INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6” x 9” black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI

A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA
313/761-4700 800/521-0600
EARTH SCIENCE LITERACY OF PRE-SERVICE AND
IN-SERVICE ELEMENTARY AND SECONDARY SCHOOL TEACHERS
DISSERTATION
Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

David W. Miller, B.A., M.S.T.

* * * *

The Ohio State University

1996

Dissertation Committee:
J. F. Disinger
R. K. Barrick
G. D. McKenzie
B. S. Thomson

Approved by

Adviser
Department of Educational Studies
College of Education
Dedicated to Shelby Leigh Miller
This study focused on the Earth science literacy levels of pre-service and in-service elementary and secondary school teachers. Pre-service elementary and secondary school teachers were of senior status at an Ohio university while in-service elementary and secondary school teachers were chosen from a suburban school district located in southwestern Ohio. A 25-item Earth science literacy survey was developed for this purpose. The Earth science questions were based on the scientific literacy research of others.

The results of this study indicate that the Earth science literacy levels of pre-service and in-service elementary and secondary school teachers are similar to those of the general population as reported by Jon Miller and other researchers.

To test the null hypotheses of this study, collected data were statistically analyzed using analysis of variance, Pearson Correlations, and frequency distributions. The level of significance for all appropriate statistical procedures was set at the .05 level. No statistically significant differences were found among pre-service and in-service elementary and secondary school teachers Earth science literacy levels. Correlations of test scores and
gender, age, years of teaching, and academic background showed little difference between groups of teachers.
ACKNOWLEDGMENTS

I wish to thank the members of my Dissertation Committee, Dr. John F. Disinger, Chairman, Dr. R. Kirby Barrick, Dr. Garry D. McKenzie, and Dr. Barbara S. Thomson for their interest in this research project and their willingness to serve on my committee. I am indebted to my wife Yvette, along with my parents, Dr. Thomas O. Miller and Elaine B. Miller; without their support, this undertaking would not have happened.
VITA

July 5, 1959........... Born - Columbus, Ohio


1982..................Bachelor of Arts, Wright State University, Dayton, Ohio

1983...................Associate of Science, Sinclair Community College, Dayton, Ohio

1984...................Price Analyst, Defense Electronic Supply Center, Dayton, Ohio

1987...................Master of Science in Teaching, Wright State University, Dayton, Ohio

1987-present...........Part-time Instructor, Biology-Geology, Sinclair Community College, Dayton, Ohio

1987...................Part-time Instructor, Earth Science Urbana University, Dayton, Ohio

1988...................Contract Specialist, Wright Patterson Air Force Base, Dayton, Ohio

1989...................Career Counselor, The Ohio State University, Columbus, Ohio

1991...................Graduate Teaching Assistant, Geology, The Ohio State University, Columbus, Ohio

1992...................Groundwater Specialist, Ohio Department of Agriculture, Columbus, Ohio
1992..................Environmental Specialist II, Ohio
                     Environmental Protection Agency
                     Columbus, Ohio

1992-1995.............Instructor, Jefferson Community
                     College, Watertown, New York

1996....................Naturalist II, Five Rivers Metro
                     .........................Parks, Dayton, Ohio

PUBLICATIONS

with Dinosaurs, The Earth Scientist, Summer 1992

FIELDS OF STUDY

Major Field: Education

  Studies in Science Education, Geology, Natural
  Resources, and Educational Research with Dr. R. Kirby
  Barrick, Dr. John F. Disinger, Dr. Stanley L. Helgeson, Dr.
  Garry D. McKenzie, Dr. Robert E. Roth, Dr. Barbara S.
  Thomson, and Dr. Russell O. Utgard.
## TABLE OF CONTENTS

ACKNOWLEDGMENTS .................................................. v

VITA ........................................................ vi

APPENDICES ................................................... xi

LIST OF TABLES ............................................ xii

CHAPTER PAGE

I. INTRODUCTION .................................................. 1

   Introduction ................................................. 1
   Statement of the Problem ................................. 6
   Purpose of the Study ....................................... 8
   Assumptions Underlying the Study ...................... 10
   Limitations of the Study .................................. 11
   Statement of the Hypotheses .............................. 12
   Definition of Terms ......................................... 14
   Procedures .................................................. 16
   Summary ..................................................... 18
IV. PRESENTATION AND ANALYSIS OF THE DATA ............. 101

Introduction ........................................ 101
Demographic Characteristics of the Study
  Participants ...................................... 101
  Gender ........................................ 102
  Grade Level .................................... 103
  Number of Years Teaching ....................... 105
  Age ........................................... 106
Other Characteristics of the Study
  Participants .................................... 108
College Earth Science Content Background .... 108
Self Perceived Level of Success of
  College Earth Science Courses Taken........ 110
Self Perceived Level of Confidence of the
  Subject Matter at the Grade Level Taught . 112
Self Perceived Value of College Earth
  Science Course Taken ............................ 114
The Desire for More Science Instruction .... 116
The Desire for More Information on Science
  Education ....................................... 116
Earth Science Literacy Scores .................. 117
Results of Hypothesis Testing .................. 120
Summary .......................................... 135
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Members of Participants by Population and Sub Group</td>
<td>68</td>
</tr>
<tr>
<td>Table 2</td>
<td>Gender by Group</td>
<td>103</td>
</tr>
<tr>
<td>Table 3</td>
<td>Anticipated Grade Level Taught by Participants: Pre-service</td>
<td>104</td>
</tr>
<tr>
<td>Table 4</td>
<td>Grade Level Taught by Participants: In-service</td>
<td>105</td>
</tr>
<tr>
<td>Table 5</td>
<td>Number of In-service School Teachers by Self-Reported Years of Teaching Experience</td>
<td>106</td>
</tr>
<tr>
<td>Table 6</td>
<td>Sum Total of Pre-service and In-service Elementary and Secondary School Teachers by Self-Reported Average Age</td>
<td>107</td>
</tr>
<tr>
<td>Table 7</td>
<td>Sum Total of Teachers by Number of College Earth Science Courses Completed</td>
<td>110</td>
</tr>
<tr>
<td>Table 8</td>
<td>Sum Total of Courses by Self Perceived Level of Success of College Earth Science Courses Taken</td>
<td>112</td>
</tr>
</tbody>
</table>
Introduction

What is scientific literacy? Scientific literacy has been defined in many ways by scientists, science educators, and professional organizations such as the American Association for the Advancement of Science (AAAS) and the National Science Teachers Association (NSTA). In 1958, Paul Hurd offered this explanation of the meaning of science literacy: "to describe an understanding of science and its applications to our social experience" (DeBoer, 1991). Rutherford and Ahlgren in their book *Science for all Americans* (1990) stated that "the scientifically literate person is one who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes" (p. ix). Shamos describes scientific literacy as the level at which "the individual
actually knows something about the overall scientific enterprise" (1995, p. 89).

Some commentators have suggested that there is no such thing as scientific literacy, then have questioned who should determine what is important for people to know. For example, Champagne and Horning (1987) suggested that the educational goal of scientific literacy is vacuous and should be discarded because no one knows what it means. In the foreword section of the book *The Myth of Scientific Literacy*, (Shamos, 1995 p.x), Rowe referred to scientific literacy as "some ill-defined thing". Shamos argues as well that scientific literacy is an impossible and unnecessary goal (Wade, 1995). Others state that scientists, teachers, and educators still need to define scientific literacy (Uno and Bybee, 1994).

Yet Mitman, Mergendoller, Marchman, and Packer described an important part of scientific literacy as the teacher's attempt to link science content and its historical, societal reasoning, or attitudinal implications (Mitman et. al., 1987, p. 629). Jon Miller has been actively assessing the status of scientific literacy for some time. In 1989, he described scientific literacy as the minimal level of scientific understanding needed to function in American society.
According to Miller (1989) and Shamos (1995), the United States educational system is failing to produce scientifically literate individuals. If this is true, this failure needs to be examined to find the cause or causes for the lack of scientific literacy.

An example of how America is not meeting Miller's definition of scientific literacy was demonstrated during the 1987 commencement celebration at Harvard University. Crew members for the film A Private Universe interviewed graduating students asking them to explain why it is hotter in the summer than in the winter. Only two of the 23 graduating students responded correctly (Hazen and Trefil, 1991).

In 1995, Hazen and Trefil reported that 25 students selected randomly from a major U.S. university were asked the question, "What is the difference between an atom and a molecule?" Of the students surveyed, only one third responded correctly.

In America, scientific illiterates are in the majority, according to Fort (1993). It has been reported by Miller (1989) and other researchers that only 5% of this nation’s population are scientifically literate. "For the United States to remain strong and free, this percentage needs to change drastically" (Fort, 1993, p.675). Shamos (1995, p.
xi) agrees with Fort as he states that "regardless of all our efforts, by any reasonable measure, we remain predominantly a nation of scientific illiterates".

According to Fort (1993, p.676), the proposed goal to achieve literacy in science is "an understanding of the norms of science and a knowledge of major science constructs, as well as awareness of the impact of science and technology on society and the policy choices that must inevitably emerge".

Science educators have been investigating the ramifications of scientific literacy for many years. In 1988, the American Geological Institute and the National Science Teachers Association sponsored a conference for educators and geoscientists (Mayer and Armstrong, 1990). Its purpose was to discuss what the average 17-year-old high school graduate should know about Earth science. Several goals were established:

**Scientific thought:**

Each citizen will be able to understand the nature of scientific inquiry by using the historical, descriptive, and experimental process of the Earth sciences.
Knowledge:
Each citizen will be able to describe and explain Earth processes and features and anticipate changes in them.

Stewardship:
Each citizen will be able to respond in an informed way to environmental and resource issues.

Appreciation:
Each citizen will be able to develop an aesthetic appreciation of the Earth.

The recommendations of this conference are consistent with those of Project 2061, developed by the American Association for the Advancement of Science in 1989. Rutherford in Project 2061 describes scientific literacy as a necessity for good citizenship, which should be the central goal of American science education. Project 2061 describes “good citizenship” as being able to pick up a newspaper and have a general understanding of the scientific information that is presented (AAAS, 1989).
In summary, "If a large majority of tomorrow’s citizens do not achieve scientific literacy, society may not merely be at a scientific and technological standstill; it will be in imminent peril" (Fort, 1993, p.681). Bauer in 1992 stated that "Scientific literacy is as vital as language, historical, or cultural literacy. Those who master science have the potential to wield great power over those who do not" (Bauer, 1992, p.14).

Statement of the Problem

This study investigates differences in Earth scientific literacy and Earth science content background between and among pre-service and in-service elementary and secondary school teachers. The investigation made comparisons of data regarding Earth science literacy scores and Earth science content background from a survey type instrument developed for this study which was administered to a group of pre-service and in-service elementary and secondary school teachers.

According to educational researchers, the natural sciences are not being taught effectively in the United States. Research by Jon Miller in 1989 supports this finding as his work indicates that less than 6% of the American public is science literate. If society in general
has a low level of scientific literacy, then how does that reflect on elementary and secondary teachers? Miller performed many studies throughout the U.S. during the 1980's by administering multiple choice scientific literacy examinations he designed to individuals at various locations. Miller defined scientific literacy as an achievement of a score of 70% on a multiple choice test containing scientific terms and concepts. His research concluded that of all college graduates, education graduates have the lowest scientific literacy level, 10 percent (Miller, 1989).

Bauer (1992), Duckworth (1990), and Mallow (1981) have found through their research that teachers possess science teaching anxieties at the elementary, secondary, and higher education levels. Elementary teachers feel unprepared to teach science and therefore give science little time in their curricula which they pass along their science anxiety to their students by "science avoidance or by authoritarian presentations of science terminology and generalizations" (Duckworth, Easley, Hawkins, and Henriques, 1990, p. 61).

Evidence suggests that another reason for lack of effective science education in the classroom is that teacher beliefs are often inconsistent with scientific research, adding to the inadequacies found in science instruction. A
specific problem is Earth science illiteracy among elementary and secondary teachers who need to become better educated about Earth systems (hydrological, geological, atmospheric). Education in these areas will improve their understanding of concepts and avoid incorporating scientific misconceptions into their lessons and activities.

Purpose of the Study

The purpose of this study was to explore, describe, and compare literacy in the Earth sciences of pre-service and in-service elementary and secondary school teachers. Pre-service elementary and secondary school teachers were of senior status at an Ohio university while in-service elementary and secondary school teachers were chosen from a suburban school district located in southwestern Ohio. A secondary purpose was to develop an instrument for assessing the Earth science literacy scores of pre-service and in-service elementary and secondary school teachers to gauge their Earth science literacy scores.

Statistical analyses such as ANOVA, Pearson Correlation, t-tests, and frequency distributions were used to compare the following: (1) demographic characteristics of participants, (2) number of Earth science courses taken, (3) perceived level of success, (4) perceived confidence level,
and (5) perceived value of Earth science courses taken with (6) the Earth science literacy scores obtain from the Earth Science Literacy Survey. The overall purpose of this study was to look for and interpret statistically significant relationships between pre-service and in-service elementary and secondary school teachers and the variables mentioned above.

Research by Miller (1987, 1989), Vagelos (1989), Philips (1991), and Shamos (1995) indicates that American adults possess many Earth science literacy problems. Rubba and Harkness reported that pre-service and in-service elementary and secondary science teachers may not "hold adequate understandings of the nature of science and technology and their interactions" (Rubba and Harkness, 1993, p.429). However, no research has been reported to-date in general on the status of Earth science literacy of pre-service and in-service elementary and secondary teachers.

In summary, many educational researchers have identified problems with the scientific literacy of American adults. Rubba and Harkness (1993) reported that research has been performed on the status of scientific literacy of science teachers; few have investigated the scientific literacy of school teachers in general at the pre-service
and in-service elementary and secondary levels. The purpose of this study, therefore, was to explore and describe the Earth scientific literacy scores of these groups.

Assumptions Underlying the Study

(1) It is assumed that the Earth Science Literacy Survey designed for this study is an adequate and appropriate instrument based on validity and reliability studies, with which to gather information/data regarding Earth science courses taken, perceptions concerning them, and Earth science literacy scores. This assumption is based upon the review of the instrument by a panel of experts and a pilot study conducted in the spring of 1992 to determine validity and reliability.

(2) A second assumption underlying this study is that the group of pre-service elementary and secondary teachers from an Ohio university College of Education and the in-service elementary and secondary school teachers from a suburban southwestern Ohio school district are representative of pre-service and in-service elementary and secondary school teachers in general based on demographic data.
Limitations of the Study

1. The central focus of this study concerned itself with (a) college course work in the Earth sciences taken by pre-service and in-service elementary and secondary teachers, along with their (b) Earth science literacy scores and their (c) perceptions including (a) self-perceived level of success, (d) self-perceived level of confidence in personal knowledge of the subject matter at the grade level taught, and (e) self-perceived value of Earth science courses taken. The scope of this study was limited to the comparison of the different groups by their Earth science literacy scores, number of college Earth science courses taken, and their perceptions.

2. The samples used in this study included pre-service elementary and secondary teachers from an Ohio university College of Education and in-service elementary and secondary teachers from a southwestern Ohio school district. Generalizations from this study can only be inferred to the populations from which the samples were drawn.
3. Pre-service and in-service teachers used a self-reported instrument to determine science content background and to respond to the Earth science literacy questions. No attempt was made to confirm self-reported information.

4. No attempt was made to assure equal representation of sexes of teachers or years of teaching experience.

Statement of Hypotheses

1. Are there significant differences between pre-service elementary and in-service elementary teachers’ Earth science literacy scores?

2. Are there significant differences between pre-service secondary and in-service secondary teachers’ Earth science literacy scores?

3. Are there significant differences between pre-service secondary and in-service elementary teachers’ Earth science literacy scores?

4. Are there significant differences between pre-service elementary and in-service secondary teachers’ Earth
5. Are there significant differences between pre-service and in-service elementary teachers’ Earth science content background?

6. Are there significant differences between pre-service secondary and in-service secondary teachers’ Earth science content background?

7. Are there significant differences between pre-service secondary and in-service elementary teachers’ Earth science content background?

8. Are there significant differences between pre-service elementary and in-service secondary teachers’ Earth science content background?

9. Are there significant relationships between the Earth science literacy scores and Earth science content backgrounds of pre-service and in-service elementary and secondary teachers?
10. Are there significant relationships between the desire to obtain science instruction and science content background for pre-service and in-service elementary and secondary teachers?

Research questions were transformed into null hypothesis for statistical analysis.

Definition of Terms

**Elementary Teacher:**
Kindergarten through 6th grade teachers were the elementary teachers involved in this investigation.

**In-service Teacher:**
A college graduate who was teaching in a public elementary or secondary school under a valid teaching certificate at the time of this investigation.

**Pre-service Teacher:**
An enrolled college student in an institution’s teacher preparation program who was actively
participating in student teaching during this investigation.

Secondary Teacher:
Grades 7 through 12 teachers were the secondary teachers involved in this investigation.

Science Anxiety:
The general fear, or aversion, toward scientific concepts, scientists, and science-related activities. (Mallow, 1981)

Scientific Literacy:
The minimal level of scientific understanding needed to function in society (Miller, 1989).

Science Misconception:
An incorrect assumption one holds concerning a natural phenomenon.
1. To identify past research in the literature base on science literacy, a search was initiated on the educational CD-ROM system at the College of Education library at The Ohio State University, The University of Dayton library, Ohio Link, and the library of Jefferson Community College located in Watertown, New York. National Science Teachers Association Home Pages obtained from the internet along with information from the Eisenhower National Clearinghouse for Mathematics and Science Education located at The Ohio State University was utilized as well. The ERIC database was searched, along with Dissertations Abstracts International, to locate past and current research in this area.

2. Instruments were developed and adapted to collect data on Earth science literacy scores, demographic characteristics, Earth science content background, self-perceived level of success in the Earth science courses taken, self-perceived level of confidence in the subject matter at the grade level taught, and the
self-perceived value of Earth science courses taken at the college level.

3. Questions on the Earth science literacy survey were adapted from questions developed by other researchers. Miller's index for determining scientific literacy by using a combination of three dimensions of scientific understanding (1989) was used to screen questions. The science content background survey was adapted from an earlier survey designed by Czerniak (1989).

4. Instruments were reviewed by the dissertation committee, other faculty members, and graduate students from the science and math education program at The Ohio State University College of Education to establish validity. Based on feedback from the panel of experts, some alterations were made in the instrument.

5. An application to the Human Subjects Review Board at The Ohio State University was filed and approved.

6. A pilot test was conducted at an elementary school
in southwestern Ohio in April of 1992. Fifteen elementary teachers were given the test; ten responded. An estimate of instrument reliability was calculated on the science literacy portion of the survey. A statistical package (SPSS) at The Ohio State University Academic Computing Service Center was utilized for the analysis.

Data were statistically analyzed using several descriptive statistics: reliability, inter-item correlations, covariance, corrected item total correlation, and Cronbach’s Alpha.

Summary

This study was proposed in order to carry out a comparison of Earth science literacy scores, along with the number and self perceived perceptions of Earth science college courses taken of pre-service and in-service elementary and secondary school teachers. Current research suggests that educators at the pre-service and in-service elementary and secondary levels are failing to acquire a good Earth science literacy base during their current or past educational experience. Perhaps this is one of the reasons why Earth scientific literacy is not being developed in their students.
Chapter II reviews the literature supporting this study. Included are reviews of the history of science literacy, science literacy issues, problems with teacher scientific literacy, and science misconceptions.
CHAPTER II
REVIEW OF LITERATURE

Introduction
The purpose of this chapter is to review past and current literature in science education related to scientific literacy as perceived by educational analysts and researchers. Four major topics are addressed: (1) The History of Scientific Literacy, (2) The Educational Status of Scientific Literacy, (3) Scientific Literacy Issues, and (4) Science Misconceptions.

The History of Science Literacy
At the beginning of the nineteenth century, the basic educational system in the United States inherited from the middle ages was still in use. It consisted of a primary level of reading, writing, and arithmetic while the upper levels of study were dominated by the classical languages (DeBoer, 1991).

It wasn’t until the second half of the nineteenth century that a number of prominent scientists challenged the existing classical curriculum, which ignored the sciences.
In fact, several scientists, including Charles Lyell, Michael Faraday, John Tyndall, and many others argued that science should replace the study of the classical languages in the school curriculum. They supported a "meaningful learning of science concepts" from direct contact with the outside world which would allow for skills in observation and inductive logic. (DeBoer, 1991, p.17).

Charles W. Eliot, president of Harvard University from 1869 to 1895, was a major contributor to the early science education movement. Eliot was interested in the sciences at the college level and recognized the need for the sciences to be taught in the elementary and secondary levels. He felt that science should be taught with "objects and instruments in hand", not just based on lectures from books. He was one of the first to recognize and support laboratory-based science education.

During the 1890s, major changes took place in the classroom as there was widespread condemnation of the formality, harshness, and mindlessness of the traditional educational system. Many argued that this system did not adequately prepare its students for the twentieth century. At this time, Eliot concerned himself with the development of a science-related secondary school curriculum program to prepare students for a collegiate program. He then became
chairman of the prestigious Committee of Ten of the National Education Association which was comprised of William T. Harris, the U.S. Commissioner of Education, the presidents of the Universities of Michigan, Missouri, and of Colorado, Vassar College, a member who would soon become president of Oberlin College, and three principals of secondary schools (DeBoer, 1991). To infuse science into the classroom and create a smoother transition from high school to college, The Committee of Ten presented to the educational community a series of suggested reforms which advocated the use of laboratory-based science teaching and proposed that educational experience should be for "personal empowerment" (DeBoer, 1991, p. 34).

By the beginning of the twentieth century, several courses in the sciences, including chemistry, biology, and physics, became established in the high school curriculum, as a direct outcome of suggestions made by Harvard University. DeBoer reported that these turn-of-the-century science courses were written in such a way that they had application and relevancy to the lives of the students. This theme "application and relevancy" has waxed and waned several times in the ninety years since.

About the same time, John Dewey declared in the early 1900s that science education should focus on problem
solving, believing that high school science should do more than just prepare a student to play a useful role in society. He pushed for the development of curriculum that would give students the "scientific habits of the mind" which would come from the presentation of the methods of sciences (Shamos, 1995, p. 78). Dewey also advocated a teaching practice of reconstruction of experience which takes into consideration what knowledge the student already knows or has experienced and builds on it. He also stressed the importance of connectedness and warned against isolationism. This very same rhetoric is being used today in support of science education programs, though seventy years later (DeBoer, 1991).

One of the earliest definitions of scientific literacy was offered in the 1930's by I.C. Davis as a "scientific attitude." Davis stated that one who has a scientific attitude will: "(1) show willingness to change his opinion on the basis of new evidence; (2) search for the whole truth without prejudice; (3) have a concept of cause-and-effect relationships; (4) make a habit of basing judgment on fact; and (5) have the ability to distinguish between fact and theory" (Shamos, 1995, p. 81).

During the next two decades, little happened in the field of science education as the country's attention was on
World War II. DeBoer reports that during the progressive era, "a number of important ideas were generated between 1920 and 1950s", concerning science education, "but in large part there was almost as much confusion at the end of the period as there was at the beginning" (DeBoer, 1991, p.106). In the mid-1950s, a number of scientists along with the National Science Foundation began to take a closer look at the way science was being taught in the classroom. Federal funding for science education seemed to have taken the back seat until the United States lost the space race to the Soviet Union's launching of Sputnik in 1957. It was not until then that the U.S. government took notice of the problems with science education and backed initiatives by NSF and other science organizations with "enthusiasm and financial support" (DeBoer, 1991, p. 147).

The amount of science curriculum reform that took place after Sputnik was unprecedented, according to DeBoer. The National Science Foundation, as well as other agencies of the United States government, financially backed curriculum reform in the sciences for two decades. A variety of curricular programs were developed during this time by physicists, biologists, chemists, and Earth scientists.

What these curriculum makers failed to do, according to DeBoer, was to teach science in a way relevant to student
lives. According to DeBoer, science needs to "provide individuals with knowledge and skills that would help them live intelligent lives in the culture in which they found themselves" (p. 172). Paul Hurd in 1970 stated that:

1. New curriculum developed was too difficult for high school students.

2. New curriculum did not motivate students in the study of the sciences.


Along the same lines Gallagher in 1971 noted that the new curriculum projects at the time, took a limited view of science focusing only on concepts and the processes of science. He wanted students to become familiar with the social interactions with science as well as the structured disciplines themselves. He was the first to suggest that science should be presented with a broader base: Science-Technology-Society (STS) (DeBoer, 1991).

Several years after the space race began, C.P. Snow (1959) published a book entitled The Two Cultures, where he described a "rift" developing between scientists and literary intellectuals (non-scientists). He had identified the rift in the 1930s and noted that it probably had been
occurring since the beginning of the Industrial Revolution some two hundred years earlier. This divergence may be one of the causes for low scientific literacy levels in the United States. Scientists have become very specialized with their research as well as developing new terminologies that are not well understood outside of their specialized domain. This specialization of subject matter becomes irrelevant to the non-scientific person, therefore allowing a rift to occur.

 Shortly after the publication of C.P. Snow's book, Nagel in 1962 identified four problems with modern-day science which could be at the root of today's problems in scientific literacy. Nagel noted the following:

(1) First, science deals with instrumentalities and is not capable of determining values. This has caused people to become insensitive to the distinction between good and evil. Nagel noted that many scientists assert that "what is good for man lies outside the province of scientific method, because the determination of the human good requires a sympathetic understanding of the human heart and sensitivity, individualized perception of the qualities of the human personality; and the exercise of such powers, it is maintained, has no place in the procedures of science" (p.638).
(2) Second, science does not offer an "ultimate explanation" for human existence: who we are, what we are, where humans fit into the universe. Science is able to look back into prehistoric time, examine the Earth's past and track the evolution of humans. However, it does not have "the answers" (p.632) about human existence and about the universe itself.

(3) Third, science has tried to reduce the world to mechanical or materialistic properties. The universe and the world are complex; humans are just beginning to understand them. Many recent books are concerned with the topic of "chaos" in the sciences. According to Hazen and Trefil (1991), humankind can never really measure all of the variables of a system accurately enough to predict its behavior with certainty. The weather provides an example of a chaotic system. Thousands of measurements are taken all over the world in order to predict tomorrow's weather. Due to the number of variables, accurate forecasts are still difficult to make.

(4) Fourth, according to commonly accepted descriptions of scientific method, sensory qualities are not properties of objects and, therefore, are not used in science; they are part of the "immaterial mind" (p.624). Sight, smell, and sound are considered subjective.
Standardization is demanded by the scientific community so that replication of experiments can be performed by a number of scientists, but sensory qualities lack the standardization needed and therefore are not used.

Nagel (1962) reached four conclusions:

1) When learning about science, students should be encouraged to use all of their senses to realize that science does not rely totally on instrumentation.

2) Science does not offer an ultimate explanation of our existence.

3) The world cannot be totally reduced to mechanical or materialistic properties.

4) Science does not always make effective use of the natural senses.

Thus, according to Eliot, Dewey, Nagel and others, it is important for educators to present science as a relevant subject matter for students as well as to instruct in a manner that utilizes a hands-on approach. Science education should not be totally based on memorization of facts and figures but also on making personal observations from a person's five senses. Science should not be taught in an authoritarian manner but rather as a process of discovery. Lastly, according to Nagel, science educators should not shy
away from mistakes that occur in the sciences but should use examples of the mistakes of scientists to point out to students that science doesn’t always have all of the answers.

Summary of The History of Science Literacy

Scientific literacy has been an issue for over a hundred years in the educational system of the United States. Early scientists like Charles Lyell called for the replacement of the classical languages with the natural sciences in the school curricula. Lyell and others argued that science was not just a group of facts and figures; it was a process of discovery, a way of thinking that should be appreciated and understood by all. Charles Eliot, is given much credit for recognizing the need for science at the elementary and secondary levels of education. Eliot was chairman of the Committee of Ten which was responsible for numerous suggestions to the educational community concerning science education. John Dewey, at the turn of the century, declared that science education is beneficial to students as it helps them with their problem-solving skills.

During World War II, our country turned its attention from science education to the war effort. Shortly before and after the successful launch of Sputnik in the late 1950s,
many scientists along with the National Science Foundation called for reforms in science education which were backed financially by the United States government. However, much of the science taught was too difficult for students to understand, did not motivate students in the study of the sciences, and ignored the role of science in everyday life.

C. P. Snow and Nagel had much to say concerning the status of science education in the United States in the late 1950s and early 1960s. C. P. Snow noticed a rift between the scientists and the non-scientist. Nagel noted that science has many shortcomings and, in some cases, is not user-friendly for the non-scientist. Hurd and Gallagher noted in the early 1970’s, that the current science curriculum was either too difficult for high school students, lacked to motivate students in the sciences, or ignored the role of science in everyday life.

Many of the same issues in science education that were present a hundred years ago are still evident today. The next section addresses scientific literacy issues that have plagued science education in the past as well as the present.
Scientific Literacy Issues

The status of scientific literacy has been reported in the United States by educational researchers and others as being in poor condition. For example, Bauer in 1992 stated that "Scientific literacy in the United States has been an acknowledged crisis for at least thirty years." Others state that we not only suffer from scientific illiteracy but a "general illiteracy" in the United States (Howell, 1992, p. 152).

According to an article in Phi Delta Kappan (Fort, 1993), a study by Jon Miller showed that only 5% of today's society is "scientifically literate". According to papers by Miller (1987), Vagelos (1989), Hazen and Trefil (1991), and Philips (1991), scientific literacy levels in the United States are of concern. The news media have asserted that good science education in this country is "lacking" (Feck, 1989). Miller (1989) assessed the level of scientific literacy among adults in the U.S., United Kingdom, and Japan. His research indicates that the average adult in this country is appreciably less knowledgeable about basic science concepts and definitions of scientific terms than are adults in other industrialized countries.
Many educators and educational researchers have defined scientific literacy. Henry Bauer, in his 1992 book entitled *Scientific Literacy and the Myth of the Scientific Method*, listed three components one must understand to be scientifically literate: (1) "the substantive concepts within science, (2) the nature of scientific activity, (3) the role of science in society and culture" (p.2). Bauer mentions some scientists might prefer to add to component 1. "facts" or "phenomena", however he felt this would simply be a "semantic quibble". Along the same lines, Hazen and Trefil (1991, p. A44) stated that scientific literacy "is the ability to understand science in its day-to-day context".

Miller's index for determining scientific literacy is based on a combination of three dimensions of scientific understanding (Miller, 1987):

1. One's understanding of scientific study: Subjects were presented with open-ended questions concerning the meaning of scientific study and were asked to demonstrate knowledge of what it means to study something scientifically. For example, subjects needed to describe the difference between astronomy and astrology—that astronomy is scientifically based while
astrology is not. Miller reported that only 12 percent of Americans surveyed were able to demonstrate this knowledge, but did not indicate what he considered a "passing score".

2. One’s understanding of scientific terms and concepts: Respondents needed to score 70 percent on a set of questions asked concerning their knowledge of terms such as the concept of "photosynthesis" and the theory of "evolution." Only 28 percent of Americans surveyed met this criterion.

3. One’s understanding of the impact of science on society: This area covered topics such as the understanding of heart disease, radioactivity, and Earth sciences. Respondents needed to score 50 percent on the questions asked to meet this standard. Only half of Americans surveyed achieved this score.

Miller’s index for determining science literacy is paralleled by assessment domains by Yager and McCormack for Science/Technology/Science modules. They are as follows:

1. Concept Domain (mastering basic content constructs)
2. Process Domain (learning the skills scientists use
in sciencing)

3. Application and Connection Domain (using concepts and process in new situations)

4. Creativity Domain (improving in quantity and quality of questions, explanations, and tests for the validity of personally generated explanations)

5. Attitude Domain (developing more positive feelings concerning the usefulness of science, science study, scienceteachers and science careers) (Yager, Tamir, and Kellerman, 1994, p.268).

From Miller’s research concerning these three factors, only one in sixteen American adults (6 percent) could be classified as scientifically literate. The same survey was given to adults in Great Britain where one in fourteen (7%) was classified as scientifically literate.

Other studies have concluded that only 17 percent of United States college graduates and only 25 percent of those with graduate degrees have even a “rudimentary knowledge” of science (Hazen and Trefil, 1991). Shamos reports that another paper by Miller places a “fraction of adult
Americans who possess a 'minimal' understanding of scientific terms and concepts at about 30 percent" (Shamos, 1995, p. 89). Shamos and Miller fail to define what is "minimal".

It is a concern of others as to whether a scientifically illiterate society can function on a world level or make the necessary decisions about environmental issues or genetic engineering (Allman, 1993). Howell (1992) agrees with Allman in his concern about a scientifically illiterate society. Howell states that we need to concern ourselves about preparing students for a future that will be dependent on science and technology and assuring that all people are informed; that is, that they are able to react to scientific issues on a factual, not an emotional, basis (Howell, 1992).

The American Geological Institute (AGI) has also been interested in scientific literacy. In 1991 the AGI National Center for Earth Science Education proposed four interrelated goals for Earth science educators to improve the overall science literacy level of students:

**Stewardship:** Students need to become stewards of the Earth.
Appreciation: Students need to develop a deep aesthetic appreciation of the history, beauty, simplicity, and complexity of the Earth.

Scientific Thought: Students need to understand ways in which Earth scientists investigate the Earth.

Knowledge: Students need to understand essential Earth science concepts (AGI, 1991).

A part of good citizenship, according to Project 2061, can be achieved only by one who is scientifically literate. AAAS stresses the importance of becoming familiar with the natural world, understanding key concepts and principles of natural phenomena, understanding the interdependence of science with mathematics and technology, and understanding that science is a human enterprise with strengths and limitations. Project 2061 recommends that science educators change the science curriculum from a layering concept to an integrated approach which has been discussed since Dewey. By infusing relevant science into the total curriculum (For example: English, Social Science, Math), the authors of
Project 2061 perceive that student scientific literacy will be improved (1989, p.x).

Not all researchers agree on the amount of scientific literacy one needs. Church (1992) states that there is no need for the average citizen to be able to do what scientists do. Some scientists and educators believe one cannot appreciate science unless they have "done it". However, even professional scientists exhibit scientific ignorance in a different manner. They often find it difficult to discuss their ideas and findings with someone not in the same discipline. For example, in one study of a group of physicists and geologists, only a few could explain the difference between DNA and RNA (Hazen & Trefil, 1991).

According to Hopkin, the nonspecialist's understanding is the key to scientific literacy. "Scientific thinking has to be integrated into mass communication" (Hopkin, 1993, p.697). Science writers are also important factors in increasing science literacy as people are encouraged to read Science News, Natural History, Discover, and Smithsonian (Fort, 1993, p.680).

Perhaps due to a lack of individual scientific literacy, another "rift" has developed over the past 36 years according to Shamos, who has identified another group he refers to as "the science counterculture." He describes
this group as individuals who fear that science is harming "the environment" or "the physical, economic, or psychological well-being of society" (Shamos, 1995, p. 111).

Summary

There are many issues that deal with scientific literacy. There is a consensus among educators and researchers that the status of scientific literacy in the United States is poor. However, opinions of what scientific literacy is and how to remedy the problem vary from educator to educator, researcher to researcher. For example, Jon Miller's findings in the late 1980s stated that our society for the most part is scientifically illiterate according to his standards, but his standards are not clearly defined. Most researchers tend to blame the educational system for not making science interesting enough to students or for not incorporating science in the elementary or secondary classroom. The next section addresses literature dealing with what can be done to improve overall scientific literacy levels.
The Educational Status of Science Literacy

There are currently many aims, goals, and objectives developed by educational researchers and various science education organizations (Bybee, 1995). Bybee claims that these goals all share three common goals: the classroom teaching of science, teacher education in the sciences, and science curriculum development.

Many researchers have defined the educational status of science literacy. In 1974, Showalter defined unified science education in terms of the following characteristics: (1) Nature of the sciences, (2) Concepts in science, (3) Processes of sciences, (4) Values of science, (5) Science and society, (6) Interest in science, and (7) skills associated with science.

Klopfer has worked with literacy for several decades. His research has evolved to focus on specific concepts and how these concepts impact learner literacy (Klopfer et al, 1992).

A 1990 study of biology education by the National Academy of Sciences found that introductory high school biology courses provided a "notoriously poor educational experience" for students. Hazen and Trefil reported that both teachers and scientists have created "a system that
alienates students from science from their earliest years" (Steen, 1991 p. 17.) According to other educators and educational researchers as well, the status of science education in general is poor.

To combat this in the United States, the American Association for the Advancement of Science has designed a long-range, multiphase effort, Project 2061, to help the nation achieve scientific literacy (Rutherford & Ahlgren, 1990, p.204). It began in 1985, coincidentally the same year Halley's Comet visited the Earth's vicinity. Project 2061 emphasizes that "science includes humanities and the humanities include science" (Allman, 1993, p.72). Project 2061, Science for All Americans, defines scientific literacy and sets conceptual goals for K-12 science education. Science education "should help students to develop the understanding and habits of mind they need to become compassionate human beings able to think for themselves and to face life head on" (AAAS, 1989, p.12). Rutherford and Ahlgren (1989) defines the scientifically literate person as one who understands key concepts and principles of science and uses scientific knowledge and scientific ways of thinking for individual and social purposes.

To achieve the goals of scientific literacy, Bruce Alberts, president of the National Academy of Sciences, at
the annual 1995 meeting of the American Association for the Advancement of Science proposed four “bottom lines” concerning science education (Genoni, 1995, p. 3).

1. Science should become a core subject like reading, writing, and math in grades K through 12.

2. At all levels, the material taught should be interesting to both students and teachers.

3. Science teaching must become attractive as a profession that is possible to enter without superhuman efforts.

4. The scientific community must accept responsibility for achieving these three goals.

A constant effort is being set forth to change the “failing efforts to instruct American citizens in how the universe works” (Allman, 1993, p.72). Recently, the International Assessment of Education Progress concluded that in science, American 13 year olds fall last out of 15 industrial nations, “finishing behind countries like South Korea and Hungary” (Allman, 1993, p.72).

For example, astrology is a larger wage-earning field for Americans than astronomy. The problem according to Fort, is that people need to actively experience the
disciplines of science in order to understand and have the confidence in their knowledge. Science is achievable to some degree to all who are willing to try and work to comprehend it (Fort, 1993).

While establishments such as museums and nature centers are trying to increase interest in and understanding of science, there are others that stand in the way. Beginning science courses which prepare people for careers in science “should be replaced with experimentally based courses” (Fort, 1993, p.681). Many students leave science in the first years of college because of the difficulty of the presented material. Introductory science classes do not apologize, remain competitive, are intimidating and are selective to weed out the weak from the strong.

Granted, courses cannot always be easy, but initiating science in an overwhelmingly complex manner is like trying to “run before learning to walk” (Fort, 1993, p.679). “The way of the scientist deepens beauty by increasing understanding” (Fort, 1993, p.678).

There are obstacles to teaching science as well as other academic subjects, according to Fort. Science has become so intricate that no scientist can honestly say that he or she knows it all. It does not come as a surprise,
then, that science is perceived by teachers and students as an overwhelming cluster of complex, intimidating principles.

At present, education for the most part is "coming between students and science" (Fort, 1993, p. 677). If what is being taught is not being understood, it is probable that there is a deficiency in the process. Teachers should stress that every person should understand the basic principles of scientific knowledge (Allman, 1993). The disconnected facts, the almost meaningless conglomeration which is being taught, is not going to help to enhance interest in science (Allman, 1993). Designing a program that teaches basic scientific principles is an on-going experiment in itself. The National Science Teachers Association is trying to entice students to learn science through laboratory exploration rather than "being encumbered by obscure terms and equations" (Allman, 1993, p. 73).

Broadening exposure to science and improving the educational process in science cannot lie on the shoulders of the schools alone. "Changing the attitudes of the public towards science is a must" (Fort, 1993, p. 676). Most Americans are brought up in science-shy families, in science-shy communities, and attend science-shy schools where they study a science-shy curriculum presented by a science-shy instructor (Fort, 1993). "Going public" is what
Dr. Leon Lederman, Chairman of the American Association for the Advancement of Science Board of Directors, suggests. His view is that media paraphernalia, TV (sitcoms), newspapers, magazines, cereal boxes and sky writing, need to be used to make America aware of the importance of science. It is essential that people understand science and its importance in the past, present, and future.

According to Duschl (1988), science should be looked upon as a field of study where students can broaden their knowledge by asking questions and creatively discovering the world around them. He studied the way science was being taught in the K-12 grades and found teachers are somewhat textbook-dependent, recount mostly factual knowledge, and ignore discovery or inquiry exercises. Similarly, Easley (1990) found that elementary school teachers, along with secondary and college-level science teachers, "often unconsciously imitate the authoritarian approach of scientists" when presenting science in the classroom. Therefore, students fail to think critically as they simply memorize what their teachers have reported (Duckworth et al., 1990, p. 62)

In 1985-86, a national survey reported that between 70 and 90 percent of elementary school teachers teach science directly from the textbook (Weiss, 1987). In some cases,
Duschl found that science was not being taught at all. This appears to be common from kindergarten through the sixth grade.

Teacher training could also be part of the cause for the low science literacy in the United States. Conceivably, many educators have not taken any science classes in decades, perhaps for reasons mentioned above. "Only 35,000 of the nation's one million primary-grade teachers are specifically trained in science. Two-thirds of elementary teachers reported feeling unprepared to teach science" (Fort, 1993, p.677).

More important than knowledge, teachers must show enthusiasm when teaching science to be effective in the classroom (Fort, 1993). To become familiar with science and teaching techniques, teachers can take well designed in-service training programs. Teachers should take advantage of these programs and then share what they have learned with their home school (Fort, 1993). "The job of educators is to open the world of science first to themselves and their colleagues and then to their students" (Fort, 1993, p.677).

The attitude of the science teacher can have an impact on what children learn. If teachers found science lessons dull during their own school days, they are likely to convey that same attitude toward science to their students (Kyle,
Bonnstetler, Gadsen, 1988). To be effective, teachers must convey positive images of science and scientists to their students. Kyle, et. al.(1988) concluded by stating that if teachers are provided with appropriate in-service education in science, they will be able to present science as an interesting area of study that will foster a student’s curiosity.

Teacher certification requirements may be a factor in low scientific literacy level in this country. A 1987 survey conducted by the Council of Chief State School Officers reported each state’s teacher certification requirements in mathematics and science at the elementary, middle, and secondary levels. The survey found these problems:

(1) Fourteen of the fifty states did not require any course work in the sciences for elementary certification.

(2) Only 27 states required some course work in the sciences for elementary certification. In states that did require science courses for elementary teaching certification, only 3 to 12 semester credit hours in science were required. Only six states of the 27 required 21 or more semester hours of science content for elementary
certification, while ten states allowed the degree-granting institution to determine the certification standards.

(3) Nine states were not reported in this study.

Ohio’s state certification requirements, as of 1996, are determined by the degree-granting institution and do not require that science teaching methods be taught. Many institutions in Ohio require three to four science courses for elementary and secondary certification for those not preparing to teach science.

Research by Rowe (1980) concluded that science is a "vanishing species" in the elementary classroom. Rowe found the following to be true:

(1) K-3 teachers report spending an average of only 17 minutes per day teaching science. Twenty-eight minutes per day were reported by grade 4-6 teachers.

(2) Student performance in the sciences on the National Assessments of Education Progress (NAEP) tests has deteriorated over the years.

(3) Twenty-two percent of elementary teachers surveyed felt
unqualified to teach science.

(4) Eighty percent of K-6 grade schools do not have a budget for science materials.

(5) Teachers almost exclusively use textbooks as the source for science teaching.

(6) Ninth grade students report an interest in science but know very little about it.

The 1985-86 researchers in the National Survey of Science and Mathematics Education surveyed in-service teachers to discover what science and math courses they had taken at the college level. This self-reported survey found that 88 percent of the teachers surveyed had taken an educational methods course. Eighty-six percent had taken a college biology course, but only 44 percent had taken a college course in the Earth and space sciences. Seventy-two percent had taken at least one course in the physical sciences, but very few had studied chemistry or physics.

The National Science Teachers Association has recommended that elementary science teachers should have at least one course each in biology, Earth and space science,
the physical sciences, and one methods course in science education. Only 34 percent of the teachers surveyed met the recommendations of the National Science Teachers Association (Horizon Research, 1990).

The same survey reported that elementary school teachers are not receiving the in-service training they need in the sciences. One of every two elementary school teachers had had no in-service training in the sciences in the past 10 years. Twenty-two percent had received less than six hours of in-service training in the sciences (Horizon Research, 1990). In addition, more than half of America’s principals report difficulty finding science teachers (Fort, 1993).

Bauer (1992) stated that science should be integrated more into the K-6 level to achieve a higher overall science literacy rate. Children might be more interested if they start at an earlier level before the “institution of education” has crushed their creativity, according to Bauer. At the elementary level, teachers could teach science with an emphasis on hands-on investigation of the child’s immediate world. “Children should learn not only about the birds, the bees, and the flowers, but a little also about the galaxies and the stars, and about the substances we
encounter and use and of which they themselves are made” (Bauer, 1992, p.17).

Science anxiety also plays a role in scientific literacy. Mallow (1981) defined science anxiety as a fear of, or an aversion to, science concepts, scientists, and science-related activities which can result in learning problems in science. Children are born with some kind of natural curiosity about nature; this curiosity may turn into negativism and anxiety as they grow older. Chiavelott and Czerniak (1987) stated that non-threatening science education curricula need to be developed for student use prior to the fourth grade, especially for females, and that science teachers should be made aware of their own science anxieties.

Finally, scientific literacy or lack thereof, can also be linked to parents and the social family environment (Heller, Padilla, Hertel, Olstad, 1988). Family interaction can be even more important than the school as an educational environment. If the parents dislike science, then the children may also. In some cases, parent-child interaction has a positive effect on the child’s science education, which in turn may impact heavily upon improving the scientific and technological literacy of American society (Heller et al., 1988).
Summary

Many researchers and educators have commented concerning the status of science education in the United States. Many programs have been instituted to improve the overall scientific literacy levels of the United States like Project 2061, “Science for All Americans”, or the program of educational goals instituted by the American Geological Institution (AGI). These programs focus on altering current science curricula by increasing the relevancy to the student of the science being taught. Teacher certification requirements at the elementary and secondary levels were found to be lacking in many states. The way science is presented in the classroom was found by researchers to be textbook-dependent and poorly taught, often with little or no time given to science during the overall school day.

The next section deals with science misconceptions which researchers and educators have identified as affecting the overall scientific literacy levels of students and adults in the United States.

Science Misconceptions

One of the possible reasons for low scientific literacy levels in this country is simply misconceptions about the sciences held by students and adults. Lack of knowledge
about the sciences by the teacher could lead to scientific misconceptions, which the teacher could easily pass on to the student. This could easily jeopardize the nation’s scientific literacy level. “Nowadays, science and technology are so inextricably a part of our lives that ignorance and misconception about them may have particularly regrettable consequences” (Bauer, 1992, p. vii).

Smith (1989) noted that high school students possess preconceptions that actually obstruct instruction. He argued that the existence and persistence of students’ preconceptions imply that learning involves not only the acquisition or formation of new concepts but also the modification of existing concepts or their replacement with appropriate concepts. McIntosh (1995, p. 16) found that students are reluctant to change their misconceptions because "their understandings of the concept appeared to be useful and logical."

However, teaching for conceptual change is inappropriate, according to Smith (1989). Some students attend primarily to their own individual "set up" (which is the misconception), and ignore other attempts to correct this misinformation (Smith, 1989). According to McIntosh, these preconceptions of students are "a sum total of life’s
prior experiences" which makes them difficult to correct (McIntosh, 1995, p.16).

For example, the following Earth science misconceptions of adults have been identified by recent research as indicated:

1. Gravity is selective and acts differently on all matter (Watts, 1982).


3. Seasons are caused by the Earth’s distance from the sun (Rastovac & Slavsky, 1986; Marquand, 1988; Schoon, 1989).

4. The sun is directly overhead at noon (Schoon, 1989).

5. The sun will never stop giving off heat and light (Lightman and Miller, 1989).

6. The universe is static and not expanding (Lightman and Miller, 1989).

7. The universe contains only the planets in our solar system (Lightman and Miller, 1989).

8. The sun goes around the Earth (Rachlin, 1988; Miller, 1989).

10. Radiation can be reduced by boiling radioactive material (Miller, 1989).

11. All radioactivity is human made (Miller, 1989).

12. The Earth is 6 to 20 thousand years old (Zimmerman, 1990).

13. Dinosaurs and humans existed at the same time (Schoon, 1989).

14. Evolutionary changes are driven by need (Brumby, 1988).

15. The "Garden of Eden" is where human life began (Hively, 1988).

16. Human beings did not evolve from earlier species of animals (Miller, 1989).

17. The oxygen we breathe does not come from plants (Miller, 1989).

18. All rivers flow down from north to south (Meyer, 1987).

19. Salt added to water doesn't change the weight of the solution (Lawrenz, 1986).

20. Glaciers are created rapidly (Happs, cited in Osborne, et al., 1985).

22. The Earth's gravitational attraction is reduced on the tops of mountains (Gunstone and White, 1981).

23. Winter weather can be predicted by examining the thickness of fur on animals (Schoon, 1989).

24. Mountains are created rapidly (Happs, cited in Osborne, et al., 1985).

25. Any crystal that scratches glass must be a diamond (Schoon, 1989).

26. Phases of our moon are caused by the shadow of the Earth (Marquand, 1988; Schoon, 1989).

27. Gravity cannot exist without air (Watts, 1988).


29. Floods along many rivers occur only after the snow melts in spring (Schoon, 1989).

30. The Earth is molten inside except for the crust (Meyer, 1987).

31. Sound travels faster than light (Miller, 1989).

32. Atoms are smaller than electrons (Miller, 1989).

With so many misconceptions, it is an asset for teachers to identify the misconceptions of their students before they start teaching. Bell, Osborne, and Tasker
(1985) urged teachers to sit alongside, rather than opposite, a child or group of children and collect the students' ideas in their own words. Unfortunately, according to Yager (1984), some science teachers define science education as a process simply to divulge scientific information to students; they place a great emphasis on the mastery of a special vocabulary. Yager notes that students learn more new terms in a one-year science course than they would if had they studied a foreign language for two years.

The constructivist theory in education states that learners actively construct knowledge for themselves (Magoon, 1977); knowledge is constructed in the mind of the learner (Bodner, 1986). This is accomplished by using existing knowledge and utilizing this knowledge to interpret new information. This interpretation allows the learner to understand that information. Learners then build their own conceptual patterns. Adaptations and restructuring must occur if the learner is to coalesce the scientist's interpretation of the event (Hewson and Hewson, 1988). Therefore, if one holds the constructivist view then one must hold that teachers as learners build their own conceptual structures in which they use their knowledge base to understand the sciences.
According to Hawkins, today's educational system is simply too "book centered" (Hawkins, 1990, p. 2). Textbooks, according to Bauer (1992) and Abimbola and Baba (1996), cause students to develop misconceptions concerning the overall operation of science (scientific method); they contain misinformation concerning topics in the sciences which provide students with science misconceptions and alternative conceptions. Textbooks provide students with a rosy view of how science works and talk little of "unsuccessful science" (Bauer, 1992, p. 11). Abimbola and Baba (1996) found that a number of biology texts surveyed contained information which was out of date or incorrect. Duschl reported in 1988 that because the majority of school teachers rely heavily on their science textbooks to instruct science courses, school teachers unknowingly are passing along scientific misconceptions to their students.

Miller (1989) published a partial list of field-tested scientific misconception questions to assist him in describing the status of scientific literacy on a world-wide basis. In June and July of 1988, the Public Opinion Laboratory at Northern Illinois University surveyed 2,041 American adults by telephone to determine their scientific interest and literacy level. A sample question follows:
1. Does the Earth go around the sun, or does the sun go around the Earth?
   a. Earth goes around the sun
   b. sun goes around the Earth
   c. Don’t know

Miller found that 21 percent of Americans incorrectly believe that the sun goes around the Earth, while only half of those who knew that the Earth goes around the sun also knew that it takes one year to make the trip.

Other results of Miller’s findings are as follows:

1. A similar study to the one conducted by Miller in the United States found Great Britain’s scientific literacy to be about seven percent. Miller defines scientific literacy as the minimal level of scientific understanding needed to function in our society (Horizon Research, 1990).

2. A larger portion of college graduates are scientifically literate (17%) than high school graduates (5%). Those college graduates who majored in the sciences and engineering were the most scientifically literate (27%). The lowest was among
education majors with about a ten percent literacy level (Horizon Research, 1990). Men were found to be more science-literate than women (Culliton, 1989).

3. A college level science course is the "single most important" predictor of science literacy (Culliton, 1989).

Summary

Many science misconceptions identified by educators and researchers are of great concern because of their effect on the overall scientific literacy levels of society. Misinformation concerning a scientific phenomenon that is passed along to a student or adult is, in some cases, difficult to change to the correct concept. Students and adults pick up science misconceptions from a variety of sources not limited to textbooks, including school teachers at the elementary and secondary levels, college or technical instructors, the media, and family and friends.
Chapter Summary

To the extent that the United States is behind other countries in scientific literacy, American scientists and business leaders warn the public that something must be done to reverse this trend and keep the U.S. more competitive in the world marketplace. Not only do important decisions need to be made in the marketplace but understanding of the ways the Earth's finite resources are managed is also needed. Global decisions affecting the environment must be made with a great deal of confidence; confidence to make these decisions needs to be based on knowledge, understanding, and education (Mullins and Jenkins, 1988).

Smith and Gessler (1989) estimated that the number of scientists and engineers needed to keep the United States competitive in the world marketplace is approximately four percent of the general population. Therefore, the importance of scientific literacy in the coming years cannot be overstated. As our society becomes more complex, technical support personnel will be needed in greater numbers.

Scientific illiteracy in both technical and non-technical fields is everywhere in our society. "If the
The large majority of tomorrow's citizens don't achieve scientific literacy, society may not be merely at a scientific standstill; it will be in imminent peril, for ignorance in the postindustrial era can devastate the planet" (Fort, 1993, p. 681). Efforts are being made by schools as well as local and national science organizations to bring the world of science to people in cultural, thematic forms of understanding. The entire nature of being human is science. All aspects of the world have scientific connotations. Science is an art of discovery. "In the long run, the scientist knows a kind of success, but daily it comes from intelligent failure" (Fort, 1993, p. 677).

Butts (1990) asked if it was possible that what students know and believe is influenced by what their teachers know and believe, and is it possible that what teachers know and believe is influenced by their formal schooling experiences, both pre-service and in-service K-6. These are valid questions. If teachers possess misconceptions concerning science, will they pass them along to their students?

To make informed decisions, people "must become familiar both with fundamental scientific principles and their impact on society" (Fort, 1993, p. 676). Issues such as "the depletion of the ozone layer, increasing rate of
species extinction, the disposal of hazardous wastes and the loss of arable soil are just a few problems the world faces” (Fort, 1993, p.681).

In Chapter III the procedures pertaining to this investigation are set forth; also, elements of research design, hypotheses, participants, data collection, variables, statistical treatment, and limitations of the study are discussed.
CHAPTER III
PROCEDURES

Introduction

The analysis of Earth science literacy of pre-service and in-service elementary and secondary school teachers was carried out through the use of the research methodologies described in this chapter. The chapter is organized in the following sections: Design of the Study, Design of the Data Collection Instrument, Description of the Participants, Selection and Justification of Questions, Question Analysis, Data Collection Procedures, Hypotheses, Demographic Variables, Data Treatment, Statistical Treatment of Data, and Summary.

Design of the Study

The research design for this study can be classified as a one-shot case study (Campbell and Stanley, 1963) which was descriptive and correlational. The study was designed to investigate and compare the Earth science literacy scores of pre-service elementary and secondary school teachers from a university located in Ohio and in-service elementary and
Design of the Data Collection Instrument

The methodology and procedures used in this study involved several processes: 1) selection of samples of pre-service and in-service elementary and secondary school teachers, 2) development of the Earth Science Literacy Survey, 3) adaptation of the science content background survey, 4) the collection of data, 5) the treatment of data, and 6) the analysis of data.

A self-reported survey, Earth Science Survey for Teachers, was developed for this study. The survey consists of two parts: teacher content background information and a set of Earth science literacy questions. The first part consists of a series of questions designed to determine demographic data and educational backgrounds of the participants. This instrument for measuring teacher background was slightly modified for use in this study with permission of its author, Charlene Czerniak (1989).

A set of questions dealing with Earth science literacy was identified from past Earth science literacy research and was matched to topics found in several publications. Two such publications were produced by The American Geological Institute in 1991, Earth Science Education for the 21st
Century and Earth Science Content Guidelines Grades K-12. Research for these studies was funded by the National Science Foundation. Science Matters, Achieving Scientific Literacy, by Hazen and Trefil, and Science Education, The Report of a Conference by the American Geological Institute and the National Science Teachers Association (Mayer and Armstrong, 1990) were used as well as sources of questions.

The Earth science survey questions were reviewed by members of the dissertation committee, other faculty members and graduate students from the College of Education, Department of Geological Sciences, and School of Natural Resources of The Ohio State University, and were revised based on their feedback to enhance validity.

During the validity review, one reviewer stated that the questions were about facts, not concepts. However, most of the scientific literacy literature base in the early 1990's dealt with factual information and was not conceptually based. According to the current literature base, a relatively recent movement for improving science literacy attempts to teach students concepts, not to memorize facts. Future studies should address this point by designing conceptual Earth science questions.

The survey was also pilot-tested to assure its reliability. Fifteen in-service elementary teachers from a
school district in southwestern Ohio were surveyed. Of those surveyed, ten responded. Reliability was calculated through the Statistical Packages for the Social Sciences (SPSS) at The Ohio State University Academic Computer Center. The reliability analysis (Cronbach's Alpha) produced an alpha level of .75 which equates to a very high reliability for the survey questions (Davis, 1971). This means that the instrument has acceptable internal consistency. The science content background portion of the survey was not tested in the pilot test as its reliability had already been established in past research by its author, Charlene Czerniak (1989).

The proposal was submitted to and approved by the Human Subjects Research Review Board of The Ohio State University before instruments were distributed.

Description of the Participants

Data for the research portion of the study were obtained from two populations, each including two sub-populations: pre-service school teachers at the elementary and secondary levels and in-service school teachers at the elementary and secondary levels.

The study population included pre-service school teachers majoring in elementary and secondary education. A
list of pre-service teachers for Spring Quarter 1992 was obtained from a university located in Ohio. Pre-service elementary and secondary student teacher names were selected randomly.

Student teachers (pre-service) were screened as to the courses they would teach; Art, Learning Disabled, Music, and Physical Education teachers were excluded due to their specialized educational topics. Selected pre-service elementary and secondary teachers included those who were preparing to teach elementary classroom subjects or English, Social Studies, Math, Science, and the Industrial Sciences.

In-service elementary and secondary school teachers from a southwestern Ohio school system made up the second population. In-service participants were selected randomly from the 1991-92 teacher telephone directory supplied by the district. Teachers were screened as to the courses they taught; Art, Learning Disabled, Music, and Physical Education teachers were excluded due to their specialized educational topics. Selected secondary teachers included those who taught English, Social Studies, Math, Science, and the Industrial Sciences while elementary teachers were teaching various classroom subjects.

The participating southwestern Ohio school district includes one senior high school, two junior high schools,
and eight elementary schools which contained (as of September 1991) 7,690 students and 405 teachers. The average classroom teacher in the school district holds a master’s degree and has 18 years of teaching experience.

No attempt was made to control for age, gender, years of teaching experience, or educational background of those school teachers surveyed. All in-service school teachers were certified.

TABLE 1
Members of Participants Queried by Population and Sub Group

<table>
<thead>
<tr>
<th></th>
<th>Pre-service</th>
<th>In-service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary Teachers</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Secondary Teachers</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

Selection and Justification of Questions

Questions 1 through 50 (Appendix B) obtained information about college Earth science content background along with the self-perceived level of success, self perceived level of confidence of the subject matter at the
grade level taught, and the self-perceived value of course work taken by each participant. Correlations were used to compare the responses received from questions 1 through 50 to questions 51 through 76, the science literacy section, and to questions 77 and 78, the desire to obtain more Earth science/science education.

Justifications for selection of each Earth science knowledge question were based on a literature review conducted in 1992. Various researchers have identified many Earth science misunderstandings that are commonly held by students and adults. These misunderstandings have been identified by other researchers as being important to the overall Earth scientific literacy level one should have to function reasonably in today's society.

Earth Scientific Literacy Questions

51. Astrology can predict the future.

This misconception was researched by Gratzer in 1987 and Hively in 1988. In support of their findings, a Gallop poll indicated that 55 percent of American teenagers surveyed believe that astrology works. Another poll in Great Britain indicated that 75 percent
of the British general public believe that astrology is scientific (Hively, 1988). This indicates people sometimes confuse astrology with the science of astronomy.

52. Gravity is selective and acts differently upon different types of matter.

This misconception was researched by Watts in 1982. Research indicates some students believe gravity acts differently on different types of matter. Gravity, in the eyes of some, would work harder on lead than it would on feathers. No data were given by Watts.

53. Does the Earth go around the sun, or does the sun go around the Earth?

Research was performed by Miller (1989) on the misconception concerning relationships between the Earth and sun. Miller found that 28 percent of those adults surveyed in 1988 thought the sun went around the Earth.
54. Based on your response from question #53, how long does the journey take?

Research was performed by Miller in 1989 concerning knowledge of the length of time it takes the Earth to revolve around the sun. Miller found that 55 percent of U.S. adults surveyed could not answer this question correctly. Of British adults, 66 percent of those surveyed could not answer the question correctly.

55. The sun will some day stop producing heat and light.

Research was performed by Lightman and Miller (1989) on the misconception of the production of light and heat from the sun in the future. Their research indicates that some adults believe the sun will never stop producing heat and light. No data were given.

56. The universe began with a huge explosion.

Research on this question was performed by Miller (1988) and Lightman and Miller (1989). Both indicated adults possess a misconception of the origin of the
universe. Miller found that 46 percent of American adults and 36 percent of British adults surveyed did not answer this question correctly.

57. Light travels faster than sound.

Research by Miller (1988) revealed many adults do not know the relative speed of sound and light. Miller found 24 percent of American adults and 25 percent of British adults surveyed did not answer this question correctly.

58. The continents of the Earth are continually moving.

Research by Miller (1988) found adults have a misconception concerning the movement of the continents. Miller found 20 percent of American adults and 29 percent of British adults surveyed did not answer this question correctly.
59. The center of the Earth is very hot.

Research by Meyer (1987) and Miller (1987) showed adults have a misconception concerning the temperature at the center of the Earth. Research by Miller in 1988 found that 20 percent of American adults and 14 percent of British adults surveyed did not know if this was true or false.

60. The Earth is about 4.7 billion years old.

Research reported by Zimmerman (1990) indicated adults do not know the age of the Earth. He found that 69.4 percent of American newspaper editors surveyed did not answer the question about the age of the Earth correctly.

61. Dinosaurs and humans did not live at the same time.

Research by Miller (1988), Schoon (1989), and Zimmerman (1990) shows adults have a major misconception concerning the existence of humans and dinosaurs. The authors conclude that perhaps cartoons like The
Flintstones have influenced the misconception that humans and dinosaurs co-existed. Miller found 63 percent of American adults and 54 percent of British adults surveyed did not know that dinosaurs and humans did not live at the same time. Zimmerman found 48.7 percent of newspaper editors surveyed stated that dinosaurs and humans lived at the same time.

62. Human beings developed from animal species.

Miller (1988) found many adults do not understand the process of evolution. He found that 54 percent of American adults queried and 21 percent of British adults surveyed did not answer this question correctly.

63. Human life began in "The Garden of Eden".

Miller (1988) found adults possess a misconception concerning the origins of human life. He found some American adults believe that life began in "The Garden of Eden". Other research conducted on more than 2,000 college students at 41 campuses across the country indicates that 38 percent of those surveyed believe
that life began in "The Garden of Eden".

64. The oxygen we breathe is produced by plants.

Miller (1988) found many adults possess a misconception concerning the production of oxygen on the planet Earth. He found 19 percent of American adults and 40 percent of British adults surveyed did not answer this question correctly.

65. Electrons are smaller than atoms.

Miller (1988) found adults possess a misconception concerning atoms and their parts. He found 57 percent of American adults and 69 percent of British adults surveyed did not answer this question correctly.

66. Ozone depletion in our atmosphere is responsible for global warming.

Over the past several years of teaching Earth science to pre-service and in-service teachers, the researcher has noticed that many teachers do not understand ozone depletion or global warming. When talking about air
pollution, ozone depletion and global warming, issues are bound to come up. To date, no data are available on this misconception.

67. Winter weather can be predicted by examining the fur thickness of animals and "woolly worms".

Schoon (1989) found adults and students both possess a misconception concerning the prediction of winter weather by examining the fur thickness of animals and caterpillars. He reported 12 percent of those surveyed believe winter weather can be forecast by the fur thickness of animals and caterpillars.

68. We see things because light brightens them.

Research by Eaton, Anderson, and Smith (1984) indicated fourth, fifth, and sixth graders did not understand why we are able to see things. Over the past several years of teaching Earth science to pre-service and in-service teachers, the author has noticed this same problem with pre-service and in-service teachers in the class. To date, no data are available.
69. Seasonal changes are caused by the

a. Earth's distance from the sun;
b. Earth's tilt on the axis;
c. unequal heating of the Earth's atmosphere;
d. spinning of the Earth on its axis;
e. don't know.

Research by Rastovac and Slavsky (1986), Marquand (1988), and Schoon (1989) indicated adults and students do not understand the seasonal changes of the Earth. Schoon found that 77.6 percent of those Americans surveyed thought summer is warmer than winter because in the summer the Earth is nearer the sun.

70. The phases of the moon are caused by

a. the Earth's shadow on the moon;
b. the sun's shadow on the moon;
c. the moon's position with regard to the Earth;
d. an eclipsing event on the moon;
e. don't know.

Research by Schoon (1989) showed adults and students did not know why we experience phases of the moon.
Schoon's research indicated that 51.9 percent of those surveyed thought the reason for the different lunar phases is the shadow of the Earth falling on the moon.

71. We can see other planets in our solar system without a telescope.

Research by Schoon (1989) found adults and students possess misinformation concerning the observation of planets in our solar system. He found that 41.5 percent of those surveyed thought they could not see other planets in our solar system without the aid of binoculars or a telescope.

72. The sun is directly overhead at noon.

Research by Schoon (1989) found adults and students misunderstand where the sun is positioned at noon. He reported that 82.4 percent of those surveyed thought that at noon the sun was directly overhead.

73. The Earth's gravitational attraction is greatly reduced on the tops of mountains.
Research by Gunstone and White (1981) found adults in Australia possessed misconceptions concerning the effect of gravity on the Earth. They reported that 88 percent of those surveyed thought the pull of gravity is less on the tops of mountains than on the ground. Watts (1982) found an alternative framework in the thinking of U.S. students. Students claimed the higher you go, the more gravity is needed to hold you down. No data were reported by Watts.

74. Gravity cannot exist without air.

Research by Watts (1988) found students had a misconception of the effect of gravity on the Earth. Watts reported some students felt, because the moon has no atmosphere and very little gravity, that air is needed to have gravity. No data were reported.

75. Our sun is a star.

Research indicates American adults possess a misconception concerning the Sun as related to the Universe (Hively, 1988). In his survey of 1,120 adults only 55 percent of those surveyed responded to this statement correctly. Fifteen percent said the sun
is a planet, while the remaining 20 percent were not sure.

**Question Analysis**

It is noted that the questions in this survey are not well distributed; only a few focused on scientific study or on society and science while the majority (22 of 25) focused on scientific terms and concepts. This follows along with Miller's index for determining scientific literacy which is based on a combination of these three dimensions of scientific understanding. However, the range of the questions was limited to what was available in the current scientific literacy literature base as of early 1992. Future research should address questions which deal with scientific study or society and science.

**Demographic Variables**

Demographic data collected from pre-service and in-service elementary and secondary school teachers consisted of the following independent variables:

a. grade level taught;

b. years of teaching experience;
c. gender;
d. college Earth science courses taken;
e. perceived level of success in the Earth science courses taken;
f. perceived confidence level in the teacher's ability to teach the content of college Earth science courses taken at the current or intended grade level they are teaching or will teach;
g. the perceived value of the Earth science courses taken; and
h. the level of desire to obtain more education in the sciences and/or in science education.

The dependent variable in this study was the Earth Science Literacy Survey score.

Data Collection Procedures

This survey was administered under normal procedures to obtain valid data. Pre-service and in-service elementary and secondary school teachers were sent a questionnaire along with a separate cover letter explaining the purpose of the study and instructions on how to properly complete the survey (Appendix B). The letter was signed by both the
researcher and the adviser. Questionnaires were mailed to pre-service elementary and secondary teachers May 8, 1992. Questionnaires to in-service elementary and secondary teachers were delivered to the assistant school superintendent for distribution to the teachers on May 11, 1992.

A self-addressed stamped envelope was included in each survey packet to simplify returning the surveys. To ensure confidentiality, participants were instructed not to sign the survey and not to write a return address on the envelope. After a 10-day waiting period, a postcard was sent out to all participants thanking those who had sent in their surveys and reminding those who had not to do so soon (Appendix B).

If no response was received after a two month time period from the date of the mailing, subjects were considered non-respondents and reported as such. This study acknowledges that the instruments used to determine Earth science literacy scores were self-reported measurements. The value of the responses is based on the truthfulness of each respondent.
Null Hypotheses

The following null hypotheses were addressed (See Appendix A):

1. There is no statistically significant difference between the Earth science literacy scores of pre-service elementary and in-service elementary teachers.

This hypothesis was tested by comparing Earth science literacy scores of random samples of pre-service elementary teachers at an Ohio university and random samples of in-service elementary teachers in a southwestern Ohio school district.

2. There is no statistically significant difference between the Earth science literacy scores of pre-service secondary and in-service secondary teachers.

This hypothesis was tested by comparing the Earth science literacy scores of random samples of pre-service secondary teachers and in-service secondary teachers.
3. There is no statistically significant difference between the Earth science literacy scores of pre-service secondary and in-service elementary teachers.

This hypothesis was tested by comparing the Earth science literacy scores of random samples of pre-service secondary teachers and in-service elementary teachers.

4. There is no statistically significant difference between the Earth science literacy scores of pre-service elementary and in-service secondary teachers.

This hypothesis was tested by comparing the Earth science literacy scores of random samples of pre-service elementary teachers and in-service secondary teachers.

5. There is no statistically significant difference between Earth science content backgrounds of pre-service and in-service elementary teachers.

This hypothesis was tested by comparing the Earth science content backgrounds of random samples of pre-
6. There is no statistically significant difference between Earth science content backgrounds of pre-service secondary and in-service secondary teachers.

This hypothesis was tested by comparing the Earth science content backgrounds of random samples of pre-service secondary teachers and in-service secondary teachers.

7. There is no statistically significant difference between Earth science content backgrounds of pre-service secondary and in-service elementary teachers.

This hypothesis was tested by comparing the Earth science content backgrounds of random samples of pre-service secondary teachers and in-service elementary teachers.

8. There is no statistically significant difference between Earth science content backgrounds of pre-
service elementary and in-service secondary teachers.

This hypothesis was tested by comparing the Earth science content backgrounds of random samples of pre-service elementary teachers and in-service secondary teachers.

9. There is no statistically significant relationship between the Earth science literacy scores of pre-service and in-service elementary and secondary teachers and each of the following:
   a. Number of Earth science courses taken in college
   b. Perceived level of success in the courses taken
   c. Perceived level of confidence in the course content at the grade level taught
   d. Perceived value of the course

This hypothesis was tested by comparing the following:

9.1. Number of Earth science courses taken in college by pre-service and in-service elementary and secondary school teachers

9.2. Perceived level of success in the courses taken
9.3. Perceived level of confidence in the course content at the grade level taught

9.4. Perceived value of the course

10. There is no statistically significant relationship between the desire to obtain science instruction and Earth science content background for pre-service and in-service elementary and secondary teachers.

This hypothesis was tested by comparing the following:

10.1. Number of Earth science courses taken in college by pre-service and in-service elementary and secondary school teachers

10.2. Perceived level of success in the courses taken

10.3. Perceived level of confidence in the course content at the grade level taught

10.4. Perceived value of the course
Data Treatment

Respondents were given four points for each correct response to the Earth Science Literacy survey, chosen so that a total of 100 points could be seen as a perfect score. Scoring of the surveys was agreed upon by the advising committee at The Ohio State University. Scoring of the surveys was as follows:

51. Astrology can predict the future.

  a. Definitely true 0 points
  b. Probably true 0 points
  c. Probably untrue 0 points
  d. Definitely untrue 4 points
  e. Don’t know 0 points

52. Gravity is selective and acts differently upon different types of matter.

  a. Definitely true 0 points
  b. Probably true 0 points
  c. Probably untrue 0 points
  d. Definitely untrue 4 points
53. Does the Earth go around the sun or does the sun go around the Earth?

   a. Earth goes around the sun  4 points
   b. Sun goes around the Earth  0 points
   c. Don't know                0 points

54. Based on your response from question # 53, how long does the journey take?

   a. One day  0 points
   b. One month 0 points
   c. One year  4 points
   d. Don't Know 0 points

55. The sun will someday stop producing heat and light.

   a. Definitely true  4 points
   b. Probably true  4 points
   c. Probably untrue 0 points
d. Definitely untrue 0 point

56. The universe began with a huge explosion.

a. Definitely true 4 points
b. Probably true 4 points
c. Probably untrue 0 points
d. Definitely untrue 0 points
e. Don’t know 0 points

57. Light travels faster than sound.

a. Definitely true 4 points
b. Probably true 0 points
c. Probably untrue 0 points
d. Definitely untrue 0 points
e. Don’t know 0 points

58. The continents of the Earth are continuously moving.

a. Definitely true 4 points
b. Probably true 0 points
c. Probably untrue 0 points
59. The center of the Earth is very hot.

- a. Definitely true 4 points
- b. Probably true 4 points
- c. Probably untrue 0 points
- d. Definitely untrue 0 points
- e. Don’t know 0 points

60. The Earth is about 4.7 billion years old.

- a. Definitely true 4 points
- b. Probably true 4 points
- c. Probably untrue 0 points
- d. Definitely untrue 0 points
- e. Don’t know 0 points

61. Dinosaurs and humans did not live at the same time.

- a. Definitely true 4 points
- b. Probably true 0 points
- c. Probably untrue 0 points
62. Human beings developed from animal species.

a. Definitely true 4 points
b. Probably true 0 points
c. Probably untrue 0 points
d. Definitely untrue 0 points
e. Don’t know 0 points

63. Human life began in “The Garden of Eden”.

a. Definitely true 0 points
b. Probably true 0 points
c. Probably untrue 0 points
d. Definitely untrue 4 points
e. Don’t know 0 points

64. The oxygen we breathe is produced by plants.

a. Definitely true 4 points
b. Probably true 0 points
c. Probably untrue 0 points
65. Electrons are smaller than atoms.

a. Definitely true  4 points
b. Probably true  0 points
c. Probably untrue  0 points
d. Definitely untrue  0 points
e. Don’t know  0 points

66. Ozone depletion in our atmosphere is responsible for global warming.

a. Definitely true  0 points
b. Probably true  0 points
c. Probably untrue  0 points
d. Definitely untrue  4 points
e. Don’t know  0 points

67. Winter weather can be predicted by examining the fur thickness of animals and "woolly worms".
68. We see things because light brightens them.

a. Definitely true 0 points
b. Probably true 0 point
c. Probably untrue 0 points
d. Definitely untrue 4 points
e. Don’t know 0 points

69. Seasonal changes are caused by the:

a. Earth’s distance from the sun. 0 points
b. Earth’s tilt on its axis. 4 points
c. unequal heating of the Earth’s atmosphere. 0 points
d. spinning of the Earth on its axis. 0 points
e. don’t know. 0 points
70. The phases of the moon are caused by:

a. the Earth’s shadow on the moon. 0 points
b. the sun’s shadow on the moon. 0 points
c. the moon’s position with regard to the Earth. 4 points
d. an eclipsing event on the moon. 0 points
e. don’t know 0 points

71. We can see other planets in our solar system without a telescope.

a. Definitely true 4 points
b. Probably true 0 points
c. Probably untrue 0 points
d. Definitely untrue 0 points
e. Don’t know 0 points

72. The sun is directly overhead at noon in Ohio.

a. Definitely true 0 points
b. Probably true 0 points
c. Probably untrue 0 points
73. The Earth’s gravitational attraction is greatly reduced on the tops of mountains.

- a. Definitely true 0 points
- b. Probably true 0 points
- c. Probably untrue 0 points
- d. Definitely untrue 4 points
- e. Don’t know 0 points

74. Gravity cannot exist without air.

- a. Definitely true 0 points
- b. Probably true 0 points
- c. Probably untrue 0 points
- d. Definitely untrue 4 points
- e. Don’t know 0 points
75. Our sun is a star.

a. Definitely true 4 points
b. Probably true 0 points
c. Probably untrue 0 points
d. Definitely untrue 0 points
e. Don’t know 0 points

Statistical Treatment of Data

Data were analyzed by the Statistical Package for the Social Sciences (SPSS), a statistical package at The Ohio State University Academic Computing Center. Further analysis was performed at Jefferson Community College, Watertown, New York, using Abstat. The methods of analysis were as follows:

1. The ANOVA procedure was used to compare the four groups for the following different characteristics: background, number of courses taken, self-perceived level of success, self-perceived level of confidence of the subject matter at the grade level taught, self-perceived value of the Earth science course taken, and science literacy level (test score).
2. Pearson's Product-Moment Correlation Coefficients were utilized to test possible relationships between the following variables: demographic background, number of college Earth science courses completed, self-perceived level of success, self-perceived level of confidence of the subject matter at the grade level taught, self-perceived value of the Earth science course taken, the desire to obtain more science instruction, and the desire to obtain more information on science education.

3. T-tests were used to explore the relationships between the variables, the correlational method of analyzing research data. This method of analysis is useful in studying problems in education and the behavioral sciences. T-tests are a valuable way to treat data because they provide information concerning the degree of the relationship between the variables studied. The alpha level selected for this study was .05. This level was selected because it is the level generally employed in educational research (Borg and Gall, 1989).

4. Listed below are the adjectives used to describe the magnitude of the correlations that were developed by J. A. Davis in 1971. These adjectives were used to describe
the correlations found while analyzing data for hypothesis number nine.

<table>
<thead>
<tr>
<th>r</th>
<th>Adjective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Perfect</td>
</tr>
<tr>
<td>0.70-0.99</td>
<td>Very High</td>
</tr>
<tr>
<td>0.50-0.69</td>
<td>Substantial</td>
</tr>
<tr>
<td>0.30-0.49</td>
<td>Moderate</td>
</tr>
<tr>
<td>0.10-0.29</td>
<td>Low</td>
</tr>
<tr>
<td>0.01-0.09</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

**Summary**

The design of this study is considered to be a Pre-Experimental Design: The One-Shot Case Study (Campbell and Stanley, 1963). The general null hypothesis is that there are no differences in the Earth science literacy scores of pre-service and in-service elementary and secondary school teachers. Participants in this study consisted of elementary and secondary pre-service school teachers at a university located in Ohio (Spring 1992) and elementary and secondary in-service school teachers from a southwestern Ohio school district also in the Spring of 1992.

Data for this study were collected through the use of the Earth Science Literacy Survey designed by the researcher and a brief demographic questionnaire and Earth science content background survey adapted from Czerniak. Both were administered in the Spring of 1992.
Such variables as the number of Earth science courses taken at the college level, gender, grade level taught (pre-service or in-service elementary and secondary), number of years teaching, and date of birth were compared to participant Earth science literacy scores. The correlational method of analyzing the research data was implemented in order to determine the degree of relationship between the different variables addressed in this study.

Chapter IV describes the results of the study in both tabular and narrative form. Demographic as well as statistical data are treated in the process of reporting the findings of this study.
CHAPTER IV

PRESENTATION AND ANALYSIS OF THE DATA

Introduction

The findings of the study are presented in this chapter. The findings pertaining to the demographic characteristics of the teachers surveyed are presented first. Subsequent sections address findings of the statistical analysis comparing the four groups of teachers (pre-service elementary, pre-service secondary, in-service elementary, in-service secondary) in terms of science content background and Earth science literacy scores as determined by scores on a researcher-designed Earth science literacy survey instrument.

Demographic Characteristics of the Study Participants

All groups surveyed were requested to provide background data before they completed the survey. For this purpose, an instrument (See Appendix B) adapted from Czerniak (1989) identified four background characteristics
arranged in the following order: gender, grade level taught, number of years teaching, and date of birth.

Surveys were marked by the researcher before they were sent out indicating teacher status (pre-service elementary, pre-service secondary, in-service elementary, in-service secondary).

A total of 65 pre-service and in-service elementary and secondary school teachers participated in this study (Table 2). Of those who participated, 14 were identified as pre-service elementary, 17 pre-service secondary, 20 in-service elementary, and 14 in-service secondary. This represents 42% of the 160 pre-service and in-service school teachers to whom survey forms were sent.

**Gender**

The majority of those teachers who responded to the survey were female. Forty-five participants or 70% were female. Males comprised the remaining 30% (n=20).
TABLE 2
GENDER OF RESPONDENTS BY GROUP

<table>
<thead>
<tr>
<th>Gender</th>
<th>Pre-service Elementary</th>
<th>Pre-service Secondary</th>
<th>In-service Elementary</th>
<th>In-service Secondary</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>12</td>
<td>7</td>
<td>18</td>
<td>8</td>
<td>45</td>
</tr>
<tr>
<td>Male</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>17</td>
<td>20</td>
<td>14</td>
<td>65</td>
</tr>
</tbody>
</table>

Note: A total of 40 teachers received the instrument in each group.

Grade Level

Participants were grouped by self-reported grade level taught, or for pre-service elementary and secondary school teachers, self-reported grade level to be taught. Thirteen different groups are represented, Kindergarten through 12th grade. Represented grade levels of school teachers, both pre-service and in-service, elementary and secondary, are as follows:

PRE-SERVICE (Table 3)

(a) Four (12.9% of the total group) reported Kindergarten through third grade.

(b) Five (16.1% of the total group) reported fourth
through sixth grade.

(c) Ten (32.2% of the total group) reported seventh through eighth grade.

(d) Twelve (38.8% of the total group) reported ninth through twelfth grade.

**TABLE 3**

Anticipated Grade Level Taught for Pre-service School Teachers N=31

<table>
<thead>
<tr>
<th>Anticip. Grade Level Taught</th>
<th>sub-group n</th>
<th>% of N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten-third grade</td>
<td>4</td>
<td>12.9%</td>
</tr>
<tr>
<td>Fourth-sixth grade</td>
<td>5</td>
<td>16.1%</td>
</tr>
<tr>
<td>Seventh-eighth grade</td>
<td>10</td>
<td>32.2%</td>
</tr>
<tr>
<td>Ninth-twelfth grade</td>
<td>12</td>
<td>38.8%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>31</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

**IN-SERVICE (Table 4)**

(a) Fourteen (41.2% of the total group) reported Kindergarten through third grade.

(b) Six (17.6% of the total group) reported fourth through sixth grade.

(c) One (2.9% of the total group) reported seventh
through eighth grade.

(d) Thirteen (38.3% of the total group) reported ninth through twelfth grade.

<table>
<thead>
<tr>
<th>Grade Level Taught</th>
<th>sub-group n</th>
<th>% of N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten-third grade</td>
<td>14</td>
<td>41.2%</td>
</tr>
<tr>
<td>Fourth-sixth grade</td>
<td>6</td>
<td>17.6%</td>
</tr>
<tr>
<td>Seventh-Eighth grade</td>
<td>1</td>
<td>2.9%</td>
</tr>
<tr>
<td>Nineth-twelfth grade</td>
<td>13</td>
<td>38.3%</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

**Number of Years Teaching**

The number of years of teaching experience was requested from each in-service respondent. For this parameter, no data from pre-service elementary and secondary teachers were collected. From in-service school teachers, the reported highest teaching experience was 33 years and the lowest 2 years. The largest group of teachers fell within 18 to 25 years of experience. This group represented 33.8 percent of all teachers in the study. The mean number of years for in-service teachers was 17.26 (Table 5).
### TABLE 5

**Number of In-service School Teachers by Self-Reported Years of Teaching Experience**

<table>
<thead>
<tr>
<th>Teaching Experience in Years</th>
<th>In-service Elementary Teachers</th>
<th>In-service Secondary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-5</td>
<td>2 (10%)</td>
<td>2 (14%)</td>
</tr>
<tr>
<td>6-9</td>
<td>3 (15%)</td>
<td>1 (07%)</td>
</tr>
<tr>
<td>10-12</td>
<td>3 (15%)</td>
<td>0 (00%)</td>
</tr>
<tr>
<td>13-15</td>
<td>0 (00%)</td>
<td>0 (00%)</td>
</tr>
<tr>
<td>16-18</td>
<td>3 (15%)</td>
<td>0 (00%)</td>
</tr>
<tr>
<td>19-21</td>
<td>2 (10%)</td>
<td>3 (21%)</td>
</tr>
<tr>
<td>22-24</td>
<td>4 (20%)</td>
<td>3 (21%)</td>
</tr>
<tr>
<td>25+</td>
<td>3 (15%)</td>
<td>5 (37%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20 (100%)</strong></td>
<td><strong>14 (100%)</strong></td>
</tr>
</tbody>
</table>

Mean years teaching = 17.26  
Range = 2-33

**Age**

The average age of pre-service and in-service elementary and secondary school teachers is displayed in Table 6. The oldest reported age was 57 years and the youngest 22 years. The highest reported age for pre-service teachers was 42 years and the lowest 22. The highest reported age for in-service teachers was 56 years and the
The mean number of years of age of all participants was 34.5 years.

### TABLE 6
**Pre-service and In-service Elementary and Secondary School Teachers by Self-Reported Average Age**

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Pre-service Elementary Teachers</th>
<th>Pre-service Secondary Teachers</th>
<th>In-service Elementary Teachers</th>
<th>In-service Secondary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-21</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>22-26</td>
<td>11 (79%)</td>
<td>11 (64%)</td>
<td>1 (5%)</td>
<td>1 (7%)</td>
</tr>
<tr>
<td>27-31</td>
<td>0</td>
<td>2 (12%)</td>
<td>1 (5%)</td>
<td>0</td>
</tr>
<tr>
<td>32-36</td>
<td>1 (7%)</td>
<td>3 (18%)</td>
<td>1 (5%)</td>
<td>1 (7%)</td>
</tr>
<tr>
<td>37-41</td>
<td>0</td>
<td>1 (6%)</td>
<td>2 (10%)</td>
<td>0</td>
</tr>
<tr>
<td>42-46</td>
<td>0</td>
<td>0</td>
<td>5 (25%)</td>
<td>4 (29%)</td>
</tr>
<tr>
<td>47-51</td>
<td>0</td>
<td>0</td>
<td>4 (20%)</td>
<td>3 (21%)</td>
</tr>
<tr>
<td>52-56</td>
<td></td>
<td>1 (5%)</td>
<td>2 (14%)</td>
<td></td>
</tr>
<tr>
<td>57 and up</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (7%)</td>
</tr>
<tr>
<td>No Response</td>
<td>2 (14%)</td>
<td>0</td>
<td>5 (25%)</td>
<td>2 (14%)</td>
</tr>
</tbody>
</table>

**Mean Age** 23.3 26.6 42.8 45.6
Other Characteristics of the Study Participants

All groups surveyed were requested to provide other information concerning Earth science courses taken at the college level:

- College Earth science content background in terms of number of courses taken.
- Self-perceived level of success in college Earth science courses taken.
- Self-perceived level of confidence in their ability to teach the subject matter at their grade level.
- Self-perceived value of college Earth science courses taken.
- The desire for more instruction in science.
- The desire to obtain more information concerning science education.

College Earth Science Content Background

The number of college Earth science courses completed by each of the four groups is listed in Table 7. The highest reported number of college Earth science courses taken was 19; the respondent who claimed 19 courses reportedly had a career in the sciences before becoming an educator. The lowest had taken one. Pre-service elementary teachers reported from 2 to 8 Earth science courses taken at
the college level with a mean of 4.3 courses per teacher. Pre-service secondary teachers reported from 2 to 10 Earth science courses taken at the college level with a mean of 4.2 courses per teacher. In-service elementary teachers reported from 1 to 14 Earth science courses taken at the college level with a mean of 4.8 courses per teacher. In-service secondary teachers reported from 1 to 15 or more Earth science courses taken at the college level with a mean of 6.1 courses per teacher. The average number of reported Earth science courses taken for all school teachers surveyed was 4.85.
TABLE 7
Sum total of Teachers by Number of College Earth Science Courses Completed

<table>
<thead>
<tr>
<th># courses</th>
<th>Pre-service Elementary Teachers</th>
<th>Pre-service Secondary Teachers</th>
<th>In-service Elementary Teachers</th>
<th>In-service Secondary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2-4</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>5-6</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7-8</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>9-10</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>11-12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13-14</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>15 or more</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Non-Response</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Mean number of Earth science courses completed
4.3 4.2 4.8 6.1

Self-Perceived Level of Success in College Earth Science Courses Taken

Participants were requested to list their perceived level of success of each college Earth science course(s) taken. The average level of success for each group of college Earth science course(s) taken is reported as the
mean in Table 8 (1=extremely successful, 5=not successful). Pre-service elementary teachers reported a mean level of perceived success of 2.1 for Earth science courses taken at the college level. Pre-service secondary teachers reported a mean level of perceived success of 2.76 for Earth science courses taken at the college level. In-service elementary teachers reported a mean level of perceived success of 2.38 for Earth science courses taken at the college level. In-service secondary teachers reported a mean level of perceived success of 2.31 for Earth science courses taken at the college level.
### TABLE 8
**Sum Total of Courses by Self-Perceived Level of Success in College Earth Science Courses Taken**

<table>
<thead>
<tr>
<th>Level of Success</th>
<th>Pre-service Teachers</th>
<th>Pre-service Secondary Teachers</th>
<th>In-service Elementary Teachers</th>
<th>In-service Secondary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>1 (High)</td>
<td>15</td>
<td>0</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>10</td>
<td>28</td>
<td>21</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>5</td>
<td>22</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>5 (Low)</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Mean Level of Perceived Success</td>
<td>2.1</td>
<td>2.76</td>
<td>2.38</td>
<td>2.31</td>
</tr>
</tbody>
</table>

Note: Teachers' self-perceived level of success is reported for each college Earth science course taken.

---

**Self-Perceived Level of Confidence in the Subject Matter at the Grade Level Taught**

Participants were requested to list their self-perceived level of confidence to teach the content of the college Earth science course(s) taken at the grade level taught. The level of self-perceived confidence by group, of college Earth science course(s) taken, is reported in Table
9. Confidence level is defined as the teachers' self-perceived ability to teach confidently the content of the college Earth science course taken at the grade level they are currently teaching or intend to teach (1=extremely confident, 5=little confidence). Pre-service elementary teachers reported a mean level of self-perceived confidence in the subject matter at the grade level taught of 2.52 for Earth science courses taken at the college level. Pre-service secondary teachers reported a mean level of self-perceived confidence in the subject matter at the grade level taught of 3.13 for Earth science courses taken at the college level. In-service elementary teachers reported a mean level of self-perceived confidence in the subject matter at the grade level taught of 2.14 for Earth science courses taken at the college level. In-service secondary teachers reported a mean level of self-perceived confidence in the subject matter at the grade level taught of 2.14 for Earth science courses taken at the college level.
### TABLE 9
Sum Total of Courses by Self-Perceived Level of Confidence
in Earth Science Course Content at the Grade Level Taught

<table>
<thead>
<tr>
<th>Level of Confidence</th>
<th>Pre-service Elementary Teachers</th>
<th>Pre-service Secondary Teachers</th>
<th>In-service Elementary Teachers</th>
<th>In-service Secondary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>1 (High)</td>
<td>8</td>
<td>2</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
<td>8</td>
<td>25</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>15</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>5 (Low)</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Mean Level of Perceived Confidence</td>
<td>2.52</td>
<td>3.13</td>
<td>2.14</td>
<td>2.14</td>
</tr>
</tbody>
</table>

Note: Teachers self-perceived level of confidence reported for each college Earth science course taken.

**Self-Perceived Value of College Earth Science Courses Taken**

Participants were requested to list the self-perceived value to them of each college Earth science course taken. The average value level for each group, of college Earth science course(s) taken, is reported as the mean in Table 10. Value is defined as the teacher's self-perceived level of importance of the course to their classroom or to their own educational program (1=extremely valuable, 5=little value). Pre-service elementary teachers reported a mean
level of self-perceived value of 2.19 for Earth science courses taken at the college level. Pre-service secondary teachers reported a mean level of self-perceived value of 2.13 for Earth science courses taken at the college level. In-service elementary teachers reported a mean level of self-perceived value of 2.10 for Earth science courses taken at the college level. In-service secondary teachers reported a mean level of self-perceived value of 1.81 for Earth science courses taken at the college level.

### TABLE 10

**Sum Total of Courses by Self-Perceived Value of College Earth Science Courses Taken**

<table>
<thead>
<tr>
<th>Level of Value</th>
<th>Pre-service Elementary Teachers</th>
<th>Pre-service Secondary Teachers</th>
<th>In-service Elementary Teachers</th>
<th>In-service Secondary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 High</td>
<td>9</td>
<td>12</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>13</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>7</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>5 Low</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Mean Level of Perceived Value</td>
<td>2.19</td>
<td>2.13</td>
<td>2.10</td>
<td>1.81</td>
</tr>
</tbody>
</table>


The Desire for More Science Instruction

Table 11 shows the numbers of teachers who indicated that they would like to obtain more science instruction (courses). Pre-service and in-service elementary teachers desired more science instruction than did pre-service and in-service secondary teachers.

<table>
<thead>
<tr>
<th>Response</th>
<th>Pre-service Elementary Teachers</th>
<th>Pre-service Secondary Teachers</th>
<th>In-service Elementary Teachers</th>
<th>In-service Secondary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
</tr>
<tr>
<td>Yes</td>
<td>10 71.5%</td>
<td>6 35.2%</td>
<td>14 70%</td>
<td>4 28.6%</td>
</tr>
<tr>
<td>Maybe</td>
<td>4 28.5%</td>
<td>8 47.2%</td>
<td>5 25%</td>
<td>5 35.7%</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>3 17.6%</td>
<td>1 5%</td>
<td>5 35.7%</td>
</tr>
<tr>
<td>Total</td>
<td>14 100%</td>
<td>17 100%</td>
<td>20 100%</td>
<td>14 100%</td>
</tr>
</tbody>
</table>

The Desire for More Information on Science Education

Table 12 shows the number of teachers who indicated they would like to obtain more information concerning science education by group. Pre-service and in-service elementary teachers desired more information concerning science education than did pre-service and in-service
secondary teachers.

TABLE 12
Sum Total of Teachers by the Desire for More Information on Science Education

<table>
<thead>
<tr>
<th>Response</th>
<th>Pre-service Elementary Teachers</th>
<th>Pre-service Secondary Teachers</th>
<th>In-service Elementary Teachers</th>
<th>In-service Secondary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Yes</td>
<td>12</td>
<td>85.7%</td>
<td>7</td>
<td>41.1%</td>
</tr>
<tr>
<td>Maybe</td>
<td>2</td>
<td>14.3%</td>
<td>4</td>
<td>23.6%</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>0%</td>
<td>6</td>
<td>35.3%</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>100%</td>
<td>17</td>
<td>100%</td>
</tr>
</tbody>
</table>

Earth Science Literacy Scores

Table 13 and 14 presents the Earth science literacy survey scores, of pre-service and in-service elementary and secondary teachers. Table 13 presents the question number, number of correct responses, and percent of correct responses for each group. Table 14 presents the individual Earth science literacy scores by group. The highest Earth science literacy survey score was 96% and the lowest 16% (out of 100%). The mean score for all respondents was 61%.
<table>
<thead>
<tr>
<th>Q#</th>
<th>Pre-service Elementary Correct resp. (% correct) (n=14)</th>
<th>Pre-service Secondary Correct resp. (% correct) (n=17)</th>
<th>In-service Elementary Correct resp. (% correct) (n=20)</th>
<th>In-service Secondary Correct resp. (% correct) (n=14)</th>
<th>Total Correct res. (% correct) (n=65)</th>
</tr>
</thead>
<tbody>
<tr>
<td>51.</td>
<td>3 (21%)</td>
<td>11 (65%)</td>
<td>10 (50%)</td>
<td>5 (36%)</td>
<td>29 (45%)</td>
</tr>
<tr>
<td>52.</td>
<td>10 (71%)</td>
<td>16 (94%)</td>
<td>13 (65%)</td>
<td>11 (79%)</td>
<td>50 (77%)</td>
</tr>
<tr>
<td>53.</td>
<td>11 (79%)</td>
<td>16 (94%)</td>
<td>20 (100%)</td>
<td>13 (93%)</td>
<td>60 (92%)</td>
</tr>
<tr>
<td>54.</td>
<td>11 (79%)</td>
<td>15 (88%)</td>
<td>18 (90%)</td>
<td>13 (93%)</td>
<td>57 (88%)</td>
</tr>
<tr>
<td>55.</td>
<td>10 (71%)</td>
<td>13 (76%)</td>
<td>12 (60%)</td>
<td>10 (71%)</td>
<td>45 (69%)</td>
</tr>
<tr>
<td>56.</td>
<td>9 (64%)</td>
<td>15 (88%)</td>
<td>13 (65%)</td>
<td>10 (71%)</td>
<td>47 (72%)</td>
</tr>
<tr>
<td>57.</td>
<td>10 (71%)</td>
<td>14 (82%)</td>
<td>18 (90%)</td>
<td>12 (86%)</td>
<td>54 (83%)</td>
</tr>
<tr>
<td>58.</td>
<td>11 (79%)</td>
<td>12 (71%)</td>
<td>15 (75%)</td>
<td>11 (79%)</td>
<td>49 (75%)</td>
</tr>
<tr>
<td>59.</td>
<td>12 (86%)</td>
<td>16 (94%)</td>
<td>19 (95%)</td>
<td>11 (79%)</td>
<td>58 (89%)</td>
</tr>
<tr>
<td>60.</td>
<td>12 (86%)</td>
<td>16 (94%)</td>
<td>13 (65%)</td>
<td>8 (57%)</td>
<td>49 (75%)</td>
</tr>
<tr>
<td>61.</td>
<td>7 (50%)</td>
<td>14 (82%)</td>
<td>17 (85%)</td>
<td>7 (50%)</td>
<td>45 (69%)</td>
</tr>
<tr>
<td>62.</td>
<td>3 (21%)</td>
<td>5 (29%)</td>
<td>3 (15%)</td>
<td>4 (29%)</td>
<td>15 (23%)</td>
</tr>
<tr>
<td>63.</td>
<td>2 (14%)</td>
<td>7 (41%)</td>
<td>5 (25%)</td>
<td>4 (29%)</td>
<td>18 (28%)</td>
</tr>
<tr>
<td>64.</td>
<td>9 (64%)</td>
<td>14 (82%)</td>
<td>16 (80%)</td>
<td>9 (64%)</td>
<td>48 (74%)</td>
</tr>
<tr>
<td>65.</td>
<td>10 (71%)</td>
<td>14 (82%)</td>
<td>17 (85%)</td>
<td>12 (86%)</td>
<td>53 (82%)</td>
</tr>
<tr>
<td>66.</td>
<td>0 (0%)</td>
<td>3 (18%)</td>
<td>2 (10%)</td>
<td>0 (0%)</td>
<td>5 (8%)</td>
</tr>
<tr>
<td>67.</td>
<td>0 (0%)</td>
<td>5 (29%)</td>
<td>5 (25%)</td>
<td>4 (29%)</td>
<td>14 (22%)</td>
</tr>
<tr>
<td>68.</td>
<td>6 (43%)</td>
<td>7 (41%)</td>
<td>6 (30%)</td>
<td>1 (7%)</td>
<td>20 (31%)</td>
</tr>
<tr>
<td>Q#</td>
<td>Pre-service Elementary Correct resp. (% correct) (n=14)</td>
<td>Pre-service Secondary Correct resp. (% correct) (n=17)</td>
<td>In-service Elementary Correct resp. (% correct) (n=20)</td>
<td>In-service Secondary Correct resp. (% correct) (n=14)</td>
<td>Total Correct res. (% correct) (n=65)</td>
</tr>
<tr>
<td>----</td>
<td>------------------------------------------------------</td>
<td>-------------------------------------------------------</td>
<td>-------------------------------------------------------</td>
<td>-------------------------------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>69</td>
<td>12 (86%)</td>
<td>15 (88%)</td>
<td>15 (75%)</td>
<td>9 (64%)</td>
<td>51 (78%)</td>
</tr>
<tr>
<td>70</td>
<td>7 (50%)</td>
<td>9 (53%)</td>
<td>11 (55%)</td>
<td>5 (36%)</td>
<td>32 (49%)</td>
</tr>
<tr>
<td>71</td>
<td>10 (71%)</td>
<td>15 (88%)</td>
<td>17 (85%)</td>
<td>12 (86%)</td>
<td>54 (83%)</td>
</tr>
<tr>
<td>72</td>
<td>5 (36%)</td>
<td>7 (41%)</td>
<td>7 (35%)</td>
<td>6 (43%)</td>
<td>25 (38%)</td>
</tr>
<tr>
<td>73</td>
<td>5 (36%)</td>
<td>10 (59%)</td>
<td>12 (60%)</td>
<td>9 (64%)</td>
<td>36 (55%)</td>
</tr>
<tr>
<td>74</td>
<td>2 (14%)</td>
<td>10 (59%)</td>
<td>7 (35%)</td>
<td>7 (50%)</td>
<td>26 (40%)</td>
</tr>
<tr>
<td>75</td>
<td>10 (71%)</td>
<td>14 (82%)</td>
<td>19 (95%)</td>
<td>13 (93%)</td>
<td>56 (86%)</td>
</tr>
<tr>
<td>Total</td>
<td>187 (54%)</td>
<td>293 (68%)</td>
<td>310 (62%)</td>
<td>206 (59%)</td>
<td>996 (61%)</td>
</tr>
</tbody>
</table>
Table 14
Sum Total of Teachers by Earth Science Literacy Scores

<table>
<thead>
<tr>
<th>Scores In Percent</th>
<th>Pre-service Elementary Teachers</th>
<th>Pre-service Secondary Teachers</th>
<th>In-service Elementary Teachers</th>
<th>In-service Secondary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>0-10%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11-20%</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>21-30%</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>31-40%</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>41-50%</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>51-60%</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>61-70%</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>71-80%</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>81-90%</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>91-100%</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>17</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>Mean Score</td>
<td>54.5%</td>
<td>66.1%</td>
<td>58.6%</td>
<td>59.7%</td>
</tr>
</tbody>
</table>

Results of Hypotheses Testing

Below are listed the hypotheses as stated in Chapter 1, the statistic used to test the hypotheses, and the results of the tests. The statistic ANOVA was used to obtain
analysis of variance statistic for hypotheses questions one through four, as well as questions five through eight and ten. The Pearson Correlation Coefficient statistic was used to determine correlations for hypothesis question nine. Since no statistically significant differences were noted for questions one through eight, no individual group t-tests were conducted.

Table 15

<table>
<thead>
<tr>
<th>Source</th>
<th>D.F.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>1088.903</td>
<td>362.9678</td>
<td>1.4707</td>
<td>.2314</td>
</tr>
<tr>
<td>Within Groups</td>
<td>61</td>
<td>15054.8504</td>
<td>246.8008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>16143.7538</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. There are no statistically significant differences between pre-service and in-service elementary school teachers' Earth science literacy scores.

The results of the ANOVA procedure used to determine correlations between the Earth science literacy scores of pre-service and in-service elementary and secondary school
teachers indicated that no statistically significant
differences between the groups exist (See Table 17). The
calculated value of F (DF=3,61) was 1.47. The observed
significance level was 0.2314. The null hypothesis was
accepted at the .05 level of significance. Therefore, it
appears that no statistically significant differences exist
in the Earth science literacy scores between pre-service and
in-service elementary school teachers (See Table 17).

2. There are no statistically significant differences
between pre-service secondary and in-service secondary
teachers’ Earth science literacy scores.

The results of the ANOVA procedure that were used to
determine correlations between the Earth science literacy
levels of pre-service and in-service secondary school
teachers indicate that no statistically significant
differences among the groups exist (See Table 17). The
calculated value of F (DF=3,61) was 1.47. The observed
significance level was 0.2314. The null hypothesis was
accepted at the .05 level of significance. Therefore, it
appears that no statistically significant differences exist
in the Earth science literacy scores between pre-service and
in-service secondary school teachers (See Table 17).
3. There are no statistically significant differences between pre-service secondary and in-service elementary teachers’ Earth science literacy scores.

The results of the ANOVA procedure that was used to determine correlations between the Earth science literacy scores of pre-service secondary and in-service elementary school teachers indicate that no statistically significant differences between the groups exists (See Table 17). The calculated value of F (DF=3,61) was 1.47. The observed significance level was 0.2314. The null hypothesis was accepted at the .05 level of significance. Therefore, it appears that no statistically significant relationship exists between the Earth science literacy scores of pre-service secondary and in-service elementary school teachers (See Table 17).

4. There are no statistically significant differences between pre-service elementary and in-service secondary teachers’ Earth science literacy scores.

The results of the statistic ANOVA that was used to determine correlations between the Earth science literacy
scores of pre-service elementary and in-service secondary school teachers indicate that no statistically significant differences between the groups exists (See Table 17). The calculated value of F (DF=3,61) was 1.47. The observed significance level was 0.2314. The null hypothesis was accepted at the .05 level of significance. Therefore, it appears that no statistically significant relationship exists between the Earth science literacy scores of pre-service elementary and in-service secondary school teachers (See Table 17).

Table 16

ONEWAY ANOVA, HYPOTHESES 5-8

Analysis of Variance: Earth Science Content Background and Group

<table>
<thead>
<tr>
<th>Source</th>
<th>D.F.</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>F Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3</td>
<td>33.7439</td>
<td>11.2480</td>
<td>.8353</td>
<td>.4797</td>
</tr>
<tr>
<td>Within Groups</td>
<td>61</td>
<td>821.3945</td>
<td>13.4655</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>855.1385</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. There are no statistically significant differences between Earth science content backgrounds (Self-
reported number of Earth science courses taken at the college level) of pre-service and in-service elementary teachers.

The results of the ANOVA procedure that was used to determine correlations between the Earth Science content background of pre-service and in-service elementary school teachers indicate that no statistically significant differences between the groups exists (See Table 17). The calculated value of F (DF=3,61) was .8353. The observed significance level was 0.4797. The null hypothesis was accepted at the .05 level of significance. Therefore, it appears that no statistically significant relationship exists between the Earth science content background of pre-service and in-service elementary school teachers (See Table 17).

6. There are no statistically significant differences between Earth science content backgrounds (Self-reported number of Earth science courses taken at the college level) of pre-service and in-service secondary teachers.
The results of the ANOVA procedure that was used to determine correlations between the Earth Science content background of pre-service and in-service secondary school teachers indicate that no statistically significant differences between the groups exists (See Table 17). The calculated value of F (DF=3,61) was 8353. The observed significance level was 0.4797. The null hypothesis was accepted at the .05 level of significance. Therefore, it appears that no statistically significant relationship exists between the Earth science content background of pre-service and in-service secondary school teachers (See Table 17).

7. There are no statistically significant differences between Earth science content backgrounds (Self-reported number of Earth science courses taken at the college level) of pre-service secondary and in-service elementary teachers.

The results of the ANOVA procedure that was used to determine correlations between the Earth science content background of pre-service secondary and in-service elementary school teachers indicate that no statistically significant differences between the groups exists (See Table
17). The calculated value of F (DF=3,61) was 0.8353. The observed significance level was 0.4797. The null hypothesis was accepted at the .05 level of significance. Therefore, it appears that no statistically significant relationship exists between the Earth science content background of pre-service secondary and in-service elementary school teachers (See Table 17).

8. There are no statistically significant differences between Earth science backgrounds (Self-reported number of Earth science courses taken at the college level) of pre-service elementary and in-service secondary teachers.

The results of the ANOVA procedure that was used to determine correlations between the Earth science content background of pre-service elementary and in-service secondary school teachers indicate that no statistically significant differences exist between the groups (See Table 17). The calculated value of F (DF=3,61) was 0.8353. The observed significance level was 0.4797. The null hypothesis was accepted at the .05 level of significance. Therefore, it appears that no statistically significant relationship exists between the Earth science content background of pre-
service elementary and in-service secondary school teachers (See Table 17).

9. There is no statistically significant relationship between the Earth science literacy scores of pre-service and in-service elementary and secondary teachers and each of the following:

9.1. Number of Earth science courses taken in college.

The Pearson Correlation Coefficient statistic was used to determine correlations between the Earth science literacy level of pre-service and in-service elementary and secondary school teachers (Knowledge) to number of science courses taken in college. A negligible negative correlation exists between Knowledge and number of courses taken, -.0674 (See Table 18).

Therefore, it appears that there is a negligible negative relationship between the Earth science literacy level of pre-service and in-service elementary and secondary school teachers (Knowledge) and number of science courses taken in college (See Table 18).

9.2. Self-perceived level of success in college Earth science courses taken.
The Pearson Correlation Coefficient statistic was used to determine correlations between the Earth science literacy level of pre-service and in-service elementary and secondary school teachers (Knowledge) to the self-perceived level of success in science courses taken in college. A low negative correlation exists between knowledge and the self-perceived level of success of college courses taken for pre-service elementary (-.2759), pre-service secondary (-.1805), and in-service elementary school teachers (-.1805). A low positive correlation existed between Knowledge and the self-perceived level of success of college courses taken for in-service secondary school teachers (.1258) (See Table 18).

Therefore, it appears that there is a low negative relationship between the Earth science literacy level of pre-service elementary and secondary school teachers, along with elementary in-service school teachers and the self-perceived level of success in Earth science courses taken at the college level. A low positive correlation exists between in-service secondary teachers and the perceived level of success in courses taken at the college level (See Table 18).
9.3. Self-perceived level of confidence in teaching the college Earth science course content at the grade level taught.

The Pearson Correlation Coefficient statistic was used to determine correlations between the Earth science literacy level of pre-service and in-service elementary and secondary school teachers (Knowledge) to the self-perceived level of confidence in the college Earth science course content at the grade level taught. A low to moderate negative correlation exists between Knowledge and the self-perceived level of confidence in the Earth science course content at the grade level taught for pre-service elementary (−.4322), pre-service secondary (−.2556), and in-service elementary school teachers (−.2256). A low positive correlation existed between Knowledge and the self-perceived level of confidence in the Earth science course content at the grade level taught for pre-service elementary and in-service secondary school teachers (.2212) (See Table 18).

Therefore, it appears that there is a low to moderate negative relationship between the Earth science literacy level of pre-service elementary and secondary school teachers, along with elementary in-service school teachers, and in the self-perceived levels of confidence in the Earth science course content at the grade level taught. A low
positive correlation exists between in-service secondary teachers and in the self-perceived levels of confidence in the Earth science course content at the grade level taught (See Table 18).

9.4. Self-perceived value of the Earth science course taken at the college level. Value is defined as the teacher’s self-perceived level of importance of the course to their classroom or to their own educational program.

The Pearson Correlation Coefficient statistic was used to determine correlations between the Earth science literacy level of pre-service and in-service elementary and secondary school teachers (Knowledge) to the self-perceived value of science courses taken at the college level. A low negative correlation exists between Knowledge and the self-perceived value of Earth science college courses taken for pre-service elementary (-.1904), pre-service secondary (-.2506), and in-service elementary school teachers (-.2506). A negligible correlation existed between Knowledge and the self-perceived level of confidence of college courses taken by in-service secondary school teachers (.0267) (See Table 18).

Therefore, it appears that there is a low negative relationship between the Earth science literacy level of pre-service elementary and secondary school teachers, along
with elementary in-service school teachers and the self-perceived level of value of courses taken at the college level. A negligible positive correlation exists between in-service secondary teachers and the self-perceived level of value of courses taken at the college level (See Table 18).

10. There is no statistically significant relationship between the desire to obtain science instruction and the college Earth science content background for pre-service and in-service elementary and secondary teachers.

10.1. Number of Earth science courses taken at the college level.

The results of the ANOVA procedure that was used to determine correlations between the desire to obtain additional science instruction and the number of Earth science college courses taken by pre-service and in-service elementary and secondary school teachers indicate that no statistically significant differences between the groups exists. The F value was .2303, the observed significance level was 0.7950. The null hypothesis was accepted at the .05 level of significance (See Table 19).
Therefore, it appears that no statistically significant relationship exists between the desire to obtain science instruction and the number of Earth science courses taken at the college level between pre-service and in-service elementary and secondary school teachers (See Table 19).

10.2. Self-perceived level of success in Earth science courses taken.

The results of the ANOVA procedure used to determine correlations between the desire to obtain science instruction and the level of self-perceived success of Earth science college courses taken by pre-service and in-service elementary and secondary school teachers indicate that no statistically significant differences between the groups exist. The F value was 1.0188, the observed significance level was 0.3672. The null hypothesis was accepted at the .05 level of significance (See Table 19).

Therefore, it appears that no statistically significant relationship exists between the desire to obtain science instruction and the self-perceived level of success of Earth science courses taken at the college level of pre-service and in-service elementary and secondary school teachers (See Table 19).
10.3. Self-perceived level of confidence in knowledge of the Earth science course content at the grade level taught.

The results of the statistic ANOVA that was used to determine correlations between the desire to obtain science instruction and the self-perceived level of confidence in the Earth science course content at the grade level taught, taken by pre-service and in-service elementary and secondary school teachers find that no statistically significant differences between the groups exist. The F value was .3199, the observed significance level was 0.7275. The null hypothesis was accepted at the .05 level of significance. See Table 19.

Therefore, it appears that no statistically significant relationship exists between the desire to obtain science instruction and the self-perceived level of confidence in the Earth science course content at the grade level taught of pre-service and in-service elementary and secondary school teachers (See Table 19).

10.4. Self-Perceived value of the college Earth science courses taken.

The results of the statistic ANOVA that was used to determine correlations between the desire to obtain
science instruction and the self-perceived value of Earth science college courses taken by pre-service and in-service elementary and secondary school teachers, indicate that no statistically significant differences between the groups exist. The F value was .6126, the observed significance level was 0.5453. The null hypothesis was accepted at the .05 level of significance. See Table 19

Therefore, it appears that no statistically significant relationship exists between the desire to obtain science instruction and the self-perceived value of Earth science courses taken at the college level of pre-service and in-service elementary and secondary school teachers (See Table 19).

Summary

Thirty-one pre-service and 34 in-service elementary and secondary school teachers responded to the survey. Four background characteristics were obtained from each respondent: gender, grade level taught, number of years teaching, and date of birth. Along with this demographic information, respondents were requested to complete an Earth science literacy survey which consisted of questions regarding the Earth sciences, college Earth science content background, self-perceived level of success, self-perceived
level of confidence in the Earth science course content at the grade level taught, self-perceived value of courses taken, the desire for more science instruction, and the desire to obtain more information concerning science education.

The results of the ANOVA, Pearson Correlation Coefficients, and frequency distributions collected for this research led to several conclusions regarding the status of pre-service and in-service elementary and secondary school teachers surveyed. The remainder of this chapter reiterates several findings for these topics.

Findings

- The number of Earth science courses taken and the self-perceived level of success of course(s) taken are substantially (.6492) correlated.

- The number of Earth science courses taken and the self-perceived value level of the course taken are moderately (.4477) correlated.

- The level of self-perceived success of Earth science college courses taken and the self-perceived level of
confidence in the Earth science course content at the grade level taught are moderately (.4722) correlated.

- The level of self-perceived success of Earth science courses taken and the self-perceived value of the courses are very highly (.7269) correlated.

- The level of self-perceived level of confidence in the college Earth science course content at the grade level taught and the self-perceived value of the course are substantially (.5863) correlated.

- The knowledge score on the Earth science literacy survey and the number of Earth science courses taken are negligibly negatively correlated (-.0674).

Noted Frequency Distributions

- The average number of college level Earth science courses taken by pre-service and in-service elementary and secondary school teachers is reported to be five.

- Pre-service(71.5%) and in-service(70%) elementary school teachers reported the highest desire to obtain more science instruction.
- Pre-service (35.2%) and in-service (28.6%) secondary school teachers reported the lowest desire to obtain more science instruction.

Chapter V of this study sets out a summary, conclusions, and implications of this investigation. Suggestions for future research are also offered.
CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

This Chapter presents the summary, conclusions, implications, recommendations for change, and recommendations for further research derived from the findings of this study.

Summary of the Study

This study was designed to explore and describe pre-service and in-service elementary and secondary school teachers with respect to their Earth science literacy. The study sought to investigate differences between and among these four groups as to their degree of Earth science literacy and level of Earth science content background. Four background characteristics were obtained for each respondent: gender, grade level taught, number of years teaching, and date of birth. Along with this demographic information, respondents were requested to complete an Earth science literacy survey which consisted of conceptual questions regarding the Earth sciences, college Earth science content background, self-perceived level of success
of college Earth sciences taken, self-perceived level of confidence in the college Earth science course content at the grade level taught and the self-perceived value of the college Earth science courses taken, the desire for more science instruction, and the desire to obtain more information concerning science education.

Purpose and Objectives

The purpose of the study was to compare the Earth science literacy scores of pre-service elementary and secondary teachers with in-service elementary and secondary teachers. The objectives of the study were as follows:

1. To describe the following characteristics of pre-service and in-service elementary and secondary teachers: age, gender, teaching experience, grade level taught, number and name of science course taken, self-reported level of success in the Earth science course taken, self-reported levels of confidence in the college Earth science course content at the grade level taught, the self-perceived value of the college Earth science course taken, and Earth science literacy scores.
2. To compare pre-service and in-service elementary and secondary teachers’ Earth science literacy scores with respect to each of the following characteristics: age, gender, teaching experience, grade level taught, number and type of Earth science courses taken, self-perceived levels of success in the college Earth science courses taken, self-perceived levels of confidence in the college Earth science course content at the grade level taught, and the self-perceived value of college Earth science courses taken.

Structure of the Study

The following ten general hypotheses were tested in this study:

1. Is there a statistically significant difference between the Earth science literacy level of pre-service elementary and in-service elementary teachers?

2. Is there a statistically significant difference between the Earth science literacy scores of pre-service secondary and in-service secondary teachers?
3. Is there a statistically significant difference between the Earth science literacy scores of pre-service secondary and in-service elementary teachers?

4. Is there a statistically significant difference between the Earth science literacy level of pre-service elementary and in-service secondary teachers?

5. Is there a statistically significant difference between Earth science content background of pre-service and in-service elementary teachers?

6. Is there a statistically significant difference between Earth science content background of pre-service secondary and in-service secondary teachers?

7. Is there a statistically significant difference between Earth science content background of pre-service secondary and in-service elementary teachers?

8. Is there a statistically significant difference between Earth science content background of pre-service elementary and in-service secondary teachers?
9. Is there a statistically significant relationship between the Earth science literacy level of pre-service and in-service elementary and secondary teachers and each of the following:
   a. Number of Earth science courses taken in college.
   b. Self-perceived levels of success in the Earth science courses taken.
   c. Self-perceived levels of confidence to teach the Earth science course content at the grade level taught.
   d. Self-perceived value of Earth science courses taken at the college level.

10. Is there a statistically significant relationship between the desire to obtain science instruction of pre-service and in-service elementary and secondary teachers and each of the following:
    a. Number of Earth science courses taken in college.
    b. Self-perceived levels of success in the Earth science courses taken.
    c. Self-perceived levels of confidence of the subject matter at the grade level taught.
    d. Self-perceived value of the Earth science course taken at the college level.
Procedures:

To obtain the required measurements, two survey instruments were used in this study. One instrument, which was adapted from an existing instrument, assessed the Earth science content background of pre-service and in-service elementary and secondary school teachers. The other instrument, developed for this study, contains questions concerning Earth science concepts (Appendix B). The adaptation process and results of the validation and reliability testing on this instrument are presented in Chapter III.

The instruments were completed by 65 pre-service and in-service school teachers of grades one through twelve representing one school district in southwestern Ohio and one university located in Ohio. To test the null hypotheses of this study, collected data were statistically analyzed using ANOVA, Pearson Correlations, and frequency distributions. The level of significance for all appropriate statistical procedures was set at the .05 level.

A self-reported survey, Earth Science Literacy Survey for Teachers, was developed for this study. The survey consists of two parts: teacher content background information and a set of Earth science literacy questions.
The first part consists of a series of questions designed to determine demographic data and educational backgrounds of the participants. A set of questions dealing with Earth science literacy was identified from past scientific literacy research. The questions were matched to topics found in two publications published by The American Geological Institute, “Earth Science Education for the 21st Century” and “Earth Science Content Guidelines Grades K-12”. Questions chosen were also matched against topics found in the book entitled *Science Matters, Achieving Scientific Literacy*, by Hazen and Trefil, and *Science Education, The Report of a Conference* by the American Geological Institute and the National Science Teachers Association (Mayer and Armstrong, 1990).

The Earth science survey questions were reviewed by members of the dissertation committee, other faculty members, and graduate students, and revised to assure validity. The survey was also pilot tested to assure its reliability (See Appendix C). Reliability of the survey was calculated through the Statistical Packages for the Social Sciences (SPSS) at The Ohio State University Academic Computer Center. The study was submitted to and approved by the Human Research Review Board of The Ohio State University before instruments were distributed.
Sixty-five pre-service and in-service elementary and secondary school teachers responded to the survey. The results of the ANOVA, Pearson Correlation Coefficients, t-tests, and frequencies distributions collected for this study led to several conclusions regarding the status of pre-service and in-service elementary and secondary school teachers surveyed.

**Description of the Participants**

Data for the research portion of the study were obtained from two populations, each including two sub-populations. The study included pre-service elementary and secondary school teachers from a university located in Ohio and in-service elementary and secondary school teachers from a school district located in Ohio. Pre-service and in-service teachers were screened as to the courses they taught: Art, Learning Disabled, Music, and Physical Education teachers were excluded due to their specialized educational topics.

Since in-service teachers were compared to pre-service teachers, it was important that both groups be as equal as possible in respect to grade level taught. Elementary education certifications at the sampled university are valid for grades K-8, secondary certifications are valid for
grades 9-12. The southwestern Ohio school district in question includes elementary grades from K-6, middle school from 7-9, and high school from 10-12. No attempt was made to control for age, gender, years of teaching experience, or educational background of those school teachers surveyed.

Summary of Statistical Findings

- The number of Earth science courses taken and the success level of the course taken are substantially (.6492) correlated.

- The number of Earth science courses taken and the value level of the course taken are moderately (.4477) correlated.

- The level of reported success of Earth science courses taken and the confidence level of teaching that course at the grade they are teaching, are moderately (.4722) correlated.

- The level of reported success of Earth science courses taken and the perceived value of the course are very highly (.7269) correlated.
- The level of reported confidence of Earth science courses taken and the perceived value of the course are substantially (.5863) correlated.

- The knowledge score on the Earth science literacy survey and the number of Earth science courses taken are negligible negatively correlated (-.0674).

**Noted Frequency Distributions**

- The average number of college level Earth science courses taken by pre-service and in-service elementary and secondary school teachers is reported to be five.

- Pre-service and in-service elementary school teachers reported the highest desire to obtain more science instruction.

- In-service secondary teachers reported the lowest desire to obtain more science instruction and more information concerning science education.

**Conclusions, Discussions, and Implications**

Conclusions, discussions, and implications related to the general hypotheses are presented in this section. They
are accompanied by a discussion of the meaning of those findings. Statistical analyses of the data collected for this study supports several educationally significant conclusions, but few differences existed between the groups. Perhaps this study begins to answer some questions about the low overall Earth science literacy level of U.S. adults and students and the impact of teacher training on the Earth science literacy of pre-service and in-service elementary and secondary school teachers.

The following conclusions and implications are presented from the research findings. These conclusions and implications are applicable only to the subjects who participated in the study.

Conclusion 1. Differences in Literacy Levels

A. There is no statistically significant difference between the Earth science literacy scores of pre-service elementary and in-service elementary teachers.

B. There is no statistically significant difference between the Earth science literacy scores of pre-service secondary and in-service secondary teachers.

C. There is no statistically significant difference between the Earth science literacy level and pre-service secondary and in-service elementary teachers.
D. There is no statistically significant difference between the Earth science literacy level of pre-service elementary and in-service secondary teachers.

Conclusion 1-Implications and Discussion

There is no statistically significant difference in the Earth science literacy scores of pre-service and in-service elementary and secondary school teachers based on the ANOVA procedures presented in Chapter IV. Miller in 1990 reported that of all college graduates, education majors had the lowest scientific literacy levels. The results of this study support Miller's 1990 findings as school teachers' average score on the Earth science literacy survey were low at 60 percent. However, it is noted that instrumentation could be a factor as the two surveys were produced and administered independently.

In fact, a negligible negative relationship is noted between the number of Earth science courses taken and scores on the Earth science literacy survey. This statement runs contrary to what one would think logically; but, perhaps we need to take a look at how Earth science courses taken by pre-service and in-service elementary and secondary school teachers are presented in the classroom. In 1993, Allman stated that science at many levels was being taught as a group of disconnected facts, a meaningless conglomeration,
which will not enhance interest in the sciences. Another issue, is that science is still taught in some cases without a laboratory or other hands on experiences.

These findings also support Fort's 1993 findings that two-thirds of in-service elementary teachers surveyed feel unprepared to teach science. This is in part due to their lack of in-service training, as reported by Horizon Research in 1990. Horizon found that one of every two elementary school teachers had had no in-service training in the sciences for the past ten years. Perhaps this is why teachers K-3 only spent 17 minutes per day teaching science, as reported by Rowe in 1980.

Along these same lines, Project 2061, Science for all Americans stated "few elementary school teachers have even a rudimentary education in science and mathematics, and junior and senior high school teachers of science and mathematics do not meet reasonable standards of preparation in those fields" (AAAS, 1989, p. 13).

The implications of this study suggest several possible improvements for pre-service and in-service elementary and secondary school teacher training. State certification requirements for elementary and secondary school teachers should be improved to include a general core of at least six Earth science courses, 3 core courses in 2
different Earth science disciplines. University education
departments need to work closely with the science units at
their institution to develop pre-service and in-service
hands-on, lab and field oriented course work in the Earth
sciences. Through better teacher training in the Earth
sciences, students at the elementary and secondary level
will benefit. In 1993, Fort said it clearly: “the job of
educators is to open the world of science first to
themselves and their colleagues and then to their students”.

Conclusion 2. Differences in Earth Science Content

Background

A. There is no statistically significant difference
between Earth science content background of pre-service and
in-service elementary teachers.

B. There is no statistically significant difference
between Earth science content background of pre-service
secondary and in-service secondary teachers.

C. There is no statistically significant difference
between Earth science content background of pre-service
secondary and in-service elementary teachers.

D. There is no statistically significant difference
between Earth science content background of pre-service
elementary and in-service secondary teachers.
Conclusion 2—Implications and Discussion

There is no statistically significant difference of the Earth science content background of pre-service and in-service elementary and secondary school teachers based on the ANOVA procedures presented in chapter IV. The number of Earth sciences courses taken by school teachers did differ by group but the difference was not statistically significant. The average number of Earth science courses for pre-service school teachers was self-reported at 4.3, pre-service secondary 4.2, in-service elementary 4.8, and in-service secondary 6.1 (refer to Table 6, chapter IV). While it appears that the school teachers surveyed are meeting the minimum state certification requirements for the sciences, their Earth science literacy scores remain low. Perhaps this is one of the reasons why Duschl in 1988 found so many elementary in-service teachers textbook-dependent.

The lack of science content background could affect the school teacher’s attitude concerning teaching the sciences. Kyle et al. in 1988 found if teachers find their science lessons uninteresting, they were likely to convey that same attitude toward science to their students. If teachers are given the proper in-service training they may be better able
to present science as an interesting area of study that will foster the student curiosity.

State certification levels for the number of required science courses for elementary and secondary school teachers varies from state to state. Some states require no formal course work in the Earth sciences while the majority of others require only one to four courses. Results of this research indicate that pre-service and in-service school teachers surveyed had low scientific literacy scores. From this, it is evident that one to four Earth science courses are not enough to secure Earth science literacy at acceptable levels according to the results this study.

Conclusion 3. Differences in Earth Science Literacy Levels and Content Background

There is no statistically significant relationship between the Earth science literacy scores of pre-service and in-service elementary and secondary teachers and each of the following:

a. Number of Earth science courses taken in college.

b. Self-perceived level of success in the Earth science courses taken.

c. Self-perceived level of confidence in the subject
matter at the grade level taught.

d. Self-perceived value of Earth science courses taken at the college level.

Conclusion 3A-Implications and Discussion

The Pearson Correlation Coefficient statistic was used to determine correlations between the Earth science literacy scores of pre-service and in-service elementary and secondary school teachers (knowledge) to number of Earth science courses taken at the college level. A negligible negative correlation exists between literacy scores and number of Earth science courses taken, -.0674.

Logically, the more Earth science courses taken at the college level should improve the overall Earth scientific literacy level of the school teachers surveyed. However, this study implies that just the reverse is true. It is noted by the researcher that the correlation is considered to be negligible in the negative range, though one would at least think they would find a positive correlation between number of college Earth science courses taken and the scientific literacy scores.

A possible explanation exists for this finding was offered by Hazen and Trefil, who stated that teachers and scientists have created "a system that alienates students
from science from their earliest years". Most educational researchers would agree: what we put in is what we get out. If science is portrayed in the elementary and secondary classrooms as disconnected facts and figures, or is taught by a textbook-dependent teacher, this impression no doubt will be with the student into their vocational life or into college. This negative attitude toward science during college years causes some to have science anxiety, which in turn could cause one to be uninterested in the sciences, which could be one of the causes for low scientific literacy levels of American adults.

The results of this study indicate that educators perhaps need to change the way science is presented to students at all levels, not only at the college level. Science should be presented in a hands-on, experience based methodology along with a relevant presentation to the student.

Conclusion 3B-Implications and Discussion

The Pearson Correlation Coefficient statistic was used to determine correlations between the Earth science literacy scores of pre-service and in-service elementary and secondary school teachers to their self-perceived levels of success in science courses taken in college. A low negative
correlation exists between knowledge and the self-perceived level of success of college courses taken for pre-service elementary (-.2759), pre-service secondary (-.1805), and in-service elementary school teachers (-.1805). A low positive correlation existed between knowledge and the self-perceived level of success of college courses taken for in-service secondary school teachers (.1258).

Causes for the low negative correlation could be attributed to, among other things, the way Earth science was presented to the respondents at the college level. It has been the experience of the researcher that the majority of college students simply want "the facts", probably because this is what they are used to obtaining in other pre-college/college science courses. Since students are used to only obtaining science facts and figures, this may be why some students tend not to be interested in the overall big picture, or how this information fits into their lives, but simply concentrate on the memorization of facts and figures which are soon forgotten after the examination or end of the course.

Respondents reported that they were under the impression that they performed well in the Earth science courses taken. However, it is possible that information obtained during their science instruction throughout their
education was not presented in a relevant way which would lead to life long learning or in a way that may have led to Earth science misconceptions. It appears that some pre-service elementary and secondary and in-service elementary school teachers failed to receive an adequate Earth science background at the college level, perhaps due to an aversion to the sciences from an early age or lack of good Earth science training at the college level.

It is noted that scores for secondary in-service school teachers showed a low positive correlation between their perceived levels of success in sciences courses taken at the college level and their Earth science literacy level. Perhaps this difference between groups is due to the higher number of college Earth science courses taken by secondary in-service school teachers.

**Conclusion 3C-Implications and Discussions**

The Pearson Correlation Coefficient statistic was used to determine correlations between the Earth science literacy scores of pre-service and in-service elementary and secondary school teachers to the self-perceived level of confidence in the subject matter at the grade level taught. A low to moderate negative correlation exists between knowledge and the self-perceived level of confidence of
college courses taken for pre-service elementary (-.4322), pre-service secondary (-.2556), and in-service elementary school teachers (-.2256). A low positive correlation existed between knowledge and the perceived level of confidence of college courses taken for in-service secondary school teachers (.2212).

Causes for the low to moderate negative correlation could be attributed impart to the way Earth science was presented to the respondents at the college level. Responding school teachers evidently felt that the Earth science preparation was sufficient for them to teach the subject matter from the Earth science course(s) taken, at the current grade level they are teaching. The scientific literacy scores suggest that they could not do this effectively, perhaps passing along science misconceptions. It appears that Earth sciences courses reported by the respondents were not able to lead the school teachers to a comprehensive understanding of the Earth sciences after course completion.

It is noted that secondary in-service school teachers reported a low positive correlation between the self-perceived level of confidence of the subject matter at the grade level taught and their Earth science literacy level.
This is perhaps due to the higher number of reported college Earth science courses taken by this group.

**Conclusion 3D-Implications and Discussions**

The Pearson Correlation Coefficient statistic was used to determine correlations between the Earth science literacy scores of pre-service, and in-service elementary, and secondary school teachers to the self-perceived value of science courses taken in college. A low negative correlation exists between these scores and the perceived value of college courses taken for pre-service elementary (-.1904), pre-service secondary (-.2506), and in-service elementary school teachers (-.2506). A negligible positive correlation existed between knowledge and the self-perceived level of confidence of college courses taken by in-service secondary school teachers (.0267).

The majority of the respondents reported that they valued highly the Earth science courses taken at the college level, however, scored low on the Earth science literacy survey. One interpretation of this finding is that value levels concerning a Earth science course are unable to predict ones Earth science literacy scores. One would logically think that if one values highly an Earth science course(s), that they would excel in the course and exhibit a
high science literacy level, however, this was not the case for this study. Perhaps one of the many possible reasons for this to occur could be lack of a good Earth science basis at the pre-college level as discussed in Implications and Discussions 3C.

It is noted that secondary in-service school teachers reported a negligible positive correlation, perhaps due to the higher number of reported college Earth science courses taken by this group.

Conclusion 4. The Desire to Obtain More Science Instruction and the Content Background

There is no statistically significant relationship between the desire to obtain science instruction of pre-service and in-service elementary and secondary school teachers and each of the following:

a. Number of Earth science courses taken in college.

b. Self-perceived level of success in the Earth science courses taken.

c. Self-perceived level of confidence in their knowledge of the subject matter at the grade level taught.
d. Self-perceived value of the Earth science course, taken at the college level.

Discussion 4A

The results of the statistic ANOVA used to determine correlations between the desire to obtain more science instruction and the number of Earth science college courses taken by pre-service and in-service elementary and secondary school teachers, finds that no statistically significant differences between the groups exists. The F value was .2303, the observed significance level was 0.7950. The null hypothesis was accepted at the .05 level of significance.

It is noted from Table 11 that there is a clear difference between pre-service and in-service elementary and secondary school teachers when it come down to taking more science instruction/course work. Pre-service school teachers were more likely to respond positively when asked if they would like to receive more training in the sciences while In-service school teachers seemed less interested. Reasoning for this division is logical as when one leaves the college/university environment after graduation, little time in ones personal life is likely to be available for a
Another possible reason for this difference could be an aversion to science itself.

Discussion 4B

The results of the statistic ANOVA that was used to determine correlations between the desire to obtain science instruction and the self-perceived level of success of the Earth science college courses taken by pre-service and in-service elementary and secondary school teachers, finds that no statistically significant differences between the groups exists. The F value was 1.0188; the observed significance level was 0.3672. The null hypothesis was accepted at the .05 level of significance. See Discussion 4A for comments concerning this finding.

Discussion 4C

The results of the statistic ANOVA that was used to determine correlations between the desire to obtain more science instruction and the self-perceived level of confidence of the subject matter at the grade level taught by pre-service and in-service elementary and secondary school teachers, finds that no statistically significant differences between the groups exists. The F value was .3199; the observed significance level was 0.7275. The null
hypothesis was accepted at the .05 level of significance. See Discussion 4A for comments concerning this finding.

Discussion 4D

The results of the statistic ANOVA that was used to determine correlations between the desire to obtain more science instruction and the self-perceived value of Earth science college courses taken by pre-service and in-service elementary and secondary school teachers find that no statistically significant differences between the groups exists. The F value was .6126; the observed significance level was 0.5453. The null hypothesis was accepted at the .05 level of significance. See Discussion 4A for comments concerning this finding.

Summary

The results of this research and the conclusions reached begin to respond to the concerns and questions posed by other researchers in regard to the Earth science literacy of pre-service and in-service elementary and secondary school teachers. In addition, perhaps this study begins to answer some questions about the impact of teacher training on the Earth science literacy of school teachers.
The overall science literacy level in the United States according to scientists and educators, is not good. Results from this study indicate that problems with science literacy are not only a problem with our society, but also with our educational system. Jon Miller’s research estimates that only 5 to 6 percent of the United States population is science literate enough for good citizenship. A reason for such a poor showing of American adults in science literacy is due to a lack of good science education at the elementary and secondary levels.

The present study addressed this question by examining the science literacy level of both pre-service and in-service teachers. Are pre-service and in-service teachers given enough science education through course work and in-service training? Do differences or correlations exist in the science literacy rate of these two populations? What is the overall attitude of science education among pre-service and in-service educators? Information for this research was obtained from an Earth Science Literacy Survey administered to both pre-service and in-service elementary and secondary teachers.

The problems of science education/Earth science literacy in America are many and there probably is no easy
fix. We can, however, look at the results of this study and attempt to make a few suggestions for its improvement:

1. Increase the number of required Earth science content courses at the pre-service level for elementary and secondary school teachers.

Increasing the number of required Earth science courses taken at the college level would perhaps increase Earth science knowledge and awareness. This added knowledge and awareness would allow school teachers to have a wider comfort zone when it comes to teaching Earth science education. More knowledge should also decrease the number of Earth science misconceptions held by school teachers as well.

2. Increase the number of Earth science related in-service activities for elementary and secondary school teachers.

By increasing the number of required Earth science related in-service activities for school teachers should improve their overall knowledge base and awareness. This added knowledge and awareness would allow in-service school teachers to have a wider comfort zone when it comes to teaching Earth sciences.
3. Require hands-on Earth science training for pre-service and in-service elementary and secondary school teachers.

It is well documented in the Earth science education literature that Earth science education to be effective must be hands-on which allows for greater student comprehension.

4. Integrate the Earth sciences into the elementary and secondary educational system.

Infusing the Earth sciences into the overall elementary and secondary curriculum, will allow students to experience the Earth sciences in everyday life, not just in the science classroom.

Suggestions for Further Research

In the process of conducting this research, the following suggestions for further research emerged:

1. Carry out a similar study by using the Earth Science Literacy Survey on non-educators to compare with the results of this research.

2. Carry out a similar study with an expanded sample
by including pre-service and in-service elementary and secondary teachers from other universities and school districts.

3. Modify the study to include a personal interview (qualitative) component which could be compared with the Earth Science Literacy Survey results to determine possible discrepancies between survey responses and interview responses. This could provide insight on the level of Earth science literacy for each pre-service and in-service teacher.

4. Expand the study of pre-service and in-service elementary and secondary teachers by including multicultural backgrounds of participants as an independent variable in order to provide a broader base for generalization.

5. Share findings of this, as well as subsequent, studies with elementary and secondary school administrators to consider future in-service training programs in the Earth sciences.
6. Share findings of this, as well as subsequent studies, with elementary and secondary school educational institutions so they can consider changes in the number of required Earth science courses taken for a degree requirement.
REFERENCES


American Association for the Advancement of Science (AAAS) (1989), Science For All Americans, Project 2061, AAAS, Washington D.C.


Czerniak, Charlene (1989), An Investigation Of The Relationships Among Science Teaching Anxiety, Self-Efficacy, Teacher Education Variables, and Instructional Strategies, Dissertation The Ohio State University, Columbus, Ohio.


Horizon Research, Inc. (1990), Science and Mathematics Education Briefing Book.


Miller, Jon D. (1989), Scientific Literacy, Boyd Lecture Series at The Ohio State University, Columbus, Ohio.


Rutherford, James F. and Ahlgren, Andrew (1990), Science for All Americans, New York: Oxford University Press.


APPENDICES
APPENDIX A

RESULTS OF HYPOTHESIS TESTING AND SUMMARY OF CORRELATIONS
TABLE 17
RESULTS OF HYPOTHESIS TESTING

<table>
<thead>
<tr>
<th>Hypothesis Number</th>
<th>Hypothesis Statement</th>
<th>F Ratio</th>
<th>F Probability</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANOVA For Hypotheses 1 - 4</td>
<td></td>
<td>1.4707</td>
<td>.2314</td>
<td>null accepted</td>
</tr>
</tbody>
</table>

1. There is no statistically significant difference between pre-service elementary and in-service elementary teachers Earth science literacy scores.

2. There is no statistically significant difference between pre-service secondary and in-service secondary teachers Earth science literacy scores.
<table>
<thead>
<tr>
<th>Hypothesis Number</th>
<th>Hypothesis Statement</th>
<th>F Ratio</th>
<th>F Probability</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.</td>
<td>There is no statistically significant difference between pre-service secondary and in-service elementary teachers Earth science literacy scores.</td>
<td></td>
<td></td>
<td>no difference</td>
</tr>
<tr>
<td>4.</td>
<td>There is no statistically significant difference between pre-service elementary and in-service secondary teachers Earth science literacy scores.</td>
<td></td>
<td></td>
<td>no difference</td>
</tr>
</tbody>
</table>
TABLE 17
RESULTS OF HYPOTHESIS TESTING

<table>
<thead>
<tr>
<th>Hypothesis Number</th>
<th>Hypothesis Statement</th>
<th>F Ratio</th>
<th>F Probability</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>A N O V A For Hypotheses 5 - 8</td>
<td></td>
<td>.8353</td>
<td>.4797</td>
<td>null accepted</td>
</tr>
<tr>
<td>5.</td>
<td>There is no statistically significant difference between pre-service and in-service elementary teachers Earth science content accepted background.</td>
<td></td>
<td></td>
<td>no difference</td>
</tr>
<tr>
<td>6.</td>
<td>There is no statistically significant difference between pre-service secondary and in-service secondary teachers Earth science content background.</td>
<td></td>
<td></td>
<td>no difference</td>
</tr>
</tbody>
</table>
### TABLE 17
RESULTS OF HYPOTHESIS TESTING

<table>
<thead>
<tr>
<th>Hypothesis Number</th>
<th>Hypothesis Statement</th>
<th>F Ratio</th>
<th>F Probability</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td>There is no statistically significant difference between pre-service secondary and in-service elementary teachers Earth science content background.</td>
<td></td>
<td></td>
<td>no difference</td>
</tr>
<tr>
<td>8.</td>
<td>There is no statistically significant difference between pre-service elementary and in-service secondary teachers Earth science content background.</td>
<td></td>
<td></td>
<td>no difference</td>
</tr>
</tbody>
</table>
TABLE 18
Summary of Correlations

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Hypothesis</th>
<th>Correlation</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Statement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. There is no significant relationships between the Earth science literacy level of pre-service and in-service elementary and secondary teachers and each of the following: a. Number of Earth science courses taken in college</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Teachers</td>
<td></td>
<td>-.0671</td>
<td>negligible negative correlation</td>
</tr>
<tr>
<td>Pre-service Elementary</td>
<td></td>
<td>-.1914</td>
<td>low negative correlation</td>
</tr>
</tbody>
</table>
### TABLE 18
Summary of Correlations

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Statement</th>
<th>Correlation</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-service Secondary</td>
<td></td>
<td>.1100</td>
<td>Low correlation</td>
</tr>
<tr>
<td>In-service Elementary</td>
<td></td>
<td>.1100</td>
<td>Low</td>
</tr>
<tr>
<td>In-service Secondary</td>
<td></td>
<td>.2767</td>
<td>Low</td>
</tr>
</tbody>
</table>
### TABLE 18

**Summary of Correlations**

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Hypothesis Statement</th>
<th>Correlation</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-service Elementary</td>
<td>-.2759</td>
<td>low negative correlation</td>
<td></td>
</tr>
<tr>
<td>Pre-service Secondary</td>
<td>-.1805</td>
<td>low negative correlation</td>
<td></td>
</tr>
<tr>
<td>In-service Elementary</td>
<td>-.1805</td>
<td>low negative correlation</td>
<td></td>
</tr>
</tbody>
</table>

9.b. Self-perceived level of success in the Earth science course(s) taken for:
### TABLE 18
Summary of Correlations

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Hypothesis Statement</th>
<th>Correlation</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-service Secondary</td>
<td>.1258</td>
<td>Low correlation</td>
<td></td>
</tr>
</tbody>
</table>

9.c. Self-perceived level of confidence of the subject matter at the grade level taught for:

- Pre-service Elementary: $-0.4322$ moderate negative correlation
- Pre-service Secondary: $-0.2556$ low negative correlation
<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Hypothesis</th>
<th>Correlation</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-service Elementary</td>
<td></td>
<td>-.2556</td>
<td>low negative correlation</td>
</tr>
<tr>
<td>In-service Secondary</td>
<td></td>
<td>.2212</td>
<td>Low correlation</td>
</tr>
</tbody>
</table>

9.d. Self-perceived value of the Earth science course(s) taken at the college level for:

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Correlation</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-service Elementary</td>
<td>-.1904</td>
<td>Low negative correlation</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>Hypothesis</td>
<td>Correlation</td>
</tr>
<tr>
<td>----------------------------</td>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Pre-service Secondary</td>
<td>-.2506</td>
<td>low negative correlation</td>
</tr>
<tr>
<td>In-service Elementary</td>
<td>-.2506</td>
<td>low negative correlation</td>
</tr>
<tr>
<td>In-service Secondary</td>
<td>.0267</td>
<td>negligible correlation</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>F Ratio</td>
<td>F Probability</td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
<td>---------------</td>
</tr>
<tr>
<td>10. There is no statistically significant relationship between the desire to obtain science instruction and Earth science content background for pre-service and in-service elementary and secondary teachers.</td>
<td>.2303</td>
<td>.7950</td>
</tr>
<tr>
<td>a. Number of Earth science courses taken by pre-service and in-service elementary and secondary school teachers:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE 19
RESULTS OF HYPOTHESIS TESTING

<table>
<thead>
<tr>
<th>Hypothesis Number</th>
<th>Hypothesis Statement</th>
<th>F Ratio</th>
<th>F Probability</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. (Continued)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Perceived level of success in the courses taken:</td>
<td>1.0188</td>
<td>.3672</td>
<td>null</td>
<td>accepted</td>
</tr>
<tr>
<td>C. Perceived level of confidence in the course content at the grade level taught:</td>
<td>.3199</td>
<td>.7275</td>
<td>null</td>
<td>accepted</td>
</tr>
<tr>
<td>D. Perceived value of the course:</td>
<td>.6126</td>
<td>.5453</td>
<td>null</td>
<td>accepted</td>
</tr>
</tbody>
</table>
APPENDIX B

THE INSTRUMENT
May 8, 1992

Dear Colleague,

I am a Ph.D. Candidate in science education at The Ohio State University in Columbus, Ohio working along with Dr. John F. Disinger of the School of Natural Resources at Ohio State. I am working on my dissertation and I would like to invite you to participate in my study.

Your assistant superintendent has reviewed my dissertation proposal, reviewed the instrument used, and approved the study for use in your school. To make participation in this study as easy as possible, I have included everything necessary in this packet. You should find:

- 1 questionnaire
- 1 postage-paid return envelope

This study focuses on the Earth science literacy of preservice elementary and secondary education student teachers and inservice elementary and secondary teachers. The enclosed questionnaire covers teachers' thoughts about the value of science in the classroom, science course background, and an Earth science knowledge survey.

Please answer the questions honestly. To encourage you to do so, total anonymity is guaranteed. No tracking of the questionnaires will be done.

The average time of completion is twenty minutes. Please finish answering the questionnaires by May 20, 1992 and return them in the enclosed postage-paid envelope.

If you have any questions, please call collect at my home (614) 268-4324.

As with any research study, you are not obligated to take part; you have the option not to participate. If you choose to do so, please return all materials to me in the postage-paid envelope so that I may use them with another teacher.

Thanks so much for your time and understanding.

Sincerely,

David W. Miller
Ph.D. Candidate

Dr. John F. Disinger
Advisor
May 8, 1992

Dear Colleague,

I am a Ph.D. candidate in science education at The Ohio State University in Columbus, Ohio working along with Dr. John F. Disinger of the School of Natural Resources at Ohio State. I am working on my dissertation and I would like to invite you to participate in my study.

To make participation in this study as easy as possible, I have included everything necessary in this packet. You should find:

- 1 questionnaire
- 1 postage-paid return envelope

This study focuses on the Earth science literacy of preservice elementary and secondary education student teachers and inservice elementary and secondary teachers. The enclosed questionnaire covers students' thoughts about the value of science in the classroom, science course background, and an Earth science knowledge survey.

Please answer the questions honestly. To encourage you to do so, total anonymity is guaranteed. No tracking of the questionnaires will be done.

The average time of completion is twenty minutes. Please finish answering the questionnaires by May 20, 1992 and return them in the enclosed postage-paid envelope.

If you have any questions, please call collect at my home (614) 268-4324.

As with any research study, you are not obligated to take part; you have the option not to participate. If you choose to do so, please return all materials to me in the postage-paid envelope so that I may use them with another student teacher.

Thanks so much for your time and understanding.

Sincerely,

David W. Miller
Ph.D. Candidate

Dr. John F. Disinger
Advisor
Dear Colleague:  
22 May 1992

Just a quick little reminder concerning the Earth science literacy survey you received last week. If you have not gotten a chance to complete the voluntary survey, please do so now. Your response to this educational survey research is important.

If you have already sent your survey back, I want to take this opportunity to thank you for your effort. The results of this survey will greatly enhance knowledge concerning the status of science literacy in our educational system. Please, if you have any questions, do not hesitate to call me collect at (614) 268-4324. Thanks again for your time.

Sincerely,

David W. Miller  
Ph.D. Candidate

The Ohio State University  
School of Natural Resources  
Attn: Dr. John F. Disinger  
2021 Coffey Road  
Columbus, Ohio 43210
Opening Comments:

Thanks so much for taking your time to take this Earth science survey. It should take you no longer than twenty minutes to complete. This is a study conducted by The Ohio State University to survey the Earth science literacy of preservice and inservice elementary and secondary teachers. Your answers to the survey questions will be kept strictly confidential.

* Please do not spend a lot of time on any one of the questions.

* Before you begin answering the questionnaires, please fill out the following information:

  a. Female______ Male______

  b. Please indicate the grade level you teach.

     ______

  c. Please indicate the number of years you have been teaching.

     ______

  d. Fill in birth year, if you wish

     ______

* Please answer the survey to the best of your ability. Space is available under each question for your comments, which are encouraged.
Science Content Background
Adapted from Charlene Czerniak, Ph. D., 1989

In column A (items 1-10), think about the courses you remember taking in college. Circle the courses in which you have taken.

In column B (items 11-20), report the number of undergraduate and graduate courses taken for each science.

In column C (items 21-30), indicate the level of success you believe you had in the course. 1=extremely successful; 2=very successful; 3=average success; 4=only slightly successful; 5=not successful.

In column D (items 31-40), indicate how confident you are with the content of the course. In other words, how confident are you with the course content at the grade you are teaching? 1=extremely confident; 2=very confident; 3=neutral; 4=somewhat confident; 5=little confidence.

<table>
<thead>
<tr>
<th>COLUMN A</th>
<th>COLUMN B</th>
<th>COLUMN C</th>
<th>COLUMN D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Course Taken</strong></td>
<td><strong>Number of courses taken</strong></td>
<td><strong>Level of Success</strong></td>
<td><strong>Confidence</strong></td>
</tr>
<tr>
<td>1. Biology</td>
<td>11. 1 2 3 4 4+</td>
<td>21. 1 2 3 4 5</td>
<td>31. 1 2 3 4 5</td>
</tr>
<tr>
<td>2. Chemistry</td>
<td>12. 1 2 3 4 4+</td>
<td>22. 1 2 3 4 5</td>
<td>32. 1 2 3 4 5</td>
</tr>
<tr>
<td>3. Physics</td>
<td>13. 1 2 3 4 4+</td>
<td>23. 1 2 3 4 5</td>
<td>33. 1 2 3 4 5</td>
</tr>
<tr>
<td>4. Earth Science</td>
<td>14. 1 2 3 4 4+</td>
<td>24. 1 2 3 4 5</td>
<td>34. 1 2 3 4 5</td>
</tr>
<tr>
<td>5. Geology</td>
<td>15. 1 2 3 4 4+</td>
<td>25. 1 2 3 4 5</td>
<td>35. 1 2 3 4 5</td>
</tr>
<tr>
<td>6. Astronomy</td>
<td>16. 1 2 3 4 4+</td>
<td>26. 1 2 3 4 5</td>
<td>36. 1 2 3 4 5</td>
</tr>
<tr>
<td>7. Natural Resources</td>
<td>17. 1 2 3 4 4+</td>
<td>27. 1 2 3 4 5</td>
<td>37. 1 2 3 4 5</td>
</tr>
<tr>
<td>8. Computer Science</td>
<td>18. 1 2 3 4 4+</td>
<td>28. 1 2 3 4 5</td>
<td>38. 1 2 3 4 5</td>
</tr>
<tr>
<td>9. Meteorology</td>
<td>19. 1 2 3 4 4+</td>
<td>29. 1 2 3 4 5</td>
<td>39. 1 2 3 4 5</td>
</tr>
<tr>
<td>10. General Science</td>
<td>20. 1 2 3 4 5+</td>
<td>30. 1 2 3 4 5</td>
<td>40. 1 2 3 4 5</td>
</tr>
</tbody>
</table>
In column E (items 41-50), indicate your perceived value of the course listed. 1=extremely valuable; 2=very valuable; 3=neutral; 4=somewhat valuable; 5=little value.

<table>
<thead>
<tr>
<th>Course Taken</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>41. 1 2 3 4 5</td>
</tr>
<tr>
<td>Chemistry</td>
<td>42. 1 2 3 4 5</td>
</tr>
<tr>
<td>Physics</td>
<td>43. 1 2 3 4 5</td>
</tr>
<tr>
<td>Earth Science</td>
<td>44. 1 2 3 4 5</td>
</tr>
<tr>
<td>Geology</td>
<td>45. 1 2 3 4 5</td>
</tr>
<tr>
<td>Astronomy</td>
<td>46. 1 2 3 4 5</td>
</tr>
<tr>
<td>Natural Resources</td>
<td>47. 1 2 3 4 5</td>
</tr>
<tr>
<td>Computer Science</td>
<td>48. 1 2 3 4 5</td>
</tr>
<tr>
<td>Meteorology</td>
<td>49. 1 2 3 4 5</td>
</tr>
<tr>
<td>General Science</td>
<td>50. 1 2 3 4 5</td>
</tr>
</tbody>
</table>
Earth Science Literacy Survey Questions:

Circle your choice

51. Astrology can predict the future.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

52. Gravity is selective and acts differently upon different types of matter.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

53. Does the Earth go around the Sun, or does the Sun go around the Earth?
   a. Earth goes around the Sun
   b. Sun goes around the Earth
   c. Don't know

54. Based on your response from question # 53, how long does journey take?
   a. One day
   b. One month
   c. One year
   d. Don't Know

55. The Sun will someday stop producing heat and light.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

56. The Universe began with a huge explosion.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

57. Light travels faster than sound.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

58. The continents of the Earth are continuously moving.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know
59. The center of the Earth is very hot.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don’t know

60. The Earth is about 4.7 billion years old.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don’t know

61. Dinosaurs and humans did not live at the same time.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don’t know

62. Human beings developed from animal species.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don’t know

63. Human life began in the Garden of Eden.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don’t know

64. The oxygen we breathe is produced by plants.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don’t know

65. Electrons are smaller than atoms.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don’t know

66. Ozone depletion in our atmosphere is responsible for global warming.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don’t know
67. Winter weather can be predicted by examining the fur thickness of animals and "wooly worms".
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

68. We see things because light brightens them.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

69. Seasonal changes are caused by the:
   a. Earth's distance from the Sun.
   b. Earth's tilt on the axis.
   c. unequal heating of the Earth's atmosphere.
   d. spinning of the Earth on its axis.
   e. Don't know

70. The phases of the Moon are caused by:
   a. the Earth's shadow on the moon.
   b. the Sun's shadow on the moon.
   c. the Moon's position with regard to the Earth.
   d. an eclipsing event on the moon.
   e. Don't know

71. We can see other planets in our solar system without a telescope.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

72. The Sun is directly overhead at noon here in Ohio.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

73. The Earth's gravitational attraction is greatly reduced on the tops of mountains.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know
74. Gravity cannot exist without air.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

75. Our Sun is a star.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

76. Would you like to obtain more science instruction?
    1=yes  2=no  3maybe

77. Would you like to obtain more information on science education?
    1=yes  2=no  3maybe

78. In what areas are you certified, or plan to be, at the elementary and secondary level?

   Comments here please:
APPENDIX C

THE PILOT TEST
Good Morning, I have enclosed my dissertation instrument for your review and comments. The questions used in the instrument have been selected and constructed to establish the current status of Earth science literacy of preservice and inservice elementary and secondary teachers.

The Earth science literacy questions are selected and modified from prior studies conducted by numerous researchers in science education. Questions chosen are representative of the Earth sciences and corresponded to topics found in the third grade science textbook, Science Horizons, published by Silver, Burdett and Ginn, 1991.

These questions will be administered to preservice elementary and secondary student teachers at The Ohio State University and to inservice elementary and secondary teachers in the Dayton Public School System. Surveys will be mailed to each participant with a postage paid return envelope. Scores will be calculated by giving correct responses a high point value, incorrect responses a low point value. This data will be compared to the science content background survey. Information gathered by this survey will assist Dayton school administrators and the College of Education at Ohio State. It will also increase the general body of knowledge concerning the status of Earth science literacy of inservice and preservice teachers.

I would deeply appreciate your assistance in reviewing the enclosed instrument for its validity and completeness. Your comments are most welcome. Please return the surveys in the enclosed campus mail envelope to Dr. Disinger, 210 Kottman Hall, School of Natural Resources by 24 March 1992. Thanks so much for your time.

Sincerely:

David W. Miller
Thank you for taking your time to take this Earth science survey. It should take you no longer than twenty minutes to complete. This is a study conducted by The Ohio State University to survey the Earth science literacy of preservice and inservice elementary and secondary teachers. Your answers to the survey questions will be kept strictly confidential please no names on the surveys.

* Please do not spend a lot of time on any one of the questions.

* You will need to use a #2 pencil on the computer answer sheet.

* Before you begin answering the questionnaires, fill out the following information on the front of the computer answer sheet:

a. the section marked sex

b. the section marked "grade or educ", please indicate the grade level you teach.

c. Identification Number, please in the first two columns under A and B, indicate the number of years you have been teaching, for example 03 or 20.

d. Fill in birth date if you wish

e. Leave special codes blank

* Please answer the survey to the best of your ability. Space is available under each question for your comments, which are encouraged.
In column A (items 1-10), think about the courses you remember taking in college. Using the computer answer sheet, indicate whether or not you took each course by marking "A" for yes and "B" for no.

In column B (items 11-20), report the number of undergraduate and graduate courses taken for each science.

In column C (items 21-30), indicate the level of success you believe you had in the course. 1=extremely successful; 2=very successful; 3=average success; 4=only slightly successful; 5=not successful.

In column D (items 31-40), indicate how confident you are with the content of the course. In other words, how confident are you with the course content at the grade you are teaching? 1=extremely confident; 2=very confident; 3=neutral; 4=somewhat confident; 5=little confidence.

<table>
<thead>
<tr>
<th>Course Taken</th>
<th>Number of courses taken</th>
<th>Level of Success</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Biology</td>
<td>11. 1 2 3 4 5</td>
<td>21. 1 2 3 4 5</td>
<td>31. 1 2 3 4 5</td>
</tr>
<tr>
<td>2. Chemistry</td>
<td>12. 1 2 3 4 5</td>
<td>22. 1 2 3 4 5</td>
<td>32. 1 2 3 4 5</td>
</tr>
<tr>
<td>3. Physics</td>
<td>13. 1 2 3 4 5</td>
<td>23. 1 2 3 4 5</td>
<td>33. 1 2 3 4 5</td>
</tr>
<tr>
<td>4. Earth Science</td>
<td>14. 1 2 3 4 5</td>
<td>24. 1 2 3 4 5</td>
<td>34. 1 2 3 4 5</td>
</tr>
<tr>
<td>5. Geology</td>
<td>15. 1 2 3 4 5</td>
<td>25. 1 2 3 4 5</td>
<td>35. 1 2 3 4 5</td>
</tr>
<tr>
<td>6. Astronomy</td>
<td>16. 1 2 3 4 5</td>
<td>26. 1 2 3 4 5</td>
<td>36. 1 2 3 4 5</td>
</tr>
<tr>
<td>7. Natural Resources</td>
<td>17. 1 2 3 4 5</td>
<td>27. 1 2 3 4 5</td>
<td>37. 1 2 3 4 5</td>
</tr>
<tr>
<td>8. Computer Science</td>
<td>18. 1 2 3 4 5</td>
<td>28. 1 2 3 4 5</td>
<td>38. 1 2 3 4 5</td>
</tr>
<tr>
<td>9. Physical Science</td>
<td>19. 1 2 3 4 5</td>
<td>29. 1 2 3 4 5</td>
<td>39. 1 2 3 4 5</td>
</tr>
<tr>
<td>10. General Science</td>
<td>20. 1 2 3 4 5</td>
<td>30. 1 2 3 4 5</td>
<td>40. 1 2 3 4 5</td>
</tr>
</tbody>
</table>
**Science Content Background**  
Adapted from Charlene Czerniak, Ph. D., 1989

In column E (items 41-50), indicate your perceived value of the courses listed.  
1=extremely valuable; 2=very valuable; 3=neutral; 4=somewhat valuable; 5=little value.

<table>
<thead>
<tr>
<th>Course Taken</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>41. 1 2 3 4 5</td>
</tr>
<tr>
<td>Chemistry</td>
<td>42. 1 2 3 4 5</td>
</tr>
<tr>
<td>Physics</td>
<td>43. 1 2 3 4 5</td>
</tr>
<tr>
<td>Earth Science</td>
<td>44. 1 2 3 4 5</td>
</tr>
<tr>
<td>Geology</td>
<td>45. 1 2 3 4 5</td>
</tr>
<tr>
<td>Astronomy</td>
<td>46. 1 2 3 4 5</td>
</tr>
<tr>
<td>Natural Resources</td>
<td>47. 1 2 3 4 5</td>
</tr>
<tr>
<td>Computer Science</td>
<td>48. 1 2 3 4 5</td>
</tr>
<tr>
<td>Physical Science</td>
<td>49. 1 2 3 4 5</td>
</tr>
<tr>
<td>General Science</td>
<td>50. 1 2 3 4 5</td>
</tr>
</tbody>
</table>
Earth Science Literacy Survey Questions:

51. Astrology can predict the future.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

52. Gravity is selective and acts differently upon different types of matter.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

53. Does the Earth go around the Sun, or does the Sun go around the Earth?
   a. Earth goes around the Sun
   b. Sun goes around the Earth
   c. Don't know
54. Based on your response from question # 43, how long does journey take?
   a. One day
   b. One month
   c. One year
   d. Don't Know

55. The Sun will someday stop producing heat and light.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

56. The Universe began with a huge explosion.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know
57. Light travels faster than sound.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

58. The continents of the Earth are continuously moving.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

59. The center of the Earth is very hot.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know
60. The Earth is about 4.7 billion years old.

   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

61. Dinosaurs and humans did not live at the same time.

   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

62. Human beings developed from animal species.

   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know
63. Human life began in the Garden of Eden.

   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

64. The oxygen we breathe is produced by plants.

   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

65. Electrons are smaller than atoms.

   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know
66. Ozone depletion in our atmosphere is responsible for global warming.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

67. Winter weather can be predicted by examining the fur thickness of animals and wooly worms.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know

68. We see things because light brightens them.
   a. Definitely true
   b. Probably true
   c. Probably untrue
   d. Definitely untrue
   e. Don't know
69. Seasonal changes are caused by the:

a. Earth's distance from the Sun.
b. Earth's tilt on the axis.
c. unequal heating of the Earth's atmosphere.
d. spinning of the Earth on it axis.

70. The phases of the Moon are caused by:

a. the Earth's shadow.
b. the Sun's shadow.
c. the Moon's position with regard to the Earth.
d. an eclipsing event.

71. We can see other planets in our solar system without a telescope.

a. Definitely true
b. Probably true
c. Probably untrue
d. Definitely untrue
e. Don't know
72. The Sun is directly overhead at noon here in Ohio.

a. Definitely true
b. Probably true
c. Probably untrue
d. Definitely untrue
e. Don't know

73. The Earth's gravitational attraction is greatly reduced on the tops of mountains.

a. Definitely true
b. Probably true
c. Probably untrue
d. Definitely untrue
e. Don't know

74. Gravity cannot exist without air.

a. Definitely true
b. Probably true
c. Probably untrue
d. Definitely untrue
e. Don't know
75. Our Sun is a star.
   
a. Definitely true  
b. Probably true  
c. Probably untrue  
d. Definitely untrue  
e. Don't know

76. Would you like to obtain more science training? 
   1=yes  2=no  3=maybe

77. In what areas are you certified, or plan to be, at the elementary and secondary level?

Comments here please:
APPENDIX D

APPROVAL AND CORRESPONDENCE
TITLE OF RESEARCH PROPOSAL
EARTH SCIENCE LITERACY OF PRESERVICE AND INSERVICE ELEMENTARY AND SECONDARY SCHOOL TEACHERS

SUBMITTED BY

The Dissertation Committee for David A. Miller
(Name of Candidate)
in formal session on 3/8/89
(Date)

and approved the attached dissertation prospectus.

Approved by

(Candidate)

(Chairperson)

(Committee Member)

(Committee Member)

(Committee Member)
May 8, 1992

Dear Colleague,

I am a Ph.D. Candidate in science education at The Ohio State University in Columbus, Ohio working along with Dr. John F. Disinger of the School of Natural Resources at Ohio State. I am working on my dissertation and I would like to invite you to participate in my study.

Your assistant superintendent has reviewed my dissertation proposal, reviewed the instrument used, and approved the study for use in your school. To make participation in this study as easy as possible, I have included everything necessary in this packet. You should find:

- 1 questionnaire
- 1 postage-paid return envelope

This study focuses on the Earth science literacy of preservice elementary and secondary education student teachers and inservice elementary and secondary teachers. The enclosed questionnaire covers teachers' thoughts about the value of science in the classroom, science course background, and an Earth science knowledge survey.

Please answer the questions honestly. To encourage you to do so, total anonymity is guaranteed. No tracking of the questionnaires will be done.

The average time of completion is twenty minutes. Please finish answering the questionnaires by May 20, 1992 and return them in the enclosed postage-paid envelope.

If you have any questions, please call collect at my home (614) 268-4324.

As with any research study, you are not obligated to take part; you have the option not to participate. If you choose to do so, please return all materials to me in the postage-paid envelope so that I may use them with another teacher.

Thanks so much for your time and understanding.

Sincerely,

David W. Miller
Ph.D. Candidate

[Signature]

[Advisor's Signature]
Research Involving Human Subjects

ACTION OF THE REVIEW COMMITTEE

With regard to the employment of human subjects in the proposed research protocol:

92B0073   EARTH SCIENCE LITERACY OF PRESERVICE AND INSERVICE ELEMENTARY AND SECONDARY SCHOOL TEACHERS, John F. Disinger, David W. Miller, Educational Studies

THE BEHAVIORAL AND SOCIAL SCIENCES REVIEW COMMITTEE HAS TAKEN THE FOLLOWING ACTION:

____ APPROVED   ______ DISAPPROVED

x  APPROVED WITH CONDITIONS*   x  WAIVER OF WRITTEN CONSENT GRANTED

* Conditions stated by the Committee have been met by the Investigator and, therefore, the protocol is APPROVED.

It is the responsibility of the principal investigator to retain a copy of each signed consent form for at least four (4) years beyond the termination of the subject's participation in the proposed activity. Should the principal investigator leave the University, signed consent forms are to be transferred to the Human Subjects Review Committee for the required retention period. This application has been approved for the period of one year. You are reminded that you must promptly report any problems to the Review Committee, and that no procedural changes may be made without prior review and approval. You are also reminded that the identity of the research participants must be kept confidential.

Date: April 3, 1992  Signed: __________________________  (Chairperson)

 HS-025B (Rev. 8/90)
The following summary must accompany your proposal. Be specific about exactly what subjects will experience when they participate in your research, and about the protections that have been included to safeguard them. Careful attention to the following may help facilitate the review process.

1. In a sentence or two, describe the background and purpose of the research.
   It is the intent of this study to describe as well as possible the Earth Science literacy of preservice and inservice elementary and secondary teachers.

2. Briefly describe each condition or manipulation to be included within the study.
   No manipulation will be used. This is simply a survey of knowledge.

3. What measures or observations will be taken in the study? If any questionnaires, tests, or other instruments are used, provide a brief description and either include a copy or indicate when a copy will be submitted for review.
   The Earth Science Literacy Survey is composed of 10 questions concerning past course work, self reported level of success, confidence level, and value level. Twenty-five questions follow which deal with the Earth sciences. Instrument is enclosed for your review.
12 April 92

University of Toledo
Attn: Dr. Charlene Czerniak
Department of Education
2801 West Vancroft
Toledo, Ohio 43606

Dear Dr. Czerniak:

This letter is sent to follow up on our 14 April 92 telephone conversation concerning permission to adapt your "Science Content Background" survey from your 1989 dissertation into my own dissertation. I would like then to ask formal permission to do so. If you have any questions, please do not hesitate to call or write. Thanks in advance for your understanding and cooperation.

Sincerely,

David W. Miller