The impact of systemic reform of subject matter and educational coursework on early career teacher performance

Richard Thomas Rushton

The University of Montana

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The Impact of Systemic Reform of Subject Matter and Educational Coursework on Early Career Teacher Performance

by

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presented in partial fulfillment of the requirements
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In this study, the researcher explored the characteristics of the science instruction and learning in the classrooms of three early career teachers. These teachers had participated in the Systemic Teacher Excellence Preparation project as pre-service teachers at The University of Montana. The study focused on the early career teachers' students': (a) attitude toward science, (b) adoption of scientific attitudes, (c) enjoyment of their science instruction, (d) the actual and preferred degree of difficulty, satisfaction, competitiveness, cohesiveness, and friction in the science instruction, and (e) hours allocated to science instruction. An analysis of data described a learning environment in which the students: (a) had a positive attitude toward science, (b) were disposed to adopt scientific attitudes, (c) enjoyed their existing science instruction, and (d) averaged five hours of science instruction each week.
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CHAPTER I

INTRODUCTION TO THE STUDY

Background

Science education reform is a topic of much research and discussion in the United States. One can trace this research back more than one hundred years. In that time, there have been numerous panels and committees, which have issued calls for improving the quality and nature of science education, reversing the negative trend in students' attitudes toward science, and increasing the number of hours of actual science instruction occurring in the classroom.

Until early in the 1960s the United States led the world in science achievements, and the United States’ students scored as well in science as students anywhere in the world. Americans assumed that they would continue to lead the world in science and that America’s students would grow up to be scientifically literate with the ability to continue that tradition.

The earliest indicator to refute that assumption occurred in 1970 when the first National Assessment of Education Progress (NAEP) appeared; science scores were significantly lower than expected. American students were learning appreciably less science than students in many other countries. American students scored below the average on most scales, and the top 1% was only average (Howe, 1988). As reported in a variety of research efforts (Weiss, 1989; Moore, 1990), the American science education system was producing students who for all practical purposes were scientifically illiterate and who had little interest in taking any science by the time they entered secondary
school or college. It was reported that U.S. ten-year-olds were above average compared to ten-year-olds from the other industrialized countries. However, by the time U.S. fourteen-year-olds entered high school, they had dropped to 14th rank among 17 countries' student population (Moore, 1990). These studies indicated that the middle grades science education of American students was at best less than adequate and in serious need of thorough reform.

*A Nation at Risk* published on April 26, 1983, by the National Commission of Excellence in Education, reported that an additional 200 national, state, and local reports had confirmed its previously reported results (Glass, 1990). These results indicated that the American educational system was producing students who were scientifically illiterate and at the same time driving those very students away from science as a vocation and educational endeavor.

In addition to scientific illiteracy, student interest in science became a concern. In early elementary school, more than 70% of students said they were interested in science (Weiss, 1989). By the third grade, only half of all students wanted to take more science. By the fifth grade, only 20% of all students wanted to take more science. In fact, it is disturbing that, considering the current college entrance requirements, less than 50% of all students take a science course after the tenth grade (Moore, 1990). Science teachers, science education, and teacher education have been blamed for students' low achievement in science and for their reportedly poor attitudes toward science.

At a time when the reform of Kindergarten through grade twelve science education was of paramount importance, it should not come as a surprise to anyone that attention was being oriented toward teacher education (Adams & Tillotson, 1995). Science teacher
preparation is now recognized as the pivotal point in the reform of science education (Anderson & Helms, 2001). No longer can we view science teacher preparation as discreet and separate from science teacher enhancement (Brunkhorst, 1993). Kahle and Yager (1981) reported that 74% of science educators saw science teachers as the key to improving science education. Anderson and Mitchner (1994) noted that given the long history of pre-service teacher education, there was a very limited amount of research on the subject and much of what was available is rather limited in scope and usefulness. There was a lack of research in the domain of science teacher education. Two areas of interest and concerns were identified (a) current programs and practices are not informed by research and (b) there is serious need to plan and conduct research on the implementation of current science education reform efforts. After all, how can teacher education programs and practices be enhanced in the absence of knowledge?

New Curricula

A variety of reforms have been implemented to improve science instruction, interest, and achievement. Pre-service and in-service science teacher education has been improved and programmed instruction plans have been implemented in a variety of learning situations and environments. As a result of the new improved science instruction curricula beginning in 1955, and particularly during the 1960s and early 1970s, elementary, junior high, and secondary school science curricula experienced considerable growth and substantial change. These curricula were further supplemented with a large number of private and public grants for pre-service teacher education reform, teacher retraining, and teacher improvement workshops (White & Richardson, 1993). These
reform efforts, and the improved teacher training, resulted in many changes in science education that were curriculum based.

While the resulting curricula were sometimes different in scope and content there were definite similarities and trends in their methodologies. Hurd (as cited in McCormack, 1992) reviewed these curricula and presented a summary of these trends as shown in Table 1.

Table 1.  
Summary of Trends in New Curricular Development

<table>
<thead>
<tr>
<th>FROM</th>
<th>TO</th>
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<tr>
<td>1. The textbook as the authoritative source of information</td>
<td>1. Laboratory data as a primary source of information.</td>
</tr>
<tr>
<td>2. Everyday technology is presented as science.</td>
<td>2. “Pure” science is emphasized.</td>
</tr>
<tr>
<td>3. Many science topics studied briefly.</td>
<td>3. In-depth studies of fewer topics.</td>
</tr>
<tr>
<td>4. Laboratory activities used to verify concepts in textbooks.</td>
<td>4. Laboratory activities used to collect data from which concepts are derived.</td>
</tr>
<tr>
<td>5. Deductive thinking is emphasized to arrive at “correct answers.”</td>
<td>5. Inductive thinking is stressed in arriving at reasonable tentative answers.</td>
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Regardless of the motivation to improve science education in the United States through curricula reform, the initial efforts often resulted in the development of new course materials for use in existing curriculum and could be seen as course-content improvement projects that were developed to be teacher-proof. Science teachers involved in the development of these new curricula believed it was important to structure the programs in ways that other teachers could not misuse them. Curriculum developers often viewed teachers as neither creative nor energetic. They thought that most teachers depended exclusively on textbooks to define their courses, to provide the activities for
use in classrooms and for teaching strategies to use in dealing with them (McCormack, 1992).

A meta-analysis conducted nearly twenty years after the implementation of the new curricula (Shymansky, Kyle, & Alport, 1983) found only limited success resulting from their implementation strategies. New methods of improving the results of science education were researched, and in many cases, implemented after receiving funding from the federal government. This funding was provided through the National Science Foundation’s authorizations of grants. Many of those grants were for projects that were designed to produce changes in the process of science education at a systemic level.

This study investigated and characterized the classroom students’ attitudes toward and about science, and actual number of hours allocated to science instruction, (all areas of concern noted in the National Research Council’s National Science Education Standards NSES, 1996), of early career teachers who participated in the Systemic Teacher Excellence Preparation (STEP) project. STEP was a National Science Foundation funded systemic reform effort in math and science teacher education that took place within the School of Education at the University of Montana over a five-year period during the mid 1990s. This reform effort in math and science teacher education was important because of systemic reform being at the forefront of the current efforts in science education reform.

This research describes the impact of the STEP project on early career teachers’ efforts to reform science education in their classrooms. The STEP project involved reforming pre-service education and science content classes. In these classes, the content was integrated, labs were for exploration and discovery, and lectures had smaller
numbers of students. In addition, more emphasis was placed on pedagogy, thereby preparing the early career elementary teachers to implement and utilize a science program that addressed the concepts and practices advocated by the NSES document. Particular attention was given to addressing the ability of the early career teachers to establish a program that would lead to their students having a more positive attitude toward and about science as both a content discipline and as an educational experience.

The primary purpose of this study was to ascertain if the STEP project provided pre-service education students the motivation, experience and knowledge necessary (for those same students, when employed as early career teachers), to design and implement a science education program reflective of the National Science Education Standards.

Research Questions

In this study a combination of quantitative and qualitative measures were used to describe the impact of the STEP project’s efforts at preparing early career elementary teachers. Because of the seminal nature of the research project, there was no external comparison group.

The questions addressed in this study include:

1. What are the attitudes toward and about science of students (grades 5-7) who were members of a class taught by an early career teacher who participated in the University of Montana’s STEP project?

2. Do early career teachers who participated in the STEP project provide more/less instructional time per week for science education than indicated in past studies for non-STEP teachers?

The research sequence (path) involved in this study looked first at the history of
reform efforts in science education, then the development of the National Science Education Standards (NSES), the implementation of the STEP project, the classroom learning environment, and the students’ attitudes toward and about science.

The degree to which the early career teachers address the content standards contained in the NSES was not studied. This decision was based on the fact that in most cases teachers are more concerned with addressing matters of content than the areas of learning environment and the hours actually devoted to science instruction (Goodlad, 1984). However, the effects of efforts to correct that lack of concern for attention to the learning environment, for time devoted to science instruction, and for the methods of science instruction are critical issues that justify further study.

Importance of the Study

In the overview of the National Science Education Standards (National Research Council, 1996), the following statement was made:

In a world filled with the products of scientific inquiry, scientific literacy has become a necessity for everyone. Everyone needs to use scientific information to make choices that arise every day. Everyone needs to be able to engage intelligently in public discourse and debate about important issues that involve science and technology. And everyone deserves to share in the excitement and personal fulfillment that can come from understanding and learning about the natural world. (p. 1)

There is an urgent and significant need to generate a change in American science education. The primary sources of these changes include the teachers of science
education, pre-service science education students (who are the consumers of that science education), and the students these future teachers will have in their classrooms.

There has been a remarkable amount of money, time, and effort expended in recent efforts to produce more capable, literate, and productive American students related to their abilities in, and knowledge of science. These expenditures have resulted in an extensive review of the role played by the professional development and performance of those students' science teachers in the endorsement and achievement of the desired outcomes (Adams & Tillotson, 1995). One highly sought outcome was the enhanced expansion of a scientifically literate citizenry that would become astute consumers of the products and technology so prevalent in the scientifically driven society of the 21st century as set forth in the National Science Education Standards (National Research Council, 1996). The findings of the research related to past reform efforts have not been satisfactory, and therefore, there is a continuing effort being made to correct the educational predicaments resulting from the unsuccessful reform efforts of the past. One such recent reform initiative is the Montana STEP project. This study was part of the continuing effort in providing further data that can help guide future systemic reform efforts aimed at improving science education and learning.

Definition of Terms

For purposes of clarity, the terms used in this study are defined in the following way.

*Attitude Toward Science* - Attitudes toward science are learned predispositions to respond in a consistently favorable or unfavorable manner toward science (Koballa, 1988).
Early Career Teacher – This refers to a teacher with three or fewer years of teaching experience in the formal schools setting.

Evaluation – Evaluation refers to all the informal and formal methods that teachers use to measure, estimate, and form judgments about student learning. Evaluation includes teacher observation of student actions in class during the laboratory or other science activities. It also includes written work, homework assignments, laboratory reports, notebooks, quizzes, and tests (Robinson, 1979).

Inquiry - Inquiry is a multifaceted activity that involves making observations, posing questions, examining books and other sources of information to see what is already known, planning investigations, reviewing what is already known in light of experimental evidence, using tools to gather, analyze, and interpret data, proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and considerations of alternative explanations. Students will engage in selected aspects of inquiry as they learn the scientific way of knowing the natural world, but they also should develop the capacity to conduct complete inquiries. The learning cycle is often utilized to obtain much of this information. Inquiry requires reasoning capabilities and skills in manipulating laboratory or field equipment.

Learning Environment - The learning environment can be considered as the social-psychological context or determinants of learning and include the shared perceptions of the students and teachers in that environment. This definition of the learning environment also involves relationships between the teacher and his or her students, the physical aspects of the classroom, and expectations of everyone in the environment (Fraser, 1994).
New Science Curricula – New Science Curricula are those that were developed after 1955 with either private or public funds that emphasize the nature, structure, and processes of science, integrate laboratory activities as an integral part of the class routine, and emphasize higher cognitive skills and appreciation of science.

Process Skills - Process skills represent the basic (observation, inference, classification, predicting, collecting and recording data, and measurement) and the integrated skills (controlling variables, interpreting data, defining operationally, formulating hypotheses and experimentation) that represent the rational and thinking skills of science (Barr, 1994).

Scientific Attitudes - Scientific attitudes are behaviors associated with critical thinking and characterize the thinking processes of scientists (Koballa, 1988).

Scientific Knowledge - Refers to facts, concepts, principles, laws, theories, and models and can be acquired in many ways.

Traditional Science Curricula - Traditional science curricula patterned after a program developed prior to 1955. They emphasize knowledge of scientific facts, laws, theories and applications, and use laboratory activities as verification exercises or as secondary applications of concepts previously covered in class (Shymansky et al., 1983; Costenson & Lawson, 1986; Shymansky, J., Hodges, L., & Woodworth, G. 1990).
CHAPTER II
REVIEW OF LITERATURE

This review of the literature is divided into sections reflecting the foci of the study. The first section highlights two studies that describe the importance of early career elementary teachers and their problems with teaching science. The second section reviews current and recent national reform efforts in science education relevant to elementary school science instruction. The third section provides background information about Montana science education reform and the Systemic Teacher Excellence Preparation project at the University of Montana.

Early Career Elementary Teachers and Science Education

The experience in elementary science (Kindergarten - eighth) classes is of particular concern for this study. Research findings indicate that the elementary school is the most effective educational setting for intervention leading to improved attitudes, higher achievement, and increased access to science. While the elementary school setting is an important learning environment for science, several studies found that elementary teachers are not prepared or interested in teaching the subject of science.

Goodlad (1984) studied a stratified random sample of schools using interviews and guided observations to study a wide range of educational issues. His research at the elementary level indicated that only 23.3% of the elementary teachers felt prepared to teach science (N=150). In the elementary grades, the number of hours of science instruction was limited to 2.3 hours per week, or on the average, 10% of the instructional time. The allocation of time and resources to the natural sciences in the school studied
was less than, but close to, the allocation to social studies (p.133). However, it did indicate that the low amount of time instructing science in the elementary school suggested some lack of certainty about the importance of science as a field of pre-collegiate study. Goodlad also mentioned additional generalizations. First, the science curriculum appeared to be linked with health at the elementary level. Second, learning about the lives of great scientists or science as a career was missing. Third, it was difficult to connect the science topics taught with the teachers’ frequent mentions of scientific and critical thinking.

In support of Goodlad’s study, Rice and Corboy (1995) found additional results reporting that elementary teachers lack interest in science teaching. In their study focusing on the elementary school classroom setting, they found deficiencies in elementary teachers’ interest in science, in their confidence, in their ability to teach science, and in their pedagogical and content preparation. From these studies, it became clear that any systemic reform efforts in science education must involve elementary teacher’s preparation aimed at changing these deficiencies in teaching and learning science.

Review of Current and Recent Reform Efforts

The most recent science education reform movement involved a departure from the classical teacher-centered, fact and recitation approach to teaching science, and was a reaction against ingrained classicism, rote memorization of facts, didactic teaching, and a largely outdated and irrelevant science curriculum. The reported aims of the reform of the 1960s were the instillation of inquiry instruction as the standard teaching strategy and an increase in the number of students selecting science-related vocations (McCormack,
This effort to reform science education was stimulated by changes both internal and external to the United States.

External stimulus for reform came as a result of the October 1957 launching of Sputnik I. This technological achievement by the Soviet Union motivated the Congress of the United States to provide monetary funding and direction for the development of improved curricula in mathematics and science (mostly through federal grants). The primary purpose of these new curricula was to assist the United States in regaining its global superiority in science and technology.

The internal stimulus was the shortage of scientists to meet the needs of the increasingly technological society. This shortage prompted educational researchers to begin investigating the reasons behind the failure of science education in meeting the needs of the United States.

One of the most immediate results of this reform effort was the generation of dozens of alphabet-soup science curricula developed through research funded by both private and public sources. These curricula include such programs as Elementary Science Study, Science Curriculum Improvement Study, Individualized Science Instructional System, Earth Science Curriculum Project, Biological Science Curriculum Project, Chemical Education Materials Study, Science Technology and Society, and the Harvard Project Physics. These curricula projects focused on reflecting the nature of science as seen by practicing scientists, and on learning by inquiry with explicit statements of desired student outcomes that gave attention to content, science process skills, the nature of scientific inquiry, and attitudes and values (Welch, Klopfer, Aikenhead, & Robinson, 1981).
Learning by inquiry meant that the students were to behave like scientists: observing, measuring, experimenting, predicting, and analyzing data in hands-on laboratory situations. This method also removed the teachers from their familiar roles as the center of learning and the source of all knowledge. The teachers instead assumed the roles of facilitator, director, and arbitrator. These changes allowed students to generalize scientific concepts, practices, and principles for themselves from data collected through their own investigations. This was very different from learning through teacher lectures, demonstrations, and labs that were done simply to verify facts, concepts, and principles presented verbally by their science teachers and in their textbooks (McCormack, 1992). Still most such curricula efforts were seen as course content improvement projects. In fact, courses with such content discipline structure became common offerings in the junior high schools, replacing general science.

Elementary programs were organized around basic science concepts and processes that had been identified as important by scientists who were being encouraged to enter the arena of curriculum development for schools. Conceptually-Oriented Program for Elementary Science, was, for example, directed by Morris Shamos, a noted physicist, and illustrated the thinking about basic concepts as course organizers (Yager, 1983). Another example was Science-A Process Approach, sponsored by the American Association for the Advancement of Science, which had a number of scientists as developers (Yager, 1983).

A supposition reached after research and review is that after years of implementation, over five billion dollars invested, and numerous research reports, evidence indicates no real consensus on the effectiveness of these new science curricula on enhancing student
performance Stake and Easley (1978). It was not until several meta-analytical studies were conducted that data became available to validate their effectiveness. In a reassessment of the effects of inquiry-based science curricula of the 1900s on student performance, Shymansky et al. (1990) reviewed and reanalyzed the earlier work of Shymansky et al. (1983) using more sophisticated statistical methods developed for meta-analysis. The results of the re-synthesis generally supported the conclusions drawn in the earlier meta-analysis, i.e., the new science curricula of the 1960s and 1970s were more effective in enhancing student performance than traditional textbook-based programs of the time.

However, research has also indicated that the reform efforts were less than successful. Stake and Easley (1978) discovered that inquiry-oriented instruction was still a rarity in science classes, and they also found that students still spent most of their classroom time listening to lectures, completing worksheets, and doing verification-type laboratory exercises. Welch et al. (1981) and Crawford (2000) researched the role of inquiry in science education. They found that there were many significant roles for teachers in the implementation of inquiry teaching and that although teachers made positive statements about the value of inquiry as an instructional methodology, they often felt more responsible for teaching facts, basics, structure, and the work ethic, or responses to questions on standardized tests.

These shortcomings and the lack of success at integrating the reformed science curricula into pre-service teacher education and then into the regular school program led to the recognition that there was a need for a document that would specify the goals and objectives of professional educators involved in the reform and implementation efforts.
This led to the development and implementation of the National Science Education Standards (1996). To help implement the goals and objectives of the NSES, funding support was given by the National Science Foundation to a variety of university-based research and reform efforts with goals that addressed the needs of reform in terms of states, districts, their administrators and educators as a cohesive unit or system rather than the piece-meal efforts of the past. An example of this type of reform effort is the STEP project (Systemic Teacher Excellence Preparation) in Montana.

State Standards and The STEP Project

Montana’s public school students are at or near the top of the 50 states in mathematics and science testing results. Unfortunately, when compared to the students of the global society, against which Montana’s students must compete, these same Montana students score in the bottom third (Anderson & Charron, 1992).

In response to the concern about poor student performance in science, efforts were made in the state to rewrite the state science standards. The development of Montana’s science standards occurred before the publication of national reform documents such as Science for all Americans (Rutherford & Ahlgren, 1989), Fulfilling the promise: Biology education in the nation’s schools (National Research Council, 1990), Scope, sequence and coordination of secondary school science: the content core (National Science Teachers Association, 1992) and National Science Education Standards (National Research Council, 1996). However, key principles of the national reports, including the need to focus on truly significant concepts and to teach those well, and the need for integrated and interdisciplinary science curricula, are evident in Montana’s state science goals. The proposed mathematics and science goals were further validated in a statewide
needs assessment, conducted by Montana’s Office of Public Instruction, under the auspices of the Dwight D. Eisenhower Mathematics and Science Improvement Program. This study found a high level of endorsement for the state science goals and aligned them well with the national reform documents.

The STEP project was funded and put in place to help translate the changes made in the science standards into the elementary school classroom. The collaborative projects general goals were to (a) bring about large-scale improvement in the preparation of mathematics and science teachers in Montana, and (b) to serve as a national model for science teacher preparation in rural areas. STEP project’s objectives included the following:

1. Provide early career support for mathematics and science teachers in a rural setting during their first four years of service.
2. Design, implement, evaluate, and disseminate new ideas in preparing mathematics and science teachers at all levels.
3. Use a team approach in redesigning the mathematics, science and science education methods courses for pre-service teachers.

One advantage the STEP program had compared to most science education reform projects is that it was being implemented in a state where reform efforts in science have been attempted in the past. The lessons learned set the foundation for the need for specific research to be completed which would lead to meaningful and lasting change. This idea is clarified by a statement from the editors of the Journal of Research in Science Teaching, which was quoted by Keys & Bryan (2001). The statement is as follows:
... reform efforts represent unfinished business for the science education community. Despite seeming efficacy of the goals and claims that underline current reform, there has been little formal, scholarly effort on the part of the science education community to ground the reform carefully in research (p.631).

Given that past research studies provided little definitive evidence of the success of reform efforts in science education (Shymansky, 1989), STEP supported research on the outcomes of the reforms it was hoping to make. This study was an outcome of the need to provide further information regarding the effectiveness of systemic approaches in changing science teaching and learning.
CHAPTER III

METHODS

The methods section is divided into five major sections. The first section describes the selection process for the sample population. This is followed by the research design and timeline for data collection. The final three sections includes a description of the instruments used, implementation process in the study and the statistics.

Selection of the Sample Population

The sample population for this study included three early career elementary teachers, who were employed in three different rural school districts. The subjects were selected using a maximum variation sampling technique aimed at capturing and describing the central themes or principle outcomes that cut across participant or program variation. Common patterns that emerge from great variations in both community size and socio-economic status are of particular interest and value in capturing the core experiences and central, shared aspects or impacts of a program.

The students were selected for interviewing based on gender with an equal number of males and females. Within each gender, interview subjects were randomly selected from students who had submitted an informed letter of consent (Appendix A). Two males and two females from each school were interviewed.
Research Design

The design of the study is what Patton (1990) describes as a naturalistic inquiry or mixed form study that involves both qualitative and quantitative data collection (see Figure 1).

![Naturalistic Inquiry Study Design](image)

*Figure 1. Naturalistic Inquiry Study Design.*

The research, in the form of a summative evaluation, incorporated qualitative and quantitative research methodologies. Patton (1990) describes this research as:

- summing up judgments about a program to make a major decision about its value, whether it should be continued, and whether the demonstrated model can or should be generalized to and replicated for other participants or in other places (p.151).

The general format will be that of the case study. Justifications for applying the case study format are offered by Kenny and Grotelueschen (as cited in Merriam, 1988), when they stated:

- Case study is appropriate when the objective of an evaluation is to develop a better understanding of the dynamics of a program, when it is important to be...
responsive, to convey a holistic and dynamically rich account of an educational program, case study is a tailor made approach (p.39).

The format will involve the researcher as a participant observer in the role described by Spradley (1980), “The participant observer comes to a social situation with two purposes: (1) to engage in activities appropriate to the situation and (2) to observe the activities people, and physical aspects of the situation” (p.54).

Qualitative data were gathered through interviews, observations, and artifacts. Quantitative data were collected and scored using the hand scoring format (Appendix B) for the My Classroom Inventory (see Appendix C Actual form of the MCI instrument and Appendix D Preferred form of the MCI instrument) and selected sections of the Test of Science Related Attitudes (see Appendix E TOSRA instrument and Appendix F scoring form for the TOSRA instrument). Subsumed under this format was the process of triangulation where the quantitative data, interviews, observations, and artifacts are analyzed to provide research validity. A combination of Patton’s (1990) and Spradley’s (1980) frameworks for interviewing techniques was used for data collection. The interview questions (see Appendix K Qualitative Interview Questions) used were organized in the standardized open-ended interview (semi-structured) described by Patton (1990).

While this method did somewhat limit flexibility in probing, it also minimized variation in the questions asked to interviewees while still yielding the thick descriptions that are central to qualitative research. This type of questioning technique reduces the possibility of bias that comes from having different interviews for different people, including the problem of obtaining more comprehensive data from certain
persons while getting less systematic information from others.

This approach leads to information gathering, which has been described as a form of interpretive research, which is defined by Anderson and Helms (2001):

The multiplicity of interacting variables in the matters under study is such that controlled experiments with full prior delineation of all variables are largely possible. It is important to study the dynamics of the interrelationships of the many factors influencing the total situation (p. 12).

Qualitative data were analyzed using the methodologies described by Patton (1990). Cross-case analysis strategies were used as a means of grouping together answers from different people and for analyzing different perspectives on central issues. Inductive analysis provided a means by which the patterns, themes, and categories of analysis coming from the data could be classified and interpreted. This use of inductive analysis was preferable to pre-imposing those same classifications prior to data collection. An additional resource used in this study was the work of Erickson (1986). Erickson stated that:

interpretive, participant observational fieldwork has been used in the social sciences as a research method for about seventy years. Fieldwork research involves (a) intensive, long-term participation in a field setting; (b) careful recording of what happens in the setting by writing field notes and collecting other kinds of documentary evidence (e.g., memos, records, examples of student work, audiotapes, videotapes); (c) subsequent analytic reflection on the documentary record obtained in the field; and (d) reporting by means of detailed description, using narrative vignettes and direct quotes from interviews, as well as
by more general description in the form of analytic figures, summary tables and
descriptive statistics. Interpretive fieldwork research involves being unusually
thorough and reflective in noticing and describing everyday events in the field
setting, and in attempting to identify the significance of actions in the events from
the various points of view of the actors themselves (p.121).

The specific terms of inquiry may change in response to the distinctive character of
events in the field setting as well as changes in the researcher's perceptions and
understanding of events and their organization during the time spent in the field.

Fieldwork is effective at answering the following questions (for additional information
on these questions, and the ensuing discussion, see Erickson, Florio, & Buschman, 1980,
from which these remarks are a paraphrase):

1. What is happening, specifically, in social actions that take place in this
   particular setting?

2. What do these actions mean to participants, at the moment the
   actions took place?

3. How are the happenings organized in patterns of social organization and learned
   cultural principles for the conduct of everyday life, in other words, how are
   people in the immediate setting consistently present to each other as
   environments for one another's meaningful actions?

4. How is what is happening in this setting as a whole (i.e., the classroom) related
   to happenings at other system levels outside and inside the setting (e.g., the
   school building, the school system, federal government mandates regarding
   mainstreaming)?
The central questions of interpretive research concern issues that are neither obvious nor trivial. They concern issues of human choice and meaning, and in that sense, they concern issues of improvement in educational practice. Although the stance of the fieldworker is not manifestly evaluative, and although the research questions do not ask which teaching practices are most effective, issues of effectiveness are crucial in interpretive research. The program of interpretive research is to subject to critical scrutiny every assumption about meaning in any setting, including assumptions about desirable aims and definitions of effective teaching (Erickson, 1986).

To conclude, the history of mainstream research on teaching for the past 20 years is one of analysis using theoretical models of the teaching process, on the assumptions that what was generic across classrooms would emerge across studies, and that the subtle variations across classrooms were trivial and could be washed out of the analysis as error variance.

Time Line for Data Collection

The research was conducted during the 1998-1999 academic school year. The researcher visited each classroom a minimum of six times for testing, interviews, and observations. Data were collected throughout the school year during separate school visitations to each of the STEP early career teachers' classroom by the researcher. Some visits were one day in length while others involved visits of two days.

The first visit took place during the first quarter of the school year. Subsequent visits occurred at intervals throughout the school year with final visits taking place during the last month of the school year. This visitation schedule allowed for observing the greatest impact of the early career teachers' efforts to implement their own curriculum.
Instruments

Using a combination of qualitative and quantitative research methods, this study evaluated students' attitudes toward and about science, and the amount of time actually allocated to science instruction in the classroom. Below is a description of the qualitative and quantitative data instruments used in this study.

Qualitative Instruments

Table 2 includes a description of the types of qualitative resources utilized in data collection during this research.

Table 2

Description of Qualitative Instruments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science lesson plan</td>
<td>Teacher generated lesson plan or a series of science lesson plans on a self-selected topic.</td>
</tr>
<tr>
<td>On-site observation</td>
<td>Descriptions of the teachers and students in action in the classroom, and the classroom-learning environment.</td>
</tr>
<tr>
<td>Semi-structured interview</td>
<td>A set of questions presented verbally to the teachers.</td>
</tr>
<tr>
<td>Videotaped teaching activity</td>
<td>Recording of the teacher's presentation of the science lesson. Recordings will be destroyed after analysis and review.</td>
</tr>
</tbody>
</table>

Quantitative Instruments

Below is a narrative description of the quantitative instruments used in this research. This is followed by Table 3 summarizing the quantitative instruments used by category and a brief description of each scale.
My Classroom Inventory (MCI)

The MCI (See Appendices C & D) is a simplified form of another instrument called the Learning Environment Inventory (LEI) that is suitable for children 8 to 12 years old. Although the MCI was developed originally for use at the elementary school level, it is useful with students at the seventh grade level, especially among students who might experience reading difficulties with the LEI. The MCI differs from the LEI in four important ways. First, in order to minimize fatigue among younger children, the MCI contains only five of the LEI's original 15 scales (Cohesiveness, Friction, Satisfaction, Difficulty, and Competitiveness). Second, item wording has been simplified to enhance readability. Third, the LEI's four-point response format has been converted to a two-point (yes-no) response format. Fourth, students answer on the questionnaire itself instead of on a separate response sheet to avoid errors in transferring responses. Below is a more complete description of each scale involved in MCI questionnaire.

The cohesiveness scale measures the extent to which students, know, help and are friendly toward each other. When several individuals interact for a period of time, a feeling of intimacy or cohesiveness may develop. This property separates members of a group from non-members, and has been found in research to relate to several class and course properties. (Walberg, 1969; Anderson & Walberg, 1972). Classes of teachers inexperienced with a new course were perceived as more cohesive than those taught by teachers more familiar with the course (Anderson, Walberg, & Welch, 1969), and history and English classes were found to be more cohesive than science classes (Anderson, 1971). Also class cohesiveness has been found consistently positively related to learning criteria.
The friction scale measures the amount of tension and quarrelling among students. Energy expended in conflict cannot be channeled in other directions and the emotional upset resulting from extensive or continued conflict can be expected to impair learning. Past studies have revealed that friction is higher in mathematics classes than in other subject areas (Anderson, 1971), is higher when the class contains a larger number of boys than girls (Walberg & Ahlgren, 1970), and is negatively correlated with measures of learning.

The difficulty scale measures the extent to which students find difficulty with the work of the class. The difficulty scale can be considered important because it completes the "depth-breadth" paradigm used by some educational theorists. It assesses the extent to which students find difficulty with the work of the class. It was found that mathematics classes were considered more difficult than classes in other subjects (Anderson, 1971) and that larger classes were perceived as less difficult than were smaller ones (Walberg, 1969; Anderson & Walberg, 1972). Positive relationships exists between student-perceived difficulty and student learning outcomes.

The satisfaction measures the extent of enjoyment of class work. Whether or not pupils like their class can be expected to affect their learning. If students dislike the subject, the teacher, or their classmates, their frustrations may result in less than optimal performance. Furthermore, because satisfaction with school is itself a goal of educators, research use of this scale may help shed light on the effects of such practices as homogenous and heterogeneous grouping, sexual and racial integration. Satisfaction is negatively related to class size, the larger the class size the lower the students’
satisfaction. (Walberg, 1969), and is consistently positively associated with student learning.

The competitiveness measures the emphasis on students competing with each other. Class emphasis on students competing with each other is a central concept in group dynamics. Competitiveness tends to be greater in classes with a higher proportion of boys than girls (Walberg & Ahlgren, 1970), but consistent relationships between competitiveness and student learning outcomes have not been established.

Test of Science Related Attitudes (TOSRA)

The TOSRA (see Appendix E) is a 70-item instrument using a 5-point Likert-like scale to record responses ranging from Strongly Agree to Strongly Disagree, and contains 7 sections with 10 items for each section. The sections are: 1. Social implications of science, 2. Normality of scientists, 3. Attitudes to scientific inquiry, 4. Adoption of scientific attitudes, 5. Enjoyment of science lessons, 6. Leisure interest in science, and 7. Career interests in science. In this research, only three of the seven categories of the TOSRA instrument were used to measure students' attitudes toward and about science and science attitudes. These categories are attitudes to scientific inquiry, adoption of scientific attitudes and enjoyment of science lessons.

Thurston and later Likert (as cited in White & Richardson, 1993) hypothesized that attitudes could be measured along a continuum from greatly favorable to greatly unfavorable. Harty, Anderson and Enochs (1984) tried to show the relationship between interest in science, attitudes toward science, and reactive curiosity of elementary students. They used Secord and Backman's definition of attitudes as regularities of an individual's feelings, thoughts, and predispositions to act toward some aspect of the
environment. In addition, Koballa and Crawley (1998) added that attitudes toward science are not inherited traits but are learned dispositions acquired over a period of time, perhaps years.

Koballa (1988) gave three reasons for studying attitudes. First of all, attitudes are relatively enduring; that is, people's feelings toward objects and issues are relatively stable over time. Although attitudes can be changed, such occurrences are not random as something must happen to cause the change. Second, attitudes are learned. Our students are not born liking or disliking the study of science in school, they learn to like or dislike it. Third, and most important, attitudes are related to behavior, that is, people's actions reflect their feelings toward relevant objects and issues in a probabilistic way. The studies of attitudes have been historically based on the assumption that attitudes are related to behavior.

One area of educational research has been on student attitudes and what effect the student's attitudes have on student achievement. Attitude research has been going on formally since the 1960s; however, early attempts to measure attitudes began with Thurston in 1928 and Likert in 1932. Sophisticated psychometrics concerning attitudes were developed in the early 1960s. Two major dependent variables in much of the attitude-related research has been attitude toward science and achievement in science. Over the past ten years, many results have emerged from these studies. A list of the major findings (White & Richardson, 1993) is summarized below:
1. Within the large population of students from grade 6 through 10, attitude toward science dropped each year. The greatest drop occurred from the beginning to the middle of the year. There was also a steady decline across grades, from sixth through tenth, with an overall attitude at the end of the tenth grade being near neutral. Attitude toward science was consistently higher among boys.

2. Declines in achievement motivation were markedly similar to declines in attitude toward science. Motivation dropped both within each grade and across grades 6 through 10, and the tenth grade was near neutral. Motivation to achieve in science was consistently higher among girls.

3. Adolescents' attitude toward science is highly positively correlated with their friends' attitude toward science. This relationship peaks in the ninth grade.

4. When ability tracks were considered, declines in attitude and motivation were most noticeable in the middle group. The conclusion drawn was that the additional attention paid to the advanced and basic groups may have drawn more of the attention and energies of educators with less resulting attention being paid to the average group.

5. School variables and, particularly classroom variables are the strongest influences on attitude toward science. While individual and home influences contribute significantly to this foundation, it is clear from the studies that the basic feelings an adolescent formulated toward the enterprise of science and toward their involvement with science courses, is in large measure mediated by the science classroom.

Misiti, Shrigley, and Hanson (1991) asserted that a positive student attitude toward science not only superintends scientific literacy, it could also have a bearing on our country’s global competitiveness. If a positive science attitude is a reasonable
expectation for young Americans, science educators must research the attitudes of adolescents.

For a complete list of the TOSRA questions that fall under each of these sections see Appendix F. The decision to use only these sections was based on two premises: First, that for the fifth and sixth grade students the time necessary for completion of the entire instrument was too great and could lead to fatigue, and second, that the three sections selected would be sufficient to supply the data necessary to assess their interest in and attitudes toward and about science. White and Richardson (1993) used the same three sections successfully.

Table 3

Description of Quantitative Instruments

<table>
<thead>
<tr>
<th>Quantitative Instrument</th>
<th>Categories/Scales</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>My Classroom Inventory</td>
<td>Cohesiveness</td>
<td>Measures extent to which students know, help and are friendly toward each other.</td>
</tr>
<tr>
<td></td>
<td>Friction</td>
<td>Amount of tension and quarrelling among students.</td>
</tr>
<tr>
<td></td>
<td>Difficulty</td>
<td>Extent to which students find difficulty with the work of the class.</td>
</tr>
<tr>
<td></td>
<td>Satisfaction</td>
<td>Extent to which the instruction meets expectations of the students</td>
</tr>
<tr>
<td></td>
<td>Competitiveness</td>
<td>Emphasis on students competing with each other.</td>
</tr>
<tr>
<td>Test of Science Related</td>
<td>Attitudes to</td>
<td>Interest, attitude, values and other affective behaviors of students.</td>
</tr>
<tr>
<td>Attitudes</td>
<td>scientific inquiry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adoption of</td>
<td>The degree to which students respond to and utilize the concepts and procedures of science</td>
</tr>
<tr>
<td></td>
<td>Scientific attitudes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enjoyment of</td>
<td>The degree to which students enjoy their science class, content, and applications</td>
</tr>
<tr>
<td></td>
<td>Science</td>
<td></td>
</tr>
</tbody>
</table>
Implementation

After selecting the instruments and researching the reliability and validity of the various instruments to insure that they would function as needed for the study the researcher began the process of preparing for the actual field study. During the first quarter of the school year, approximately one month before the beginning of the study, those early career teachers who had volunteered to participate in the study were contacted. The researcher received from each the names and phone numbers of their local administrators, and then proceeded to make arrangements for my initial visit to each of the schools. This early visit was initiated in order to meet the administrators and explain the nature, intent and procedure of the research. The researcher also arranged to meet with the early career teacher in order to deliver the necessary copies of the teacher, parent, and student consent forms (see Appendix A).

Initial Assessment and Procedures

After meeting with the administrators, the researcher went to the classrooms involved and introduced himself to the teachers and students. The researcher explained the research procedure and the necessity of the consent forms. He discussed each of the instruments and how the results would be used. The researcher explained the means by which the privacy and anonymity of all teachers, students and schools involved would be insured. He distributed the consent forms and remained in the classroom for the duration of the visit to gain an initial overview of the learning environment, teaching style of the instructor, and resources available. Before leaving, the researcher arranged for the second visit, a time to collect the consent forms, answer any new questions, and conduct the initial interviews with the early career teachers.
During the second visit, the researcher arrived so as to meet with each teacher during her scheduled preparation period; it was during this time that the initial interviews were conducted. In addition to the semi-structured questions related to the STEP project, the NSES, the teacher's instruction techniques and educational goals and objectives, the researcher also gathered information about the school, local community, demographics of the students, and answered any questions or concerns that the teacher might have; collected the consent forms, and encouraged those who had not returned their forms to do so. The researcher also distributed additional forms to those students who might have lost or misplaced their original copy.

During the third visit to each school, the researcher began the initial testing with the MCI as it required less time to administer (less than 30 minutes) and would allow for the students to be introduced gradually to the testing procedure. It was during this visit that the researcher collected the last of the consent forms and set up a procedure whereby the students who were not part of the study could continue their science education without interruption, usually by being allowed to participate in special projects, visit other classrooms, or work on assignments given by the classroom teacher in a location other than the research classroom. In addition, during this visit, the researcher collected copies of the science teachers' lesson plans and completed recording teacher and student initial interviews. Arrangements were made for the evaluation of the students using the TOSRA instrument on the following day.
Assessment During Study

Subsequent visits during the school year were used for observing the social, physical, and teaching/learning aspects of the learning environment. They were also used for the purposes of videotaping classroom instruction, student-student, and student-teacher interactions.

Final Assessment

The final two visits were used to conduct the end of research interviews and the concluding administration of the test instruments, the same protocol was used in all interviews and assessments. These were multiple day visits to allow sufficient time for complete and through interviews of both teachers and students.

Statistics

The data collected from quantitative reports were used for the following statistical analysis. For each student a change score was calculated from the results of the initial assessments and the final assessments for each scale or category. These change scores are employed in an analysis of the change in student attitudes toward science. The means of these scores are computed for the entire class, within each category for the associated instrument, i.e., the five levels of the MCI (satisfaction, friction, competitiveness, difficulty, and cohesiveness), and the three scales or categories of the TOSRA (attitudes to scientific inquiry, adoption of scientific attitudes, and enjoyment of science). The 57 students represent 57 data points for each of the 8 scales that will be employed for comparison and analyses of the effect of the three teachers on their students. An ANOVA will be calculated to determine the differences between teachers. Significance will be calculated at the 0.05 levels.
Measures

The following format (Table 4) was used for measurement and appraisal during the use of each of the qualitative instruments:

Table 4

Format for Qualitative Instruments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Measurement or Appraisal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science lesson plan</td>
<td>Did the lesson plans indicate a knowledge and utilization of practices and information related to the NSES? Was the lesson inquiry in nature? Was it student centered?</td>
</tr>
<tr>
<td>On-site observation</td>
<td>Focused on adherence to lesson plan, was the lesson plan followed in the presentation? Pedagogical implementation, classroom management, professional and personal interactions (teacher-student &amp; student-student), and a variety of descriptions of the learning environment were noted in the observations.</td>
</tr>
<tr>
<td>Semi-structured interview</td>
<td>The questions related to the early career teacher's pedagogical knowledge, knowledge of the NSES, and general information about the amount and kind of materials and support.</td>
</tr>
<tr>
<td>Videotaped teaching activity</td>
<td>These were used to support documentation of the on-site observation.</td>
</tr>
</tbody>
</table>

Conclusion

There is ample evidence and need for further research into the effectiveness of current reform efforts of science education. This is especially true in the area of science teacher preparation particularly for early career teachers. Two appropriate instruments for this research are the MCI, and the TOSRA. These instruments provide very relevant and important data related to students' views of their science learning environment, as well as
their attitudes toward and about science and their enjoyment of their science instruction. By investigating changes in their attitudes toward and about science and the number of hours allocated to the instruction of science in classrooms, we can arrive at a more comprehensive view of how well science reform efforts are influencing the pedagogical practices of early career teachers. In addition, this research describes how their teaching impacts the students in their classes. While quantitative data are very important and necessary, it is just as important that our views and conclusions are verified by the depth and richness of information that is only derived through supplementation with accurate and appropriate qualitative research.
CHAPTER IV

RESULTS

If research related to the recent efforts to reform science education is to be effective then the final evaluation of those efforts will be focused on the changes that occur in the behaviors and attitudes of the primary recipient of that science education, the students themselves. Teachers plan, present, and facilitate the science lesson, but the students evidence the results of those efforts. To assess the effect of early career STEP teachers on students' attitudes and time spent learning science, this research study used both qualitative and quantitative research methods. Data were gathered from students, their teachers, and the science-learning environment. Measures used included questionnaires, interviews with teachers and students, videotapes of actual classroom instruction and related artifacts (lesson plans, student work, and assessment items). The focus of this study was the impact of the teachers' pre-service training as related to the reform proposals in science education stressed in the NSES document and on their students' learning in classrooms. Emphasis was placed on determining change in the students' attitudes toward science, adoption of scientific attitudes, enjoyment of their science instruction, and the amount of time allocated to science instruction.

The results section involves two major sections. The first section presents the qualitative data and is organized around data gathered at each school, School A, then School F, and finally School U. Quantitative data is presented following each instrument used. First the TOSRA questionnaire data is presented by scale followed by the MCI questionnaire by scale.
Qualitative Data

To understand the text related to the following qualitative data, it is necessary to remember that the teacher at School A is Ms. A, the teacher at School F is Ms. F, and the teacher at School U is Ms. U. In the discussion of the qualitative data for each of the three schools observation data is discussed first followed by interview data and data obtained from the artifacts.

School A

The community in which School A is located in an area known for its recreational opportunities, geographic beauty and a large number of artisans with their associated specialty shops. These resources and resulting tourism give the population an economic base that would be considered to have an average distribution for annual income. The population tends to fluctuate seasonally with the majority of the students coming from families that are permanent residents in the area. While there is a middle school within the system, it is operated more as an extension of the elementary program and reflects few of the practices representative of the modern middle school program. The average class size in School A is approximately 25 students. The school’s facilities are relatively modern having been constructed within the last 10 years. The teaching staff has an average of over 10 years experience within the district. Facilities and materials for the teaching of science are limited in variety and availability, with the majority of new curriculum materials being in the form of kits and other consumable items. It should be mentioned that each classroom has at least one computer with Internet access, which is often used in the educational process for research and enrichment by both students and teachers.
Observations

Teacher A is employed in a combined elementary and middle school located in an artists community in northwest Montana. In the classroom of Ms. A, there were large numbers of student-centered, inquiry-oriented, minds-on activities. Of particular note was the fact that these activities placed an emphasis on science process skills, critical and creative thinking, and cooperative group learning and included a variety of student-centered, teacher facilitated science activities.

The science activities were based on cooperative group procedures that required students to collect data, make inferences, and draw a consensus conclusion. The format was one in which the students, assuming pre-assigned community and societal roles, performed critical-thinking, decision-making activities related to a variety of environmental and social issues. The students then individually, and as a group, report their conclusion (including justifications) to the entire class. These activities were based upon science trunks containing a variety of artifacts that supported the activities and related scenarios.

The researcher had the opportunity to visit Ms. A's classroom for both observations and interviews during two of the weeks in which the bear trunk and the elk trunk activities were being conducted. While the instructor decided many of the universal procedures and limitations, overall the students decided on their individual and group actions used to reach a final solution to the activity. During the observations, the students were actively reading and summarizing the written documentation that directed and supported the introduction of the activities. The students were free to move around the classroom, self-directing their own research and activity plans.
For fifth graders, the students showed an exemplarily degree of self-control and motivation causing no interruptions in the activities of the other groups or of the overall learning process. Additionally, the students used their time efficiently, were consistently on task and advancing toward their perceived goals, with a very minimum of intrusion on the efforts on the other classroom groups. The serious effort placed on their activities indicated great interest and enjoyment in their science class. This is supported by the consistent manner in which the interviewed students stated that they enjoyed their science class and the related activities. On the day when the students were involved with the Elk Trunk, groups of students (divided into teams that were teacher selected to insure each group contained members of both genders, the only diversity within the class group) viewed and handled the artifacts in the Elk Trunk (antlers, major bone groups, and a hide). The purpose of the students working with the artifacts was to facilitate each group's use of critical and creative thinking to develop a written description of the physical appearance of the elk. Following the preliminary part of the activity, the groups joined large sheets of paper in an attempt to draw the elk to actual size.

A concurrent activity involved the students using the Internet to research the environmental impact of elk. They researched the habitat and food requirements per animal followed by the average herd size. Then the teams used that information to determine the habitat and food requirements for an average sized herd. This information was then used to generate graphs that were used to support the final presentations to the class. The presentations were to portray a negotiated decision between locally concerned individuals and groups (the societal roles of farmer, real estate agent, scientist, and citizen
groups) on the feasibility based upon the positive and negative impacts of importing and establishing a herd of elk on local resources.

The entire “trunk” activity required approximately 6 days to complete, so the researcher was able to see the first day and then the final presentation one week later. Ms. A plans for a science lesson each day (information from interviews and lesson plans). She teaches in a self-contained classroom and thus she utilizes her instructional schedule flexibility to allow the science instruction time to range from a minimum of about 40 minutes to a maximum of about 60 minutes.

**Interviews**

When interviewing the students after the completion of the unit on elk, the researcher asked questions related to the enjoyment of science. The researcher first asked, “What do you like most, or least, about the way your science class is being taught this year?” The students responded with comments such as “I like how we all work together, and the teacher helps us when we raise our hands and ask questions or seem stuck, she just doesn’t let us do our worksheets.” Another question asked was “How is your science class different this year?” The responses were very similar to those of student Ann—

Well-um—my teacher last year, she didn’t do much science. She was more like math. She wasn’t much of an outdoors person. [Ms. A] does a lot of outdoors stuff, field trips, and bug catching. And we get these trunks and we had a town meeting, I was a farmer in the con group. I was against it [the introduction of the elk herd]. We talked to each other about it, and we were bringing up all the bad points and stuff. I realized that I wouldn’t allow them to bring them here now so it really changed my attitude about it.
Ann was one of the students who originally wanted to reintroduce elk into the local forest but was given the role of a farmer. In the scenario, the farmer was against the reintroduction but her group was given the task of researching data sources looking for information related to the negative impact related to the elk reintroduction. Julie’s response to the same question was:

Um—well most I like — [Ms. A] is good at teaching [science]. She participates with us. I mean she works with us, she doesn’t make us um just give us a written out test, we get to explore and we get to look around and stuff. If I told her that I thought that there was some type of graph for [referring to the task related to the presentation on the elk unit] she would let me go and look for something. She is really free with it like she wants us to learn just because it’s a science class; she wants us to learn all we can about it.

Another comment by the same student further supports the attitudinal change;

“Well, I didn’t like science that much for a long time; I mean, I like science now, but I mean that it was not something that I looked really forward to in the day when we got to come to science. It is fun now.”

In the end of the study interviews, Ms. A’s students made similar comments. When the researcher asked about differences in their science class from past years and their enjoyment of their class, one student replied, “Well, we are doing a lot more of it this year. We’ve learned about the human body and like we had groups and we each made paper human bodies and we taught systems, I did the respiratory system, and I think it is a lot more fun… science is my favorite subject.” Another response was “I like this year better because we have more time and we usually do it at the end of the day and
I usually just get into it and then it is like time to go.” A final comment of interest was “This is the most science I have ever learned, I like science.”

When asked about the amount of time spent on science lessons and how that compared to years past the responses were indicative of daily science teaching from 40 to 60 minutes, or that science was taught five times a week. The students often commented that their teacher in grade four rarely did science and then it consisted of reading from the text as she really liked math and they did math instead of science. Ms. A’s lesson plans also indicated approximately 50 minutes of science instruction each day, and that was corroborated by observations on each visit.

Adoption of scientific attitudes is a very important and positive indicator of a modern reformed science education program. In the observational notes, and in reviewing the video-taped classroom activities, the researcher noted many instances where the students, while discussing the best way to complete an activity or assignment suggested and implemented the science process skills in a self-planned experimental approach to that activity or assignment.

The students generated hypotheses, tested those hypotheses, collected data, made observations and inferences, and then drew conclusions based on the results of their efforts. One such activity involved a challenge to scientifically determine the correct amount of water that a seed needs to germinate. The students were given cups, potting soil, seeds, containers of distilled water, and graduated cylinders. The activity “challenge” and those materials were the basis for the students’ activity. The students were divided into teams and then allowed to work together to devise an experiment to
arrive at the correct answer. Upon arriving at their proposed experiment, each team had to obtain the teacher's permission to continue with the experiment.

During this activity, no proposals were refused as Ms. A wanted to allow the students to have the opportunity to learn from mistakes in their plans. With the experimental plan approved, the students then had to formalize the steps to be used in their experiments and then implement them. They designed lab sheets, divided responsibilities, determined variables and controls, and began their experiments. The activity became a daily part of the time allocated to science instruction. A laboratory notebook was maintained by each group and checked weekly by the instructor for completion and accuracy.

Even though the researcher was not able to visit during each day of the activity, conversations with the teacher and students indicated that all parties involved had a very positive attitude toward the challenge and the resulting activity. There was great excitement when the seeds started to sprout, and an equal amount of discussion concerning possible causes of failure to get the seeds to sprout among those team members whose experimental designs or procedures were not being successful. It was in any case very evident that the students knew, and recognized the importance of, a scientific approach to problem solving.

An analysis of Ms. A's lesson plans indicated that very early in the school year she had allocated considerable time to the students learning the concepts and practices associated with the processes of scientific inquiry. On no occasion during the activities that the researcher observed in Ms. A's classroom did the students fail (often with some discussion and guidance from the entire class or instructor) to follow the scientific
method, utilizing at least the basic science process skills in their laboratory or class activities.

During the end of study interviews, students often made very positive comments about the cooperative group work and the hands-on nature of their activities. Julie commented that she did “more hands-on and no taking notes from the textbook.” Other comments about their preference for science instruction were “This year we are doing more like the trunk with animal skins, and a lot more than last year. Last year we mostly had books and just studied. Now we do that rarely and we do activities and teach people in the class about that lesson.” “Our teams work together well, I’ve been in groups at times when you have people who usually don’t get along well, but we tend to work better together than people who really get along well.”

School F

School F is located in an area surrounded by a national forest, resulting in an isolated rural community with a stable population of less than 500 people. The economic base of this community is dependent upon timbering and related forestry resources. This results in a population, and school district, whose financial situation fluctuates with current timbering policies and practices. The social and educational philosophy is best described as conservative in nature. It is slow to implement change and tends to retain beliefs and practices. This is perhaps best demonstrated by the fact that their textbooks are all over eight years old, their use of lab manuals are based upon verification activities, and the lack of modern laboratory equipment. A strong indicator concerning the hesitancy to adopt more modern educational practices is seen in the non-utilization of computer resources during instructional efforts, often the computers
do not have Internet access or the computers themselves are non-functional. The physical plant is small, with no new buildings. This reflects a school population approaching 100 students, approximate 10 students per class, with grades Kindergarten through eighth grade. The faculty is composed of mostly older teachers with many years of experience who tend to have a proprietary attitude toward available resources. Indeed, there exists a sense of isolation within the facility with little interaction occurring among teachers.

Ms. F teaches in a school that contains students enrolled in grades Kindergarten through eighth. Ms F has her students for most of the day except for physical education and fine arts, and is responsible for teaching all content areas. The school has an enrollment of approximately 80 students. The school is located in a small town located in a national forest area, where most of the local jobs are related to the timber industry. She only has 11 students in her class of which only 7 participated in the research. Having so few students in her class, it is her belief that whole class activities are as beneficial as small group ones, so only occasionally does she break them down into smaller groups of three or four per team. There are still numerous cooperative activities, but there is usually only one group of which everyone is a member.

Observations

The initial activity, which the researcher observed, involved a specialist from the United States Forest Service who directed a study of the flora and fauna on land owned by and adjacent to the school. At first the students observed and made notes concerning the characteristics of the various types of trees and then used identification keys to determine the species of each tree. Following this part of the activity the students did a representative population count of the number of each identified species. Using this data
the students generated graphs and figures illustrating the relative numbers of each species.

The visiting specialist then lead a discussion on the value and utilization of each type of tree (home building, paper making, general construction, fire wood, erosion prevention, and habitat for the native species which made their home there) and the employment opportunities that were associated with forest use in general. A student (John) when interviewed about this activity responded: “We have been doing this forest thing most of the year. We find tracks from the game trails and find what kinds of trees are out there because we are going to log it, in about,... I don’t know, five years probably.” The students seemed particularly interested and knowledgeable about this portion of the activity since the majority of their families have financial income that is in some way related to the forest industry and thus it had very real world relevance for them.

The specialist also led the students in a discussion related to the animal species in the forest. The students found and identified animal tracks on game trails. The researcher asked them who hunted, what they hunted and how that hunting might effect the populations of the various species. This was followed by a discussion of the importance of the different animals to the overall health of the habitat for the native species present. The students were very aware of the predator-prey relationship. During the discussions there was substantial student response and participation, asking questions, giving answers and offering personal opinions.
Interviews

There were occasions when the entire class became very actively involved in the discussion process. One student, Leslie, noted in an interview, that the whole class discussion was something different for them in their science instruction. The comment was “When we have to come to a decision, we [the whole class] get together and decide all the possibilities and decide what we are going to do.” A sample of these lively discussions of benefits and disadvantages developed among the members of the class, when the topic switched over to the necessity of having fishing and hunting regulations to help preserve a viable population of the assorted game animals in the forest. This enthusiastic participation may reflect the fact that many of the students’ families use hunting as a means to supply meat for food requirements.

In the researchers’ observation notes, there were few notations related to the formal instruction, or implementation, of the scientific method in a formal laboratory activity. However, the students did utilize the basic science process skills and many activities required critical and creative thinking. There was no textbook used in the science instruction and the use of student-centered activities and instruction were the rule rather than the exception.

The students in Ms. F’s class responded in much the same fashion as those in Ms. A’s class when asked about their enjoyment of their science instruction and the amount of time allocated to science instruction. For example, all of the four students interviewed responded to the researcher’s question with comments that indicated that their science instruction the year before had been textbook driven with no laboratory or outside activities. Ms. F’s and her students’ commitments correlate with observations made of
them in later November or early December when they were performing an activity (with approximately two feet of snow on the ground) to determine the difference between the temperature of air, the snow, and the snow-covered ground. They spent approximately 30 minutes outside in the data gathering area (the air temperature was below freezing), collecting data that they then collated and graphed for display and follow-up discussion. One student (Carol) commented, “What I like most is we get to do more activities, we don’t just sit down and work.”

Many comments were made about there being much more science instruction during the current year compared to previous years. One student (John) commented, “Well, other years it was mostly out of the book. This year we go outside a lot and it’s a lot more funner.” Another student’s (Leslie) comment was, “We do a lot of experiments and sometimes we may find out that those experiments just don’t work out.” There was one student whose comments while initially not as positive as the others did in fact support the general trend of positive comments. The researcher asked “How do you feel about the science instruction in your class this year?” The reply was “I guess it is ok.” The researcher followed up with the question “If you could change your science class, what would you change?’ The reply was “more activities.” When asked how often they did an activity, the response was “Maybe twice a week.” This student’s comments were corroborated when the next student responded to the question “Is your science instruction different this year than in years past?” with the response “Yeah, it is different. We work more in experiments and stuff instead of out of the book. We do more activities, some every week.” There were comments about working in teams and on projects that required research.
However, there is minimal use of the Internet and related technology as the school has little available (there are two computers in the classroom one does not have a modem card and therefore has no Internet capabilities, the other computer allows only occasional access to the Internet as it is shared with other teachers in the adjacent classrooms). Most of the inquiry is completed using printed materials in the library and from interviews with local resource people. However, this did not reduce the learning opportunities for the students or their enjoyment of the activities.

In interviews, the students consistently expressed a positive attitude toward science, the important impact it had on their lives, and their science instruction. There was genuine interest in the subject matter and the students actively participated in all assignments and activities. The students’ lack of knowledge about the basic science process skills became very evident during an activity that was conducted near the end of the research. The activity related to the four basic types of chemical reactions. The students were doing an activity from one of the commercially available science kits on chemical reactions. That activity required the students’ utilization of basic laboratory equipment such as, graduated cylinders, balances, funnels and filters. The students demonstrated no hands-on skills related to the use of the instruments, and did not know the correct methods for measuring using the cylinders or balances, they did not understand the impact of the meniscus or the necessity of “zeroing” the balances before measuring. Each of these concepts and practices had to be taught before the students could proceed with the lab activity. This led to a comment by Ms. F. that this was not uncommon and that it made her less willing to have the students become involved in what she called “difficult and complex laboratory activities.”
There was also a minimum of laboratory safety equipment, some older safety glasses, a fire extinguisher, and a very basic first aid kit (it was actually located in the gym, which was adjacent to the classroom). However, these were sufficient to meet the safety requirements associated with the activities that were conducted by the students. Ms. F also commented that this was an additional concern for her and did increase her reluctance to conduct many laboratory activities that would have been advantageous to her students' learning experiences.

At Ms. F's request, the researcher visited the classroom for three consecutive days in order to observe the completion of the lesson. Students were able to utilize the process skills taught on the first day in subsequent days' science activities. In fact, there were examples where the students were reviewing the processes, and helping other class members refine their utilization and understanding of some basic process skills, observing, measuring, recording data, predicting and hypothesizing.

The students were very enthusiastic about their science lessons and when interviewed expressed great delight in their science instruction and its related activities. They liked the class, they enjoyed their science content and activities, and they were excited that they were learning more about how to do science than in previous years. In each of the science activities that were observed the students were verbally enthusiastic about, and eager to demonstrate, their learning in the use of science laboratory skills and processes.

During those interviews, the students said that they had science class everyday; this was collaborated by Ms. F's lesson plans. However on some of the days that the researcher visited the classroom, during the time noted on the lesson plan for science, the students were engaged in language arts activities (writing or working on a play they were
to perform later at an all school activity—an extra-curricular activity Ms. F was supervising) or were working on math worksheets. Ms F explained that she did not maintain a strict time schedule for teaching, but rather used the days’ instructional time to complete activities as needed. Ms. F said this practice included science education; this statement was substantiated by observations of extended science instruction on the days involving the visiting Forest Service resource person.

It is worth noting that Ms. F often integrated science into her other content lessons. One example relates to the play activity situation in which the students worked on composing and performing a commercial for classroom safety during an earthquake, another example dealt with a math lesson, the students were using problem-solving activities that involved units that were science related (i.e. mass, density, metrics, speed.) These problem-solving activities did occur during some of the times scheduled for science instruction. Some students made comments reflecting that they had confused this instruction to be science centered rather than mathematics instruction. This was reflected in the interviews when they made the statements that they had received science instruction on that and every other day. These researcher questions and the students’ answers were from interviews conducted during the entire research cycle. There were no obvious differences in the general classifications of the response categories when reviewing the observation or interview notes.

School U

School U is located in a community that is often considered a “bedroom community” of a nearby city in which a major state university is located. The economic base for this community is very much dependent upon its proximity to the
nearby city with a population approaching 50,000. Even though there are no major employers, services, or industry within the community, the average family income would be considered average or higher for Montana. The average class size is 25.

Over the past decade, there has been continued support for the school district demonstrated in the community successively passing bond issues for the construction of new school facilities and for the purchase of supplies and equipment. The population is generally stable although there are families that relocate seasonally. The community and educational philosophy for School U is one that is also very centrist; it allows for change and growth, while at the same time it retains many of the “traditional” values related to family structure and Christian foundations. Educationally, School U has implemented a science curriculum that is not textbook based, utilizes a number of hands-on activities, and is well supported with materials and supplies. This program is implemented to differing degrees by the faculty. Some of the older faculty still utilize the teacher-centered approach to science instruction, but verbally support the efforts of those teachers implementing the newer curriculum. The faculty is an even mixture of experienced and early career faculty members. As in School F, there are several cliques within the faculty group; however, unlike School F, the faculty at School U are very willing to share materials, ideas, and teaching suggestions. In addition, the faculty meet often to discuss their common curriculum and students.

Ms. U is employed in a community located in close proximity to a state university. The school receives good local support in the form of voter approved school bonds and tax levies. It has a middle school section that is less than ten years old, and a faculty that
has a significant number of very experienced teachers. Ms. U's sixth grade class has a daily rotating schedule spending slightly less than one hour a day in science. There is a further rotation on a quarterly schedule where students are scheduled for electives during one period a day. The number of science classes Ms. U teaches does not change, but each quarter she gains one new section of science students as it replaces one section that is then rotated to the elective classes.

Observations

Ms. U's method for teaching science can best be described as conventional, that is, she utilizes textbooks for content and the publisher's associated laboratory manual for many of the labs and activities. However, she does employ cooperative learning teams during the labs, and there is emphasis on the scientific method and science process skills. During lab activities that were observed, the students were very proficient with their usage of scientific apparatus such as balances, graduated cylinders, thermometers, funnels, beakers, laboratory burners, and an assortment of beakers. They had access to and correctly used all necessary safety equipment, and were very practiced at laboratory safety procedures. When performing laboratory activities in the classroom (there was no separate laboratory facilities) safety rules were posted and safety procedures demonstrated before and during the activities. The students were very attentive, often replying to questions from Ms. U related to procedures and activities voluntarily and accurately.

The first observed activity during the research dealt with the physical characteristics of mixtures and compounds. Ms. U first explained, using the lecture and discussion method for content delivery, the scientific concepts related to the activity and then
explained the laboratory procedures and demonstrated the relevant techniques. The students were divided into teams of four students and then allowed to collect their safety glasses and aprons. Then using balance pan and triple beam balances the students accurately measured the required amount of each component to be used in the activity. There was no evident “horseplay” in the room during the activity and the students went about the undertaking with an attitude of serious determination to complete the laboratory activity in a well-organized manner utilizing all of the time allotted. As teams they discussed the laboratory report sheet requirements, completing data and observation sheets as each step in the activity was accomplished.

As the research cycle continued, the researcher observed the students involved in more activities and they were generally more positive toward their instruction. Ms. U had them perform a number of activities in which some physical phenomena was unexplained and the students were instructed to work in their groups to hypothesize how the particular phenomena occurred and to share their hypothesis and inferences with the rest of the class. It was often very competitive and the students became very animated and vocal. During one observation, the researcher saw just such an activity that involved working with yip sticks. The students seemed to be having a difficult time developing a hypothesis on the mechanics of the yip sticks. However, they were obsessive in their determination to solve the problem. The teams worked well together coming up with several possible solutions, but when they tried them, they failed to reproduce the phenomenon, and they immediately went back to their efforts. While it was competitive, there were no harsh or derogatory comments within or across the teams. The atmosphere
was one of the students against the problem. Successfully solving the problem was the goal of the entire class.

**Interviews**

At the beginning of the research cycle, when asked about differences in their science classes, one student replied “I don’t think it is very different but is a little bit — learning more than 10 to 20 elements at once.” The same student when asked how often they did laboratory activities replied. “I think only once and we did like experiments of something she already did; the teacher is set, so it’s alright.” Asked about his previous year’s science instruction he stated, “It was my best year in science. We did lots of space science and that is my favorite subject.” He continued with “Mr. X was great- he liked space science too, and we did lots of fun activities in class.”

However, when the researcher asked another student a follow-up question related to their opinion of whether Ms. U’s teaching style matched his preference for science instruction he replied, “Yes, basically because when we were learning the first three groups of the elements we, she, set up this activity where we had little pieces of paper with clues on them and we had to figure out which element, we had to go through the castle, each room in the castle was made up of a different element, that was really fun.” The same student was asked about their favorite way of learning science the answer was “I like to learn by doing or reading, I really don’t like the teacher to tell me because that takes all the fun out of it, and I like a challenge.” The researcher then asked if the student felt that Ms U’s teaching style was what she liked or desired in her science instruction. She replied with an unyielding “Yes!”
The third student in this interview group was very much the science aficionado, a student who “loved science.” The student especially liked chemistry. However, the student’s choice for science instruction was for “the teacher to tell you.” The student went on to say that the castle activity was “kind of cool” and they were the first one to figure it out. The student was very proud of her accomplishments in science and wanted to take more science classes later. The fourth and final student in the interview group was also a science enthusiast, his favorite thing was “experiments.” He said that in the previous year they had done more experiments, but that they were just “getting there” in the current year. If he could make a change in the way science was being taught during the current year, that change would be “more experiments.”

All the students interviewed agreed that they worked in groups of three or four and they like doing so and were very comfortable with that method of learning. When the researcher asked questions related to the previous unit on chemistry, memorizing the first 20 elements of the periodic table, the students were able to answer all questions correctly, if not passionately.

In later interviews and observations, the students continued to express a desire for more “experiments” and “more activities where they got to do things.” They were always more dynamic when their activities involved the use of laboratory equipment. For example, in a lab where they worked with prisms, they were often involved in activities that were not part of Ms. U’s plan, but were on task talking, questioning, trying to explain, and generally expressing awe at their discoveries. However, when involved in the laboratory activities that were mainly an endeavor of following the laboratory sheet
instructions, they were often bored and showed little or no eagerness for the tasks assigned.

While the results of reviewing artifacts and the qualitative data were very powerful, to allow for verification through triangulation, quantitative data were also collected and analyzed through statistical manipulations.

Quantitative Data

The results of the quantitative data is presented in a fashion that allows a more comprehensive overview of the results as they were compiled and evaluated through the use of data collected from all the students involved in the research. This allows for a population size that facilitates the use of more responsive and sensitive statistical procedures. Results are presented with the TOSRA data first followed by the MCI data.

The N for the samples changes between the MCI and the TOSRA. This happened because if a student withdrew from the study all materials related to that student were destroyed. In addition, if a student was missing either the first or second administration of the test item, then both were removed from the data. In order to define the N for each test Table 5 presents the number of students participating at the beginning of the study and the number actually involved in the data calculation for each test instrument and teacher.

Test of Science Related Attitudes

The first quantitative data presented will be the three subcategories of the TOSRA instrument. Those subcategories are 1) attitudes toward science 2) adoption of scientific attitudes and 3) enjoyment. As previously mentioned, the data was analyzed for a change in attitude using two different test applications, the first near the beginning of the study and the second at the end of the study. The change was calculated by subtracting the
mean of all students' (from each early career teacher's class) scores on the second test application from the mean of all students' scores on the first administration of the test.

This gives a view of the resulting change for each classroom group of students.

The figures representing the data will be presented in the following order: first will be Attitude Toward Science, this is followed by Adoption of Scientific Attitudes, and last will be the figure related to the measure of the students' Enjoyment of Science.

Table 5

Description of the N for each Quantitative Instrument

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Number of students at beginning of study</th>
<th>Number of students participating in study</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ms. A</td>
<td>25</td>
<td>21</td>
</tr>
<tr>
<td>Ms. F</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Ms. U</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Totals MCI</td>
<td>60</td>
<td>53</td>
</tr>
<tr>
<td>TOSRA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ms. A</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>Ms. F</td>
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<td>8</td>
</tr>
<tr>
<td>Ms. U</td>
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<td>24</td>
</tr>
<tr>
<td>Totals TOSRA</td>
<td>60</td>
<td>56</td>
</tr>
</tbody>
</table>

Attitudes Toward Science.

The figure generated from the data representing change in attitudes toward science is presented in Figure 2 below. This figure indicates that the students, N=21 in Ms. A's class showed a change in mean of 0.321 in their attitude toward science. Ms. F's class, N=8 showed a change in mean of 0.005. Ms. U's class, N=24, showed a change in mean...
of 0.217. These three change scores had a positive value, suggesting a more positive attitudes toward science at the time of the second testing.

![Bar chart showing change in mean scores for subcategory Attitudes Toward Science.](chart.png)

*Figure 2. Change in mean scores for subcategory Attitudes Toward Science.*

*Adoption of Scientific Attitudes.*

The data representing the change in means scores for the subcategory adoption of scientific attitudes, the second of the subcategories for the TOSRA instrument are displayed in Figure 3. The change in mean scores for Ms. A was a positive value of 0.363. Ms. F’s class had a positive change in mean scores of 0.187. The positive change in mean scores suggests that the students in these two classes had a greater adoption of scientific attitudes at the end of the study than at the beginning. However, Ms. U’s class had a change in mean scores value of −0.708. This negative value suggests that the
students demonstrated less adoption of scientific attitudes at the end of the study than at the time the first test was administered.

![Graph showing change in mean scores for subcategory Adoption of Scientific Attitude.](image)

**Figure 3.** Change in mean scores for subcategory *Adoption of Scientific Attitude*.

*Enjoyment of Science.*

Figure 4, Change in Mean Scores for Subcategory “Enjoyment of Science” shows that Ms. A’s class had a negative value for the mean score change of −0.008, or essentially zero. This suggests that the students’ perceptions were unchanged at the end of the study compared to the time of the initial testing. Ms. F’s class had a mean score change that was a positive 0.700 indicating a more positive enjoyment of their science instruction at the time of the final testing than at the time of the initial testing. The change for Ms. U’s was very small but negative at a change value of −0.155. Again this
suggests less enjoyment of the science instruction at the conclusion of the study than at the time of the initial testing.

\[ \text{Figure 4. Change in mean scores for subcategory } \text{Enjoyment of Science}. \]

\textit{My Classroom Inventory}

The second set of quantitative data presented will be five categories of the MCI. The data for all schools are represented on the same figure for each particular sub-category of the MCI. The MCI data are gathered from two instruments; first is the data from a "Preferred" form of the instrument or what students would prefer to have happen in the classroom learning environment. This is followed by data from the "Actual" form of the instrument that measures what students actually perceive is happening in the classroom learning environment. The data, figures and related discourse will be presented from the "Preferred" Form. This will be followed by the data, figures, and discourse related to the
“Actual” form of the MCI. The titles are indicative of the type of questions asked on the two instruments; first the questions ask for the students’ preferred classroom learning and teaching environment and the second set of questions ask for their actual perception of the classroom learning and teaching situation.

As with the TOSRA data the change in mean score was calculated by subtracting the mean of the second utilization of each form of the instrument administered near the end of the project from the mean from the first measurement administered early in the research project using the same form of the instrument.

Preferred Form

Satisfaction. The figure generated from the data representing change in the means for the preferred satisfaction subcategory is presented in Figure 5.

![Figure 5. Change in means from the preferred form of the MCI in the subcategory Satisfaction.](image-url)
The data in Figure 5 show that Ms. A’s class had a positive mean change in the value of 0.73. This indicated the students preferred more satisfaction with their classroom at the end of the study that at the time of the initial testing. Ms. F’s class had a positive mean change in the value of 0.95. This indicated her students also preferred more satisfaction with their classroom. Ms. U’s class had a small positive change in the mean value of 1.08. This indicated a slightly greater preference for satisfaction.

Difficulty. The figure generated from the data representing the changes of the means from the MCI preferred difficulty subcategory is presented in Figure 6.

*Figure 6.* Changes in means from the preferred form of the MCI in the subcategory *Difficulty.*
The data in Figure 6 show that Ms. A's class had a mean change in value of -0.17. This indicated that the students actually preferred less difficulty in their science instruction at the end of the study than at the time of the initial testing. Ms. F's class had a change value in the means of -0.20, also indicating a preference for less difficulty at the end of the study. Ms. U's class had a change value of 0.06, indicating a minimal preference for less difficulty at the end of the study.

Competitiveness. The figure generated from the data representing the changes in the means from the preferred competitiveness subcategory is presented in Figure 7.

![Figure 7. Changes in means from the preferred form of the MCI in the subcategory Competitiveness.](image)

The data in Figure 7 show that the change in mean values for the students in Ms. A's class was -0.13, which indicated a preference for slightly less competition in the classroom. Ms. F's class had a change in mean value of -0.75. Ms. U's class had a
change value that was 0 indicating that the students had no desire for change in competitiveness between the two administrations of the MCI, related to competitiveness.

*Cohesiveness.* The figure generated from the data representing the changes in the means in the preferred cohesiveness subcategory is presented in Figure 8.

*Figure 8.* Changes in means from the preferred form of the MCI in the subcategory *Cohesiveness.*

Figure 8 displays data that shows the students involved in the study indicated a preference for only minor changes in cohesiveness between the two administrations of the MCI instrument. Ms. A's class had a mean change value of -0.09. The mean change value for the students in Ms. F's class was 0.45. Ms. U's class had a mean change value of -0.17.
Friction. The figure generated from the data representing the changes in means for the preferred friction subcategory is presented in Figure 9.

![Figure 9](image)

Figure 9. Changes in means from the preferred form of the MCI in the subcategory Friction.

Figure 9 displays data, which indicates that Ms. A's class had a mean change value of 0 for friction. Indicates a no preference for less friction in their classroom teaching/learning situation. The mean change value for Ms. F's class was -0.75. The change in mean value for Ms. U's class was 0.02 related to the preferred amount of friction in their class. These minimal change values for the subcategory-friction.

Actual Form

The following five figures represent data collected from the actual version of the MCI instrument.
Satisfaction. The figure generated from the data representing the change in means for the actual satisfaction subcategory is presented in Figure 10.

![Figure 10](image-url)

Figure 10. Changes in means from the actual form of the MCI in the subcategory Satisfaction.

Figure 10 shows data for the subcategory – satisfaction for the actual form of the MCI; it shows that Ms. A’s class had a change in mean value of -0.89. This score indicates that the students perceived less actual satisfaction with their science instruction at the end of the study than when the initial assessment was taken. Ms. F’s class had a change in their mean scores of -0.75. This score also indicates less actual satisfaction at the end of the study. Ms. U’s class had a mean change in their scores of -0.02. Thus, indicating a lower degree of satisfaction at the end of the study than at the initial testing.
Difficulty. The figure generated from the data representing changes in means and average mean change for the actual difficulty subcategory is present in Figure 11.

![Figure 11](image)

Figure 11. Changes in means from the actual form of the MCI in the subcategory Difficulty.

The data in this figure indicates that Ms. A's class had a change in mean score values of 0.12. This value indicates that the students perceived an increase in the actual degree of difficulty in their science instruction. Ms. F's class had a change in mean score values of 0.35. The students in her class also perceived an actual increase in difficulty in their science instruction. Ms. U's class had a change in mean score values of 0. This indicates a perception of a very small increase in difficulty related to their science instruction.
**Competitiveness.** The figure generated from the data representing the change in means values in the actual competitiveness subcategory is presented in Figure 12.

![Figure 12](image_url)

*Figure 12.* The means of change values from the actual form of the MCI in the subcategory *Competitiveness.*

Figure 12 shows that the students in Ms. A's class had a change in mean score values of 0.36. This indicates an increase in competitiveness at the end of the study compared to the time of the initial testing. Ms. F's class had a change in mean score values of 0.53. This also indicates an increase in competitiveness during the time of the study. The change in mean score values for Ms. U's class was -0.08. This value indicates that the students in her class perceived the classroom teaching and learning situation to be less competitive at the end of the study.
Cohesiveness. The figure generated from the data representing the changes in the mean for the actual cohesiveness subcategory is presented in Figure 13.

![Figure 13. Mean of the changes from the actual form of the MCI in the subcategory Cohesiveness.](image)

The mean of the change score values for cohesiveness in Ms. A’s classroom was -0.32. This value indicates an actual decrease in the amount of cohesiveness in the classroom. Ms. F’s classroom had a change in mean score values of 0.70. This data value also indicates a decrease in the amount of cohesiveness in the classroom. There was also a small negative value for the change in means scores for Ms. U’s classroom. The change value for her class was -0.07.
Friction. The figure generated from the data representing changes in the mean scores for the actual friction subcategory is presented in Figure 14.

![Figure 14. Change in means from the actual form of the MCI in the subcategory Friction.](image)

The data in Figure 14 indicates for Ms. A. had a change in the mean score value for friction of 0.80, this means that there was an increase in friction in the classroom at the end of the study when compared to the final assessment. Ms. F’s class had a change in mean score values of 0.95 for the subcategory friction. The change in mean score values for Ms. U’s classroom was -0.14. The data indicated that the students in Ms. U’s classroom perceived that there was less actual friction at the termination of the study (final assessment using MCI) compared to the friction at the initial assessment. This indicates that there was an overall increase in friction during the course of the study.
The statistical analyses includes means, ANOVA, and Post Hoc test—Bonferroni & Tamhane (George & Mallery, 2000) are included in the appendices for this report, and they indicate the relationships that exist between groups of students who have a significant difference at the 0.05 level of significance.

The maximum numerical value for a response on the MCI was a 3, the maximum change value was either a -2 (final value of 1 minus an initial value of 3) or a +2 (final value 3 minus an initial value of 1). The maximum numerical value for a response on the TOSRA was 5, therefore the maximum change value was either a -4 (final value of 1 minus an initial value of 5) or a +4 (final value of 5 minus an initial value of 1).

On the analysis of the Preferred form of the MCI, range of the maximum change value calculated for the subgroup — satisfaction was from a minimum value of 0.73 (Teacher A) to a maximum value of 1.08 (Teacher U); for the subgroup friction, the range of changes in mean values was from to −0.75 (Teacher F) to 0.02 (Teacher U); for the subgroup cohesiveness, the range of changes in mean values was from −0.17 (Teacher U) to 0.45 (Teacher F); for the subgroup difficulty, the change scores ranged from a value of −0.20 (Teacher F) to 0.06 (Teacher U); for the subgroup competitiveness the range of change scores was from a value of −0.75 (Teacher F) to 0.0 (Teacher U).

For the Actual form of the MCI the range of the value changes for the subcategory satisfaction was from −0.89 (Teacher A) to a value of -0.02 (Teacher U); for the subcategory friction the range of change scores was from a value of −0.14 (Teacher U) to a value of 0.95 (Teacher F); for the subcategory cohesiveness the scores were from a value of −0.70 (Teacher F) to a change score of −0.07 (Teacher U); for the subcategory difficulty the range of change score ran from a value of 0.00 (Teacher U) to a change...
value of 0.35 (Teacher F); for the final subcategory competitiveness the range of change score ran from a value of -0.08 (Teacher U) to a change value of 0.53 (Teacher F).
CHAPTER V
DISCUSSION

The purpose of this study was to examine and describe the science instruction that was delivered in the classroom of early career teachers who participated in the STEP program. To arrive at a meaningful description of the science instruction, data were collected related to (a) the attitudes towards and about science of the students in the classes being taught by the early career teachers who had participated in the STEP program, and (b) the amount of time allocated to science instruction within those classrooms.

The setting for the study was three community schools geographically located in western Montana. The community in which School A is located is an area known for its recreational opportunities, geographic beauty and a large number of artisans with their associated specialty shops. While there is a middle school within the system, it is operated more as an extension of the elementary program and reflects few of the practices representative of the modern middle school program. The average class size in School A is approximately twenty-five students. School F is located in an area surrounded by a national forest, resulting in an isolated rural community with a stable population of less than five hundred people. This results in a school population (grades Kindergarten through eighth grade) approaching 100 students, with an approximate class size of 10 students. School U is located in a community located near a major state university. Educationally, School U has implemented a science curriculum that is not textbook
based, that utilizes a number of hands-on activities, and that is well supported with materials and supplies.

Within the framework of this study, to fully describe the impact of the science instruction occurring in the early career teachers' classroom, the researcher focused on the recipients of that instruction, the students. Specifically the researcher gathered qualitative and quantitative data from the teachers, the students, and from a variety of artifacts. The data were related to the students' attitudes toward science, adoption of scientific attitudes, enjoyment of science, and to the amount of time allocated to science instruction.

The students in School A were fifth graders, and were in a self-contained classroom with the same teacher all day. The students in School F were seventh graders, and changed classes when switching teachers (each teacher taught two or more subjects). The students in School U were sixth graders, they not only changed classes each period, they also changed schedules each quarter in order to include elective subjects in their schedule. In School A, there were 22 students who participated in the study. In School F, there were eight students who participated in the study. In School U, there were 24 students who participated in the study. Thus the population for the study involved a total of 54 subjects in the MCI segment, and 58 in the TOSRA segment. Additionally, initial and final assessments were made using each of the quantitative instruments. The qualitative data from artifacts and observations were collected throughout the course of the study. However the interviews with students and teachers were only conducted at the beginning and end of the study.
Overall, there was sufficient data to allow for triangulation and verification of information. This triangulation allowed the researcher to verify the validity and strength of the data, to identify patterns and trends in the data that related to each of the research questions, and to generate a description of the classroom learning environment in which the study population was receiving their science instruction.

Limitations

Preceding the analysis of the study results, it is pertinent to review the limitations of the study. None of the teachers, students or schools involved were predominately Native American, nor were the schools located in communities on reservation lands. Within the selected population there was very little diversity with regards to ethnicity or race. There were no early career teachers who had been fully involved in the STEP project (had a mentor teacher, and had worked in a model school) who were available for participation in the study. This means that data describing the full impact of the STEP project on early career teachers' students' attitudes toward and about science, or on the number of hours allocated to science instruction in those teachers' classrooms were not accessible. Due to the paucity of research and reported findings related to the endeavors of the recent projects and programs which propose to reform science education, the value of the descriptive data gathered from this study are still very important and potentially significant in our efforts to better understand future research needs, both in scope and direction.

The research was conducted with three different groups of students, over a seven-month period of the 1998-1999 school year. Each class (group) of students was visited a minimum of six times for testing, interviews, and observations. The first visit occurred...
during the first quarter of the school year, with subsequent visits taking place during the second through fourth quarters, and the final visits taking place during the last month of the school year. This schedule allowed for the greatest impact of the early career teachers' efforts to implement their own curriculum, teaching style, and learning environment to be determined, measured, and described.

The instruments used for the quantitative data collection were the MCI (preferred and actual forms) and the TOSRA. For the collection of qualitative data, students and teachers were interviewed, instruction was video-taped, observations were made on several occasions, and artifacts were examined. The artifacts included, lesson plans, notebooks, tests, lecture notes, and other teaching resources (science kits and trunks).

Analysis

The analysis and discussion of the data resulting from the study is organized around each research question. The qualitative data collected from observations and interviews is first, followed by the discussion of the quantitative data collected related to that question.

Research Question One: What are the attitudes toward and about science of students who are members of a class taught by an early career teacher who participated in the University of Montana's STEP project?

Qualitative Data

The combined qualitative data generally describes students who have very positive attitudes toward the science instruction they are receiving in their classrooms. Both observational and interview data indicated they are very enthusiastic about the cooperative teamwork, and the hands-on, student-centered nature of their work. In
responses to interview questioning, they also expressed very affirmative feelings toward
the discovery nature of their science activities. The qualitative data indicated that there
were no noticeable differences between the males and females in the classes related to
their attitudes toward science. However, in both observational and interview data the
females did express a greater willingness to work in cooperative groups. While there was
no data to indicate a difference between genders within the classes studied, there was a
moderate increase in this gender difference corresponding to the grade level involved.
Specially, the difference was greater among seventh grade girls and boys than between
fifth grade girls and boys.

Following is a discussion of a general trend that emerged from the qualitative data
that are particular to the students' attitudes about science.

The students, were very active in applying the various science process skills,
including hypothesizing, predicting, measuring, collecting data, and analyzing the data
they collected. In addition, they presented that data in variety of means including graphs,
figures, and drawings—they drew conclusions and compared them to their original
predictions and hypotheses. While the students in School A were given many more
opportunities to be involved in discovery activities than those in either School F or
School U, they all practiced and used the appropriate process skills to some degree.
Based on observations and interviews of fifth graders at School A and the sixth graders at
School U, there were increased interest and enthusiasm when students were allowed to
become involved in the decision making process involved in their science instruction.
Even when the science related activities were less discovery and more verification type,
the students still actively applied the process skills learned in prior lessons where they
were appropriate to the tasks. During the interview process, all students expressed
greater interests in their science education when they were involved in some type of
investigative activity. The students' positive responses to questions about their attitude
towards their science instruction related very closely with the increase in the number of
science activities, the increased amount of time spent on science instruction, and the
variety of science activities initiated by the STEP teachers. Observational data indicated
that as students participated in a greater number of laboratory investigations they became
more proficient in utilizing and applying the processes of science. They were more
willing and able to comprehend when and how they should be used. In addition, the
researcher observed that as the number of laboratory investigations increased, the
students were more disciplined and rigorous in successfully completing the “science
challenges” presented in their science instruction.

In review, the qualitative data describes a group of students who have a highly
positive attitude toward science. The data also indicates students who have adopted into
their science learning environment many of the concepts and practices associated with the
discipline of the many scientific endeavors and educational disciplines. The trend toward
greater proficiency with the science process skills and many student statements
concerning their enjoyment of science instruction as the number of laboratory activities
increased is noteworthy.

Quantitative Data

Test of Science Related Attitudes. The quantitative data indicates different situations
for the students based upon a change in mean scores for the groups. Looking at the
TOSRA data for the sub-category “change in attitude toward science,” all groups of
students showed a positive change in the mean scores. This indicates that overall the students had a more positive attitude toward science at the conclusion of the study than they had indicated at the beginning of the study; this was especially true for students at School A and School U. It should be noted that the scores in this sub-category were high on the initial results and changed very little when the comparisons were made. A possible source of these changes lies in the fact that throughout the school year the students were consistently exposed to student-centered laboratory type activities. The situation at School F, where there was limited availability of science equipment and supplies, the variety of laboratory activities was somewhat restricted and some of the "novelty" of the laboratory experience was diminished was possibly related to the smaller increase in positive attitude toward science.

On the TOSRA sub-category "adoption of scientific attitudes," the students' scores for School A and School F were higher at the conclusion than initially, however the students at School U showed a negative change in the mean value. To better understand the possible cause for the actual reduction at School U one should reflect on the large number of verification type laboratory activities to which they were exposed. This reduced the opportunity for discovery and inquiry in the classroom, potentially inducing boredom and tedium into the learning environment. The sameness in techniques and experiences, offered little direction or stimuli for the students to adopt new ideas or practices.

In the TOSRA sub-category "enjoyment of science" three different results were obtained. The students at School A showed a very small but positive change score. The
students at School F showed the largest amount of change in their mean scores. The students at School U showed a small but negative change score.

These results possibly reflect the students' enjoyment of science at the time of the initial assessment. At School A, the students were very positive about their enjoyment of the science learning environment, and although the score change was small at the end of the study it was still positive. There was very little margin for positive change between the initial and final assessment. At School F, the students were still becoming accustomed to their new science learning environment. They related in the interviews a very negative attitude toward the previous years' science learning environment. They were very positive about their current experience, but had yet to develop a full appreciation for the difference. During the study, this appreciation was more fully developed and was demonstrated in the rating that was given during the final assessment at the conclusion of the study. The students at School U were enthusiastic about their enjoyment of science during the initial assessment, but experienced little growth during the course of the study.

*My Classroom Inventory.* The MCI has two forms, the actual and the preferred. Within each form there are the same five sub-categories. They are (a) satisfaction, (b) difficulty, (c) competitiveness, (d) cohesiveness, and (e) friction. In analyzing the data from the class using the MCI instrument, the same calculation was used; the change in the means of the initial and final assessments.

In the sub-category "satisfaction" the extent to which the class meets the expectations of the students is measured. All three groups of students had responses which showed a positive change in the mean score for satisfaction. This indicated that all groups would
have preferred a higher level of satisfaction at the conclusion of the study than they preferred at the time of the initial testing. This is not unexpected. The results from the TOSRA indicated that the students had high scores on the "attitude toward science" sub-category, and their scores on the "enjoyment of science" sub-category were still high, even through the mean change was minimally positive or negative. The qualitative data also indicated that the students were enjoying their science instruction. The MCI data indicated that they wanted to experience more of the positive aspects of their science experience. Again, it should be noted that the end of research study coincided with the end of the school year.

The change in mean scores on the MCI actual form for the "satisfaction" sub-category was negative for most groups of students. There was almost no change for the students at School U. The negative change value indicated that the students perceived less satisfaction with their science instruction at the final assessment than at the time of the initial assessment. These negative values indicating less satisfaction with their science instruction may well reflect that the initial high values in this sub-category were indicative of the differences between the manners in which they compared their current science instruction to the instruction in prior school years. Therefore, at the end of the study, the differences were not as compelling or influential in their ratings for this sub-category.

The MCI sub-category "difficulty" measures the extent to which students find difficulty with the work of the class. The data from the preferred form of the MCI describes two groups of students, those from School A and School F, who indicate through their responses that they would have preferred work that was less difficult at the
the students at School U indicated a preference for their work to be more difficult. These preferences of the students at Schools A and F could have been influenced by disequilibria due to the changes in schedule and routine related to the closing of school, than those in School U. The students in School U were more familiar with change due to the fact that they had practiced schedule changes throughout the school year and were therefore experiencing less disruption due to the changes. It should be mentioned again that the changes in mean score were very small in all three groups of students.

On the actual form of the MCI, for the sub-category "difficulty" the mean change scores indicated an increased degree of difficulty being experience by the students. The larger values for change were among the students in Schools A and F, with a much smaller change value for the students in School U. Again, the actual changes were very modest. No student data indicated extraordinary difficulty with their science instruction. The reasoning related to the change in mean values is the same as that for the preferred form of the MCI.

The sub-category of the MCI "competitiveness" measures emphasis on students competing with each other. The results from the preferred form had scores that describe students in all three schools who would prefer less competitiveness. In schools A and U, where the classes are much larger, and the number and changes in composition of cooperative groups is also larger, the preference for less competitiveness is smaller. The students at School F had a larger change value for their preference for competitiveness, it was a negative value, and might well indicate that Ms. F's tendency to use the entire class as one cooperative group lead to a group dynamic that allowed the students to develop
some greater degree of competitiveness among the individuals. On the actual form of the MCI for this sub-category, the change in mean value describes students who feel that there has been an actual increase in the amount of competitiveness. The change in mean values was highest among the students at School U. This value could support the reasoning applied to the change in mean score value among the students on the preferred form for this sub-category.

The sub-category "cohesiveness" measures the extent to which students know, help and are friendly toward each other, presents data which may reflect the impact of gender and the amount of competitiveness on their learning environment. The students in Schools A and F actually indicated a preference for less cohesiveness, there are more boys, numerically, among these students and they may actually be expressing a preference for more competitiveness and individual performance. The responses of the students at School U having described a preference for less competitiveness in their responses to that sub-category, would reasonably show a preference for more cohesiveness.

The students' responses on the actual form of the MCI, on the sub-category "cohesiveness" produce a negative change in the mean score values. This indicates that the students perceived a learning environment where there was less cohesiveness at the conclusion of the study than at the time of the initial assessment. This change is small and may well be related to the disequilibria associated with the completion of the academic school year, rather than the actual amount of cohesiveness normally present in the students' science related activities.
The final of the five sub-categories of the MCI is friction, which measures the amount of tension and quarrelling among students. On the preferred forms the students indicated diversity in preferences across the schools. At School A, the preference was a negative (-0.05) indicating little change was desired by the students. At School F the change was comparatively large with a negative value (-0.75). These students' scores probably reflect their related desire for less competitiveness and need for more cohesiveness. At School U, the change in mean score values for the students' responses related to the preferred amount of friction was small but positive (0.02). This may have been gender related, as numerically there are more males in this group of students than at the other schools.

On the actual form of the MCI for the sub-category friction the students at Schools A and F saw an increase in the amount of friction at the end of the study compared with their initial view of the amount of friction in their classroom learning environment. The students at School U viewed their classroom learning environment as having less friction at the time of their final assessment using the MCI.

*Literature Related to Test Results*

A review of the literature shows that many of the results were not unexpected. With regards to the sub-category “cohesiveness,” students who have classes taught by teachers inexperienced with a new course perceived those classes to be more cohesive than those taught by teachers more experienced with the course (Anderson, Walberg, & Welch, 1969), and history and English classes were found to be more cohesive than science classes (Anderson, 1971), and class cohesiveness has been found to be positively related to learning criteria. The literature related to friction notes that friction is higher when the
classes contains a larger number of boys than girls, and is negatively correlated with measures of learning (Walberg & Ahlgren, 1970). The related literature for difficulty indicates that larger classes are perceived as less difficult than smaller ones, and positive relationships have been found between student-perceived difficulty and student learning outcomes (Walberg, 1969, Anderson & Walberg, 1972). Satisfaction was found to be negatively related to class size, and to be consistently positively associated with student learning (Walberg, 1969). Competitiveness tends to be greater in classes with a high proportion of boys than girls, but consistent relationships between competitiveness and student learning outcomes have not been established (Walberg & Ahlgren, 1970).

The literature related to studies on students attitudes toward and about science has been building since the 1960s. Some major findings are summarized below.

1. Within the large population of students from grade 6 through 10, attitude toward science dropped each year. Attitudes toward science were consistently higher among boys.

2. Students' declines in achievement motivation were markedly similar to declines in attitude toward science. Motivation dropped both within and across grades 6 though 10. Motivation to achieve in science was consistently higher among girls.

3. School, particularly classroom, variables are the strongest influences on attitudes toward science. While individual and home influences contribute significantly to this foundation, it is clear from the studies that the basic feelings an adolescent formulated toward the enterprise of science and toward their involvement with science courses is in large measure mediated by the science classroom (White & Richardson, 1993).
4. A positive student attitude toward science not only superintends scientific literacy, it could also have a bearing on our country's global competitiveness, (Misiti, Shrigley, & Hanson, 1991).

5. Literature related to students' enjoyment of science evidences a science education situation where students in the middle grades are not enjoying their science classes. Documented research informs us that in early elementary school more than 70% of all students are interested in science, but by the end of the fifth grade only 20% of all students want to take more science, by the time students enter high school (even with the enormous pressure of college entrance requirements that specify science in secondary school) fewer than half of the students will actually take a science course (Moore, 1990). These findings are certainly not indicative of a situation where students are enjoying their science education experience.

Some of the differences among the students' experiences with their science instruction can be attributed to numerous factors including community, school, and classroom environment, availability of materials and supplies, class size, previous science instruction experiences, individual differences, age and gender. These differences that often related to their current experiences were noted and described. While these differences often appeared to have only a modest impact on the resulting outcomes, they were essential when determining a holistic view of the impact of the students' current experiences and responses to their science instruction.

Overall this qualitative and quantitative data do present the impression of a science learning environment in which the students are developing positive attitudes toward and
about science. The students are both eager to practice the science process skills, and they demonstrate a high interest in their science lessons and related laboratory activities.

Research Question Two: Do early career teachers who participated in the STEP project provide more/less instructional time per week for science education than indicated in past studies for non-STEP teachers?

The comparative data for this question originated with research conducted by Goodlad (1984). Goodlad found that the amount of time allocated to science was less than one hour per week.

Qualitative Data

The interview and observational data collected from the STEP teachers indicate a science teaching environment where science is a valued discipline that receives as much, if not more, time devoted to planning, preparation, and most importantly instruction as the other content areas. Ms. A and Ms. U had a fixed starting time each day in which science instruction occurred. While Ms. A had more flexibility in the allocation of time for science instruction, the instruction was never less than 45 minutes and would often extend beyond 55 minutes changing as the science activity required. During interviews, Ms. A and her students confirmed that science instruction occurred daily and usually lasted 45-55 minutes.

The artifacts collected, lesson plans, and video-taped lessons also indicated that science instruction was planned and presented daily for the 45-55 minutes previously noted. Ms. U had far less flexibility in scheduling the science instruction because School U had a timed instructional period specifically for science instruction. This was mandated by a school wide schedule for class changes. Observational and interview data indicated
that during that instruction period, Ms. U planned for and presented a science lesson to her students. Artifact data corroborated the observational and interview data.

Ms. F used great flexibility in her allocation of instructional time. In the researcher’s observational data, it was noted that on some occasions there would be no science instruction on a given day, however on subsequent days the science instruction would involve activities that utilized a time allocation approaching two hours. This observed blend of instructional activities was not noted in the student interview data. When interviewed, the students consistently stated that science instruction occurred each day for a period of 50-60 minutes. The teacher interview data did substantiate the observational data. The researcher visited School F for a four-day sequence of instruction and made observational notes. These indicated that the students in Ms. F’s class did receive an average of 50-60 minutes of science instruction daily over the observational period. The artifacts from Ms. F indicated a planned instructional time averaging 50-60 minutes for each school day. In a review of the qualitative and quantitative data for all the STEP teachers involved in the study, it was noted that there was some difference in the amount of that time allocated to science “laboratory activities,” but in all cases the students when interviewed suggested that it was greater than they had experienced in their prior science classes. The data from this study indicates that the average number of hours allocated to science instruction, (approximately five hours per week or between 50-60 minutes per day) was appreciably greater in the classrooms of the early career STEP teachers than in those studied by Goodlad (1984).

This study is not summative or evaluative in character; rather it is and was intended to be an effort at discovering and describing the nature of the science learning environment.
in the classrooms of early career teachers who had participated in the STEP project at The University of Montana as illustrated through the experiences of the students in those classrooms. However a final review of the description of the attitudes toward and about science of the participating students, and a scrutiny of the number of hours allocated for science instruction, gives the impression that the early career teachers who participated in the STEP program are providing their students with a science learning environment which fosters a positive attitude, both toward and about science.

The students' comments made during the interviews and their actions during the observations of their science instruction and science activities indicate students who are very positive about their science experiences, and who are enjoying their science instruction. These students seem to be adopting the scientific principles associated with the various science endeavors and disciplines. They actively and enthusiastically adapt to and utilize the science process skills and the scientific methodology of research and study.

The effectiveness of the elementary K-8 science classroom at changing students' attitudes toward and about science (Rice and Corboy, 1995) is supported by the data collected in this study. The quantitative data collected from the students in the STEP teachers' classroom, using the TOSRA, showed improved student scores in all subcategories (attitude toward science, adoption of scientific attitudes, and enjoyment of science) at all study locations. The qualitative data supports the suppositions of Rice and Corboy as do the quantitative results in the TOSRA findings in the study. These data also provide a description of the STEP teachers' classrooms as those in which some of the goals of the STEP project and the NSES are definitely being achieved. While these are
very positive results, the question of long-term sustainability of these project results was not a function of this study. The question of sustainability would require a well-developed longitudinal study to appropriately measure the full impact of the project and of the results of the project.

The importance of researching the current and recent efforts directed toward science instruction is enormous if the United States is to regain both its internationally standing as a leader in science and technology, and as an economic superpower.

Implications for Science Education Reform

As the above study was conducted with only three science classes with a limited number of students, the results cannot be generalized to all grades or to all science instruction environments. Regardless, the findings do present a number of implications for early career science teachers.

1. Teachers need to have a firm understanding of the cooperative techniques of science instruction.
2. Teachers need to have the ability to implement discovery, if not inquiry-oriented, pedagogical techniques.
3. Teachers need to understand that students are more highly motivated if their science instruction is more student-centered and student-driven rather than teacher-centered and content-driven.
4. Students’ attitudes toward and about science are very closely related to the classroom learning environment and particularly the science instructional techniques.
5. Teachers need to be aware of the impact of the prior science learning experiences of
their students and the impact that it will have on their initial skill levels in cooperative team learning, science process skills, safety skills, and mathematics integration skills.

6. Overall, students enjoy doing science, much more than hearing or seeing science.

Given a supportive science learning environment, even students who have had a difficult time learning science, or those who have previously had negative attitudes toward and about science, appear to involve themselves in science activities.

Recommendations for Future Research

1. A longitudinal study that follows a larger group of early career teachers over the course of three years or more needs to be conducted. While the studies by Shymansky, et. al., (1990) did supply much important information about the success of previous reform efforts, much remains to be researched, discovered, evaluated, and reported.

1. Additional research needs to be conducted regarding the impact of a pre-service teachers’ experience with the full scope of the STEP project, i.e. support from mentor teachers, and placement in “model schools.”

2. Research directed at discovering the impact of student diversity on early career teachers’ efforts at reforming their science instructional techniques is necessary.

3. Additional research involving the development and use of a quantitative research instrument that was more sensitive to changes in students’ attitudes toward their science instruction, their peers, and their teachers is needed. This would increase the ability to relate the quantitative and qualitative data.

4. If this study were to be replicated, additional background information about the
students would provide insight to the students' behavior and attitude toward science. Gender-related, age-related issues and attitudes about science begin long before they reach the middle grades science classroom.

5. Additionally, if this study were to be replicated, the subjects need to be more culturally and racially representative of a broader-based population. In this study there was not enough variability of the participants.
References


Erickson, F. (1986). Qualitative methods in research on teaching. In M. Wittrock (Ed.), *Handbook of Research on Teaching* (pp. 119-161). New York: Macmillan.


Informed Letters of Consent for Parents, Teachers, and Students
Teacher Consent Form

You are invited to participate in a research study. The purpose of this study is to better understand how teachers teach and how children learn science. This information will be valuable in helping the researcher, classroom teacher, and the University of Montana School of Education make decisions on how to improve science education. The results of the study will also be used as the basis for an Ed.D dissertation.

The researcher will be in your classroom 8 hours (2 three-day visits and 1 two-day visit), for approximately one hour each day. I will be observing the science instruction in your classroom, and asking questions of students, colleagues, and administrators. As part of that 8 hours, twice during the year, I will need approximately 1 hour of your instructional time (two _-hour sessions during the first and last visits). This time will be utilized to administer the actual and preferred copies of the "My Classroom Inventory" (MCI). This questionnaire will allow me to get an overview of any significant differences between the type of classroom learning environment preferred by the students and what they perceive as their actual classroom learning environment. Graphical representations of this data will be given to you in case you are interested in using it in your professional development plans. At no time will individual responses be made available to you; this insures student and study confidentiality. In order to facilitate the qualitative portions of my study, I will need three separate one-hour sessions of your non-instructional time. This time will be used to discuss your perceptions of students’ science learning, your pre-service educational program, and the science teaching in your classroom. Photocopies will be made of curriculum materials, planning materials, and of students’ science writings. Some students will be asked to meet with the researcher 2-3 times for half an hour or less each time to talk about and draw out their science ideas. At no time will student or teacher interviews be conducted during normal instructional time. Rather, they will occur during preparation periods, lunch, or during times when the students will not be in your classroom. Interviews will be audio taped using a micro-recorder; the tapes will be erased, or destroyed immediately after transcription. Classroom instruction may be videotaped and reviewed by you and the researcher. This discussion/review will follow the format used in the "What’s Your Inquiry Quotient?" ("I.Q."). This instrument was developed to determine the degree of inquiry instruction being used in science instruction. In order that there is minimal intrusion on your time, I will usually complete the "I.Q." questionnaire without your involvement. On most days, I will remain in a location that will be as unobtrusive as possible. I will either maintain the video camera, if used, or I will be recording my observations for the day. All tapes (video and audio) will only be used for research purposes and will be destroyed as soon as the researcher has transcribed their contents. You will be asked to keep a teaching log, which is a daily anecdotal record describing classroom activities and student understanding. I will request that you keep this log for the week preceding my visits to your school as this will help me to enrich and verify information that I might gather from other sources. It will also remain confidential.

Your ideas will not be shared with students, parents, teachers, or school officials in a way that could identify you as the source. No references will be made in oral or written reports that could link you as the source. Names will be changed in reports and the researcher will remove all identifying information from documents before making

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photocopies. Your participation is voluntary. If you decide to participate, you may withdraw at any time without penalty. Should you decide to withdraw, all data will be destroyed. If you have any questions at any time about the study or the procedures, you may contact the researcher at the address or telephone below.

Richard T. Rushton  
POB 685  
St. Ignatius, MT 59865  
Tel: 745-2387  
E-mail: sti2387@montana.com  

Additional information can be obtained from my university faculty supervisor, Dr. Fletcher Brown, Rm. 106, Curriculum and Instruction, School of Education, University of Montana, Missoula, MT 59812. Dr. Brown can also be reached through E-mail at Brownf@selway.umt.edu or by telephone at 243-5287.

Although it is unlikely that any harm will result to you from participating in this project, in the event that you are injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by the negligence of the University or any of its employees, you may be entitled to reimbursement of compensation pursuant to the Comprehensive State Insurance Plan established by the Department of Administration under the authority of M.C.A., Title 2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University's Claims Representative or University Legal Counsel.

I have read and I understand the above information. I have received a copy of this form. I agree to participate in this study.

__________________________ CLASSROOM TEACHER'S SIGNATURE _____ DATE

__________________________ RESEARCHER'S SIGNATURE _____ DATE

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PARENT CONSENT STATEMENT

DEAR PARENT:

Your child is invited to participate in a research study. Your child’s science teacher and a University of Montana science education doctoral student are working together to increase our understanding how teachers teach and how children learn science. This information will be valuable in helping the researcher, classroom teacher, and the University of Montana’s School of Education make decisions on how to improve science education. The classroom teacher’s participation is also voluntary in this research. If at any time the teacher decides to withdraw from this study, I will inform you of that decision. The study will terminate for all students in that classroom and all collected data destroyed.

As part of the study, the researcher will be in your child’s classroom for a total of 8 hours (1 hour per visit), observing science instruction for this (1998-99) school year. During this time, he will observe instruction and ask questions of students. There will be a two-form questionnaire/instrument administered to the students participating in the study. These questionnaires are the preferred and actual forms of the “My Classroom Inventory” (MCI). These yes/no format questionnaires ask questions related to what your child likes and/or prefers about their science instruction. Any identifying information obtained from this questionnaire will remain confidential. Photocopies will be made of some student’s science writings. Some students will be asked to meet with the researcher 2-3 times for half an hour or less each time to talk about and draw out their science ideas. These interviews will not cause students to miss regular classroom instruction. Interviews will be audio taped. The tapes are used only for research purposes. Classroom instruction may be videotaped. Video and audio-recorded tapes will be destroyed as soon as the researcher had transcribed its contents. Before involving your child in this research, your consent is required.

Your child’s participation is voluntary. Your child’s class grade will not be affected by his/her decision to participate or not to participate in this study. The results of this study will not be used to evaluate your child’s behavior or performance. His/her classroom teacher determines grades based on homework, quizzes, and exams. Your child may withdraw at any time without penalty or loss of benefits. Should your child decide to withdraw, his/her data will be destroyed without penalty.

All information recorded in the study records will be kept confidential. No references will be made in oral or written reports that could link your child to the study. Pseudonyms will replace all names of persons and places. A written report in the form of a doctoral dissertation will be submitted to the researcher’s doctoral committee. In addition, copies will be available in the University of Montana’s School of Education library.

If you have any questions about this study please feel free to contact me at the following address or telephone:
Richard Rushton
PO BOX 685

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St. Ignatius MT, 59865
Tel: 745-2387
E-mail: sti2387@montana.com
Additional information can be obtained from my university faculty supervisor, Dr. Fletcher Brown, Rm. 106, Curriculum and Instruction, School of Education, University of Montana, Missoula, MT 59812. He can be reached through e-mail at brownf@selway.umt.edu, or by telephone at 243-5287.

If you and your child are interested in participating in this study, please sign and return one copy of this form. I thank you for considering this request.

Although it is unlikely that any harm to your child will result from participating in this project, in the event that your child/student is injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by the negligence of the University or any of its employees, you may be entitled to reimbursement of compensation pursuant to the Comprehensive State Insurance Plan established by the Department of Administration under the authority of M.C.A., Title 2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University’s Claims Representative or University Legal Counsel.

I have read and I understand the above information. I have received a copy of this form. My child has my permission to participate in this study.

__________________________________________ PARENT’S SIGNATURE

______ DATE

__________________________________________ RESEARCHER’S SIGNATURE

______ DATE

My parents have discussed this information with me and I assent to be part of the research.

__________________________________________ STUDENT’S SIGNATURE

______ DATE
STUDENT ASSENT FORM

DEAR STUDENT,

You are asked to be in a research study. Your science teacher and myself (a student at the University of Montana) are working together on a project that will lead to a better understanding of how teachers teach and how children learn science. The results of this study will be helpful in understanding how to prepare teachers to become better teachers and how to improve the way you are taught science.

As part of the study, I will be in your classroom 8 times this year. During these one-hour visits, I will watch your science classes, and sometimes I may ask you some questions about what you like or dislike about your science class or about science in general. I will also ask if I can make copies of your science reports. If you are in the study, you will be asked to fill in two different forms that ask what you like or dislike about your science classes. I would also like your permission to video or audio tape (record) your science lessons and the time we spend together asking and answering questions. This will help me to remember exactly what was happening and what was said. Again let me stress that you can stop at any time you want.

Being in this study is your choice. You may stop at any time you choose. Your grade will not be affected by your decision to be part of this study. That is, your grade will not improve if you are part of the study, and neither will it be lowered if you choose not to be part of the study.

All information in the records of this study will be kept confidential. No one will be able to tell who participated or who did not, which schools or classes were part of the study, or what they said or did as part of the study.

If you want to be in this study, please sign and return this form. Thank you for considering this request. If you have any questions about this study, please feel free to ask your science teacher or parents.

Although it is unlikely that any harm to you will result from being in this study, if you do get hurt because of being in this study, then you should see a doctor or nurse about it. You should also have your parents contact the University of Montana after you go to the doctor.

I have read and I understand the above information. I have received a copy of this form. I agree to participate in this study.

______________________________  Your signature  __________  Today’s date

______________________________  Researcher’s signature  __________  Today’s date

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APPENDIX B

Hand Scoring Format For The MCI Instrument
Hand scoring of the MCI

First, inclusion of the letter R in the Teacher Use Only column identifies those items which need to be scored in reverse order. Second, items are arranged in blocks and in cyclic order so that all items from the same scale are found in the same position in each block. For example, the first item in each block of five items in the MCI belongs to the Satisfaction scale. Items without the letter R are scored by allocating a score of 3 for the response YES and 1 for the response NO. Underlined items with the letter R are scored in the reverse manner. Omitted or invalid answered items are scored 2.

To obtain scale totals, the five items scores for each scale are added. The first, second, third, fourth, and fifth items in each block of five, respectively, measures Satisfaction, Friction, Competitiveness, Difficulty, and Cohesiveness.
APPENDIX C

Actual Form Of The MCI Instrument
Appendix D
MY CLASS INVENTORY
STUDENT PREFERRED SHORT FORM

DIRECTIONS
This is not a test. The questions are to find out what you would like or prefer your class to be like.
Each sentence is meant to describe what your preferred class is like. Draw a circle around

YES if you AGREE with the sentence
NO if you DON'T AGREE with the sentence.

EXAMPLE
27. Most pupils in our class would be good friends.
   If you agree that you'd prefer that most pupils in the class would be good friends, circle the Yes like this:
   [Yes]
   If you don't agree that you would prefer that most pupils in the class would be good friends, circle the No like this:
   [No]

Please answer all questions. If you change your mind about an answer, just cross it out and circle the new answer.
Don't forget to write your name and other details below.

NAME __________________ SCHOOLS ___________________ CLASS ______

Remember you are describing your preferred classroom

<table>
<thead>
<tr>
<th>Remember you are describing your preferred classroom</th>
<th>Circle Your Answer</th>
<th>For Teacher's Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The pupils would enjoy their schoolwork in my class.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>2. Pupils would be always fighting with each other.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>3. Pupils often would race to see who can finish first.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>4. In my class the work would be hard to do.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>5. In my class everybody would be my friend.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>6. Some pupils wouldn't be happy in my class.</td>
<td>Yes No R</td>
<td></td>
</tr>
<tr>
<td>7. Some pupils in my class would be mean.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>8. Most pupils would want their work to be better than their friend's work.</td>
<td>Yes No R</td>
<td></td>
</tr>
<tr>
<td>9. Most pupils would be able to do their schoolwork without help.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>10. Some pupils in my class would not be my friends.</td>
<td>Yes No R</td>
<td></td>
</tr>
<tr>
<td>11. Pupils would seem to like my class.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>12. Many pupils in my class would like to fight.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>13. Some pupils would feel bad when they didn't do as well as the others.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>14. Only the smart pupils would be able to do their work.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>15. All pupils in my class would be close friends.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>16. Some pupils wouldn't like my class.</td>
<td>Yes No R</td>
<td></td>
</tr>
<tr>
<td>17. Certain pupils always would want to have their own way.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>18. Some pupils always would try to do their work better than the others.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>19. Schoolwork would be hard to do.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>20. All pupils in my class would like one another.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>21. My class would be fun.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>22. Pupils in my class would fight a lot.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>23. A few pupils in my class would want to be first all of the time.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>24. Most pupils in my class would know how to do their work.</td>
<td>Yes No R</td>
<td></td>
</tr>
<tr>
<td>25. Pupils in my class would like each other as friends.</td>
<td>Yes No</td>
<td></td>
</tr>
</tbody>
</table>

For Teacher's Use Only: S F Cm _______ D ... Ch _______

This page is a supplement to a publication entitled Assessing and Improving Classroom Environment authored by Barry J. Fraser and published by the Key Centre for School Science and Mathematics at Curtin University.
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APPENDIX D

Preferred Form Of The MCI Instrument
# MY CLASS INVENTORY

## STUDENT PREFERRED SHORT FORM

**DIRECTIONS**

This is not a test. The questions are to find out what you would like your class to be like. Each sentence is meant to describe what your preferred class is like. Draw a circle around

- **YES** if you AGREE with the sentence
- **NO** if you DON'T AGREE with the sentence.

### EXAMPLE

27. Most pupils in our class would be good friends.
   
   If you agree that you'd prefer that most pupils in the class would be good friends, circle the **YES** like this:
   
   Yes

   If you don't agree that you would prefer that most pupils in the class would be good friends, circle the **NO** like this:
   
   No

Please answer all questions. If you change your mind about an answer, just cross it out and circle the new answer.

Don't forget to write your name and other details below.

<table>
<thead>
<tr>
<th>NAME ____________________________</th>
<th>SCHOOL ___________________________</th>
<th>CLASS</th>
</tr>
</thead>
</table>

Remember you are describing your preferred classroom.

### Questions:

<table>
<thead>
<tr>
<th>Number</th>
<th>Sentence</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The pupils would enjoy their schoolwork in my class.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2.</td>
<td>Pupils would always fight with each other.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3.</td>
<td>Pupils often would race to see who can finish first.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4.</td>
<td>In my class the work would be hard to do.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5.</td>
<td>In my class everybody would be my friend.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>6.</td>
<td>Some pupils wouldn't be happy in my class.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>7.</td>
<td>Some pupils in my class would be mean.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>8.</td>
<td>Most pupils would want their work to be better than their friend's work.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>9.</td>
<td>Most pupils would be able to do their schoolwork without help.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>10.</td>
<td>Some pupils in my class would not be my friends.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>11.</td>
<td>Pupils would seem to like my class.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>12.</td>
<td>Many pupils in my class would like to fight.</td>
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<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>14.</td>
<td>Only the smart pupils would be able to do their work.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>15.</td>
<td>All pupils in my class would be close friends.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>16.</td>
<td>Some pupils wouldn't like my class.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>17.</td>
<td>Certain pupils always would want to have their own way.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>18.</td>
<td>Some pupils always would try to do their work better than the others.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>19.</td>
<td>Schoolwork would be hard to do.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>20.</td>
<td>All pupils in my class would like each other.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>21.</td>
<td>My class would be fun.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>22.</td>
<td>Pupils in my class would fight a lot.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>23.</td>
<td>A few pupils in my class would want to be first all of the time.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>24.</td>
<td>Most pupils in my class would know how to do their work.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>25.</td>
<td>Pupils in my class would like each other as friends.</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

*For Teacher's Use Only*

| S | F | Ch | D | Ch |

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APPENDIX E

TOSRA Instrument
TOSRA

TEST OF SCIENCE RELATED ATTITUDES

Barry J. Fraser

Directions

1. This document contains a number of statements about science. You will be asked what you yourself think about these statements. There are NO “right” or “wrong” answers.

2. Do not begin this exercise until instructed to do so. Even though there is no time restrictions, We want everyone to complete this document under the same circumstances. Remember, you do not have to participate in this effort. If you do, or if you do not, your class grade will not be affected. It is NOT for grading purposes. It is purely voluntary. However, I do appreciate your time and efforts to help me in this project.

3. Only one answer should be marked for each question. If you decide to change your answer, place an “X” through the answer you want to change and then circle your new choice. Be sure to use the answer sheet to record your answers.

4. Please be sure to write your name, school, and class/year on the answer sheet.

5. For each statement, draw a circle around.

  SA if you STRONGLY AGREE with the statement.
  A  if you agree with the statement.
  N  if you are NOT SURE.
  D  if you DISAGREE with the statement.
  SD if you ASTRONGLY DISAGREE with the statement.

Practice item

0 It would be interesting to learn about boats.

Suppose that you AGREE with this statement, then you would circle A on you answer sheet, like this:

0 SA A N D SD

If you change your mind about an answer, cross it out and circle another one.

0 SA A N D SD

Although some statements on this form are fairly similar to other statements, you are asked to indicate your opinion about all statements.
3. I would prefer to find out why something happens by doing an experiment than by being told.

4. I enjoy reading about things which disagree with my previous ideas.

5. Science lessons are fun.

10. Doing experiments is not as good as finding out information from teachers.

11. I dislike repeating experiments to check that I get the same results.

12. I dislike science lessons.

17. I would prefer to do experiments than to read about them.

18. I am curious about the world in which we live.

19. School should have more science lessons each week.

24. I would rather agree with other people than do an experiment to find out for myself.

25. Finding out about new things is unimportant.

26. Science lesson bore me.

31. I would prefer to do my own experiments than to find out information from a teacher.

32. I like to listen to people whose opinions are different from mine.

33. Science is one of the most interesting school subjects.

38. I would rather find out about things by asking an expert than by doing an experiment.

39. I find it boring to hear about new ideas.

40. Science lessons are a waste of time.

45. I would rather solve a problem by doing an experiment than be told the answer.

46. In science experiments, I like to use new methods which I have not used.
47. I really enjoy going to science lessons.

52. It is better to ask the teacher the answer than to find it out by doing experiments.

53. I am unwilling to change my ideas when evidence shows that the ideas are poor.

54. The material covered in science lessons is uninteresting.

59. I would prefer to do an experiment on a topic than to read about it in science magazines.

60. In science experiments, I report unexpected results as well as expected ones.

61. I look forward to science lessons.

66. It is better to be told scientific facts than to find them out from experiments.

67. I dislike listening to other people's opinions.

68. I would enjoy school more if there were no science lessons.
APPENDIX F

Scoring Form For The TOSRA Instrument
Scale, allocations and scoring for each item used in this research:

<table>
<thead>
<tr>
<th>Attitude to Scientific Inquiry</th>
<th>Adoption of Scientific Attitudes</th>
<th>Enjoyment of Scientific Lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (+)</td>
<td>4 (+)</td>
<td>5 (+)</td>
</tr>
<tr>
<td>10 (-)</td>
<td>11 (+)</td>
<td>12 (-)</td>
</tr>
<tr>
<td>17 (+)</td>
<td>18 (+)</td>
<td>19 (-)</td>
</tr>
<tr>
<td>24 (-)</td>
<td>25 (+)</td>
<td>26 (-)</td>
</tr>
<tr>
<td>31 (+)</td>
<td>32 (+)</td>
<td>33 (-)</td>
</tr>
<tr>
<td>38 (-)</td>
<td>39 (-)</td>
<td>40 (+)</td>
</tr>
<tr>
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*positive items (+) responses SA, A, N, DA, SD are scored 5, 4, 3; negative items (-) responses SA, A, N, DA, SD are scored 1, 2, 3, 4, 5; all other responses are scored 3.*
APPENDIX G

Qualitative Questions

Open-ended (semi-structured) questions used in qualitative data gathering, to be used with students in grades 5-8.

Before and after each question, students will be reminded that they can choose to not participate in the study, and that they do not have to answer any questions. They may refuse to answer any question or even drop out of the study without there being any effect on their grade in their class.

Research question #1

a) How is your science class different than in past years?

b) What do you like most and/or least about your science class this year?

c) Describe the types of activities that you perform in your science class.

Research question #2

a) How many hours of science instruction do you have each day?

b) How many hours of science instruction do you have each week?
APPENDIX H

Data Analysis For The MCI Preferred Form
## Descriptives

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*The mean difference is significant at the .05 level.*

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APPENDIX I

Data Analysis For MCI Actual Form
### APPENDIX I

**DATA ANALYSIS FOR THE MCI ACTUAL FORM**

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APPENDIX J

Data Analysis For TOSRA
## T-Test

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### Post Hoc Tests

#### Multiple Comparisons

**Bonferroni**

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* The mean difference is significant at the .05 level.
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APPENDIX K

Scatter Plot Graphs For The MCI Actual Instrument Results
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ALL STUDENTS WITH TREND LINE
CHANGE OF MEANS COMPETITIVENESS MCI ACTUAL
ALL STUDENTS WITH TREND LINE
CHANGE OF MEANS DIFFICULTY MCI ACTUAL
ALL STUDENTS WITH TREND LINE
CHANGE OF MEANS FRICTION MCI ACTUAL
ALL STUDENTS WITH TREND LINE
CHANGE OF MEANS SATISFACTION MCI ACTUAL
ALL STUDENTS WITH TREND LINE

[Graph showing data points and a trend line]