment).
5. All learners have opportunity for active participation in two or more activities.

---

9. Teacher provides positive reinforcement for learners and encourages the efforts of learners to maintain involvement.

9. Descriptors:
a. Uses activities, or concrete materials or objects which are appropriate for learners.
b. Varies pace and nature of activity.
c. Responds positively to learners who participate, and/or encourages the efforts of learners to maintain involvement.
d. Identifies and responds to learners who are off task.

---

10. Teacher presses for wide class participation.

10. Ratings:
1. Teacher accepts student answers but does not call on individuals.
2. Teacher calls on students who raise hands or indicate willingness to answer or allows a few students to dominate.
3. Teacher calls on many students including some who have not volunteered or raised hand.
4. Teacher calls on most students in the class at least once during a class period.
5. In addition to 4, teacher uses strategies that encourage wide class participation.

---

11. Teacher attends to routine tasks.

11. Ratings:
1. Teacher does not attend to routine task.
2. Teacher attends to routine task in a disruptive or inefficient manner (e.g., learners need special permission for many routine tasks).
3. Teacher anticipates routine tasks and attends to them efficiently (e.g., having equipment, materials, supplies ready).
4. Routine tasks are handled smoothly. Teacher delegates many tasks to the students.

5. In addition to 4, learners are responsible for various dimensions of the task (e.g., distributing materials, equipment, picking up work area, returning supplies, etc.).

---

12. Teacher presses for mastery of material by asking students to explain, justify or use meta-cognitive strategies.

12. Ratings:
    1. Teacher does not press for student mastery of material.
    2. Teacher presses some students for mastery of material.
       OR
       Teacher infrequently presses for student mastery of material.
    3. Teacher routinely presses students for mastery by asking students to explain or justify answers or reasons.
    4. In addition to 3, teacher uses strategies that encourage students to explain or justify.
    5. Teacher presses or requires all students to use meta-cognitive strategies

---

13. Appropriate classroom behavior is maintained.

13. Descriptors:
    a. Uses techniques (e.g, such as approval, contingent activities, punishment, etc.) to maintain appropriate behavior.
    b. Overlooks inconsequential behavior problems.
    c. Reinforces appropriate behavior.
    d. Maintains learner behavior that enhances the possibility for learning for the group.

---

14. Teacher models cognitive strategies for students.

14. Ratings:
    1. Teacher does not model cognitive strategies for students.
    2. Teacher models cognitive strategies one time during a lesson.
    3. Teacher models cognitive strategies more than once during a class period.
    4. Teacher models cognitive strategies at least once, and has students model cognitive strategies.
    5. In addition to 4, teacher frequently refers to cognitive strategies, and uses techniques to encourage student use of these strategies.
