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# Relationships Between Previous School and Life Experiences of Pre-Service Elementary Teachers and Their Attitudes Toward Science and Science Teaching

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# RELATIONSHIPS BETWEEN PREVIOUS SCHOOL AND LIFE EXPERIENCES OF PRE-SERVICE ELEMENTARY TEACHERS AND THEIR ATTITUDES TOWARD SCIENCE AND SCIENCE TEACHING

by

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# ABSTRACT

This study examined the relationships between previous school and life experiences of pre-service elementary school teachers at the University of North Dakota and their attitudes toward science and science teaching.

The study incorporated both qualitative and quantitative methodologies. The first six pre-service teachers from one of the science methods class who volunteered were selected for taped private interviews. Based on this information gathered from the interviews a quantitative survey (Sampson Survey I) was designed for discovering the relationship between past experiences of pre-service teachers and their current attitudes toward science and teaching science. Additionally, the Shrigley Science Attitude Scale (Shrigley, 1974b), which assesses attitudes toward science, was given to two science methods classes (57 students) enrolled at the University of North Dakota during the fall semester, 1990. The population for the surveys was not randomly selected from all the science methods classes offered at the University of North Dakota; therefore, the results of the research apply only to the one

setting where the research was conducted and may not be transferable to students at other universities.

According to the Sampson Survey, 70% of the pre-service elementary teachers had the confidence to teach the life sciences, 58% to teach ecology, 53% to teach the earth sciences, 46% to teach the space sciences, 28% to teach the physical sciences, and 41% had confidence in their general science knowledge. The most important antecedent for a positive attitude toward science was the memory of how a particular science was taught to the students. The correlations indicate that confidence in the physical sciences (chemistry, physics) is more school-oriented than in the other branches of science, such as life, earth and space sciences, and ecology. Also, science acquired outside of school in an interesting fashion was important because it aroused interest and curiosity in science, especially in the life sciences. In addition, there were significant correlations ($p<.01$) between those with confidence in their general science knowledge and in their ability to teach all sciences, and those who believe anybody can be a scientist. Finally, a significant correlation ($p<.01$) was found between having confidence to teach all sciences and the deliberate practice of reading articles about science to stay informed about advances in science. The study indicated that the qualitative and quantitative data show similar patterns and relationships.

# CHAPTER I

# STATEMENT OF THE PROBLEM

## Introduction and Rationale

The focus of this research is an exploratory study of the antecedents of attitudes toward science of pre-service elementary teachers. The rationale for the study is that understanding how people form attitudes toward science will improve science education and science literacy.

For more than a decade educational and business reports have mentioned the need to strengthen the nation's commitment to science. Many current workers are not prepared to fully understand the scientific and technological world in which they live. For example, the Business-Higher Education Forum (1983) in its comprehensive report, America's Competitive Challenge, stated, "A growing number of American workers have antiquated functional skills and deficient academic skills" (p. 21).

Warnings appear that many public school graduates of today will not be employable in the future because they are not being adequately trained for the increasing number of available scientific and technological jobs. The Business-

Higher Education Forum (1983) noted the critical need for more science education in our technological age: "The gap between the nation's needs and the capabilities of its work force is most evident in the growing shortage of skilled workers--particularly technical personnel, engineers, and scientists" (p. 21-22).

This alarming report also addressed our increasing competitive disadvantage in science compared with foreign countries:

> Special attention must be given to industries targeted by industrial policies of other nations; these include biotechnology, computers, electronic devices, telecommunications, lasers, industrial robots, engineering services, air-craft, space devices, nuclear power, ocean development and high-performance polymeric materials, among many others. (p. 4)

Other recent reports have stated similar concerns about global technological competition. For example, the Task Force on Education for Economic Growth, Education Commission of the States (1983), claimed in Action for Excellence: a Comprehensive Plan to Improve Our Nation's Schools, "We need to prepare the necessary human talent to keep the people in the nation responsive to the very competitive world of international commerce and trade" (p. 48).

Furthermore, complex decisions about issues and governmental policies involving science should be made by a well-educated, rational, and scientifically-literate electorate. Unfortunately many students today do not realize the important role that science will play not only in their own careers, but in their personal lives.

Science, by its nature, is daily in the spotlight. Local, state, national and international issues involving science are constantly evolving; concerns are expressed; possible outcomes are debated; alternative plans are evaluated; and intelligent decisions are demanded by not only the governments, but also the general public. Since governments are and need to be involved in scientific research because of the legal implications, best utilization of national resources, international competition, and the vast amounts of funding required for complex scientific advances, it is imperative to have a well-informed scientifically-literate electorate.

The Twentieth Century Fund, in its 1983 report, Making the Grade, mentioned the growing interrelationships among the government, the economy, the educational system, the general public, and science:

> At the turn of the twentieth century, there was no real need for wide-spread scientific literacy. Today, training in mathematics and science is critical to our economy. Our citizens must be

> educated in science if they are to participate intelligently in political decisions about such controversial issues as radiation, pollution, and nuclear energy. (p. 14)

There have been several concerns expressed about the current state of science education. Walsh and Walsh (1982) mention the declining scores on standardized tests and decreased student enrollment in high school science. They point out, "Few students take the demanding science and math courses that are necessary for technical studies in college and careers in science" (p. 13).

Research indicates that most students do not plan on science-related careers. Jacobson and Doran (1986) in a survey of 2000 ninth-graders found that in spite of our technological society only 30% thought it was important to know science in order to get a good job while 46% disagreed, and only 2% considered becoming a science teacher.

Roy (1985) notes the need for elementary science education:

> If young students aren't given a strong foundation in the fundamentals of science, if they aren't taught how to approach science, it becomes pretty much a matter of chance whether they later will be able to move successfully into advanced science and mathematics curriculums. No matter how many computers we put in classrooms, no matter how many

state-of-the-art high school chemistry laboratories we equip, students won't use them properly or to full capacity if the basic skills and methods aren't already part of their lives. The best way to achieve that is to introduce and teach those skills at the elementary school level. (p. 39)

The problem may be aggravated by the lack of teachers who are adequately prepared to teach science and higher-level thinking skills. The Business-Higher Education Forum (1983) analysis claimed, "A growing body of evidence indicates that many American workers lack fundamental skills in mathematics, science, critical thinking and verbal expression--primarily because of a shortage of well-trained faculty in the nation's public schools" (p. 22).

The widespread and noticeable lack of interest in teaching elementary science is prominently revealed by the statistics compiled in 1983 by the Task Force on Education for Economic Growth, Education Commission of the States. This commission is a nonprofit, nationwide interstate compact formed in 1966, whose purpose is to assist governors, state legislators, state education officials and others develop policies for improving the quality of education at all levels. The Task Force noted that only one hour of science and less than four hours of arithmetic are taught during the elementary school week consisting of 25 instructional hours.

The Task Force also mentioned that 51% of elementary school teachers reported having no undergraduate training in science. In fact, they claimed that half of the mathematics and science teachers newly-employed in 1981 "were uncertified to teach these subjects" (p. 25). Furthermore, the Task Force noted that "only one hour of science [per week] is taught in many [elementary] schools across the nation" (p. 28). With many elementary teachers insufficiently prepared for science teaching and displaying a lack of interest in teaching science, an important question arises, "Is the next generation of elementary teachers qualified, capable and confident enough to be able to and want to teach the elementary science that is necessary to educate the succeeding groups of young students to become scientifically literate in our technological world?"

Among the specific recommendations suggested in 1983 by the Task Force on Education for Economic Growth, Education Commission of the States, were: "Students should be introduced earlier to such critical subjects as science and should spend more time exploring them" (p. 38), and "New skills are needed for a new age [of technological change and global competition]. Students will need more than minimum competence in reading, writing, mathematics, science, reasoning, the use of computers, and other areas" (p. 28). In addition, "States must establish higher standards to ensure that only individuals who are competent and well-qualified are licensed to teach and manage the schools" (p. 39).

The National Science Board Commission on Precollege Education in Mathematics, Science and Technology in 1983 suggested mandating science requirements for elementary teachers. The plan said, "Elementary mathematics and science teachers should have a strong liberal arts background, college training in mathematics and the biological and physical sciences, a limited number of effective education courses, and practice teaching under a qualified teacher" (p. ix).

In its 1983 report, the Twentieth Century Fund, an independent research foundation which studies economic, political, and social institutions and issues, recommended as a general solution that "The federal government emphasize programs to develop basic scientific literacy among all citizens and to provide advanced training in science and mathematics for secondary school students" (p. 14).

Boyer (1983) in his report, High School, a Report on Secondary Education in America, defined scientific literacy as "having a substantial knowledge of scientific facts and processes, and understanding more about the interdependent world in which we live" (p. 107). However, Boyer indicated the country's failure in producing scientifically literate graduates by quoting a 1980 Carnegie Foundation analysis that showed 75 percent of public high school seniors reported taking only two years or less of science.

To remedy the situation, the 1983 report from the National Science Board Commission recommended, "All secondary students should be required to take at least three years of science and technology, including one semester of computer science, prior to high school graduation" (p. 40).

However, it is a necessity in this technological age to create a society that is not only scientifically informed and functional, but also one that is scientifically creative and productive. Consequently the 1983 report by the Twentieth Century Fund offered the following challenge to the education system:

> The schools must go beyond the teaching of basic science to give adequate training in advanced science and mathematics to a large enough number of students to ensure that there are ample numbers capable of filling the increasing number of jobs demanding these skills (p. 14).

The action plan, Educating Americans for the 21st Century (1983), prepared by the National Science Board Commission on Precollege Education in Mathematics, Science and Technology, substantiated the country's lack of commitment to teach more science better to more students by noting that most Japanese pupils score significantly higher in science than their American counterparts beginning in first grade. The reason given was an insufficient number of science courses taken: "A typical Japanese secondary school graduate will spend three times the number of hours in science than even those U.S. students who elect four years of science in high school" (p. 20).

Many of the foregoing assessments generally emphasize additional science courses and programs for students from elementary through high school for improving scientific literacy. However, the question of how much science should be required for graduation remains. Hazen and Trefil (1991) feel that creating a scientifically-literate population does not require or mean forcing extensive scientific knowledge on every student. They believe that not everyone has the desire nor the ability to become a professional scientist in every realm of science, but presently only 7% can be considered scientifically literate, possessing the knowledge needed "to understand public [scientific] issues" (p. 11). They caution, "Scientific literacy does not refer to detailed, specialized knowledge--the sort of things an expert would know" (p. 11), but means being capable of understanding "the news of the day as it relates to science" (p. 11) and placing it in a meaningful context. To function as a scientifically-literate citizen, they believe that it is necessary for an individual to understand the major concepts in all of the sciences. By understanding the general laws of nature which operate our world and universe our daily lives are enriched.

There is also a need to develop positive attitudes toward science. Koballa and Crawley (1985) believe that completing more science courses may not necessarily change negative attitudes toward science into positive ones. Indeed, taking additional science classes may actually reinforce negative attitudes if confidence, understanding and success are not achieved. Frequently science classes are not taught effectively and meaningfully (Jacobson & Doran, 1986; Lazarowitz, Baird, & Allman, 1985; Watts & Ebbutt, 1988; Yager & Penick, 1986). Science instruction should incorporate scientific processes and higher level thinking skills (Zeitler, 1984) since being scientific is a way of thinking about the world in relationship to the rational, consistent and meaningful laws in nature.

Mittlefehldt (1985) says that the current attitudes of elementary teachers toward science may play a significant role in the development of the life-long attitudes of their students toward science. If an elementary student develops negative attitudes toward science, innate childhood curiosity about the world may be stifled, an interest in science may never be created, and confidence in science may never be achieved simply by taking additional high school or college science classes. This is especially true if later science courses are not conducive to improving negative attitudes. Elementary teachers who possess negative attitudes towards science may avoid teaching much science in the classroom. Hence, their students do not receive the basic knowledge about science that they should for building on in later grades.

Schibeci (1983) quotes from the 1979 National Assessment of Education Progress: "The measurement of both attitudes toward science and experiences in science is important because these attitudes and experiences influence students' decisions and action" (Schibeci, p. 597). Schibeci concludes that by assessing the current attitudes of a group of pre-service teachers toward science and determining the causes of their attitudes, their future behavior in science teaching may be predicted.

It is necessary in studying the current attitudes of pre-service elementary teachers toward science to determine which factors or antecedents may have influenced their interest in science and their confidence in teaching science in hopes that such factors can be improved for future elementary teachers.

If the current crop of elementary teachers cannot transmit positive attitudes toward science because of their own negative experiences, the cycle will continue, and another generation of elementary teachers will arise who may also convey negative attitudes toward science to their students. It has been shown that our society and national priorities cannot afford any delay in producing scientifically-literate graduates with positive attitudes toward science.

## Purpose of the Study

In view of the important role elementary school teachers may play in the formation of their students' attitudes toward science, the purpose of this study was to investigate the relationships between previous school and life experiences of pre-service elementary teachers at the University of North Dakota and their current attitudes towards science and science teaching.

The results of this study may assist the administration and science educators in the Center for Teaching and Learning at the University of North Dakota, and other teacher educators elsewhere, in their selection of science prerequisites for entry into the undergraduate elementary teacher education program and in their future planning for the needs and objectives of the science education classes. The results may aid educators in deciding the best methods for teaching science to elementary teachers. Also, it is hoped that the information obtained from this study will help other professional educators to understand which past experiences of pre-service elementary teachers may cause anxiety toward science and concerns about teaching elementary science in the future.

## Procedures

The population for the survey of the study was the 57 undergraduate students enrolled in the two elementary education science methods classes during the fall, 1990, when the survey was administered. The six undergraduate students who participated in the qualitative interviews were the first six volunteers from one of the two classes.

Although the 57 undergraduate students came mostly from North Dakota and Minnesota and were predominantly female with a few male students, it was hoped that they represent a cross-section of backgrounds and experiences of students from the Upper-Midwest. Some students may have their roots on isolated farms or have come from very small rural communities of fewer than 500 people while other students may have been educated in larger cities, including Bismarck, Grand Forks, Fargo, and even Minneapolis. Also, some of those 57 students may have received their education in the public school system while others may have attended private or parochial schools.

This group of undergraduate elementary teacher education students was required to have taken twelve college semester hours of mathematics, science and technology, which had to include four hours of laboratory science, as a prerequisite for admittance into the elementary teacher education program at the University of North Dakota. However, their prior science experiences in college vary. Some elementary education students began as majors in science before switching to the teacher education program, while others took only simple introductory science courses in college outside the College of Education. Consequently, it is possible to have fulfilled the requirements by taking courses in geography, philosophy and sociology, which involve symbolic logic and sociological statistics. This diverse educational background extends back into their elementary/junior high/high school experiences. Some students, according to the interviews, had many elementary/junior high/high school science classes and numerous opportunities in the biological, physical, geological and space sciences while others had only scant school science backgrounds. Obviously, their previous life experiences outside of school varied just as well.

The first six volunteers from one of the two undergraduate elementary teacher education science methods classes at the University of North Dakota were selected for the interviews, which were conducted in the beginning of the semester. The students were interviewed within the first two weeks of classes before they were familiar with the teaching methods employed in the science education class.

Therefore, it probably can be assumed that the students had not yet comprehended the purpose of the course in science methods nor had they been swayed by the teacher's positive attitude toward science because the class meetings prior to completion of the interviews dealt mostly with class procedures, such as course assignments, class requirements, grading system, and seating arrangements. It was hoped that the past attitudes of the students toward science along with their past experiences in science still dominated their thinking and would be reflected in their interviews. Students already interviewed by the researcher were requested not to disclose the nature of their interviews to other students who were to be interviewed. Thus, the responses to the interviews are assumed to be spontaneous and independent.

The six interviews were conducted individually for about one-and-a half hours each in a format of open-ended questions about the student's life and school experiences in science, past and present concerns about science, interests in science, and attitudes toward science and science education. (The open-ended probes for the interviews are included in Appendix A.) The interviews were taped, transcribed, and coded into categories based upon the reoccurrence of themes from the responses, replies and comments. From the categories obtained using this qualitative research interview procedure, a quantitative

Likert survey (Sampson Survey I) with 44 questions dealing with typical concerns about science, past experiences in science, and current attitudes toward science and science education was prepared. Two additional questions on the survey required a written response from the students. Those two questions, which required students' self-assessment of their current attitudes toward science and self-analysis of the causes of those attitudes, were:

45. "In general, the way I feel about science is ...."
46. "I think I feel as I do about science because...."

This questionnaire was given to the pre-service teachers, who had been attending elementary science education methods classes for two months. There were 57 students present when the survey was administered.

The internal reliability of the survey was checked, and the quantitative results from the survey were analyzed. The percentages, means and standard deviations of responses for each question in the survey were calculated. In addition, in order to determine confidence and attitudes toward science, the Pearson Correlations of seven specific attitudinal questions (chosen from the 44 questions) with the other questions in the survey were determined in an exploratory analysis. Those seven attitudinal items were:

1. (Q 21) "I have confidence about my general science knowledge."
2. (Q 23) "I feel I want to learn more science."

3. (Q 40) "It will be easy for me to teach life sciences (biology) in the elementary school."

4. (Q 41) "It will be easy for me to teach physical sciences (physics, chemistry) in the elementary school."

5. (Q 42) "It will be easy for me to teach earth sciences (geology) in the elementary school."

6. (Q 43) "It will be easy for me to teach space sciences (astronomy) in the elementary school."

7. (Q 44) "It will be easy for me to teach ecology in the elementary school."

A second instrument, the quantitative Shrigley Science Attitude Scale consisting of 20 questions, was given at the same time to the 57 students. This Likert survey was developed by Shrigley (1974b) for determining attitudes of university students toward science and science teaching. It is divided into four categories: attitudes toward science content, attitudes toward handling science equipment, attitudes toward science teaching, and antipathy toward science teaching. The percentages, means and standard deviations of responses to those 20 attitudinal questions were calculated. Then the alpha for each of the four categories was determined.

## Definition of Terms

Active inquiry science. Active inquiry science means investigation into or exploration of both objects and ideas. It is active learning through manipulation of materials (McNairy, 1985). The terms, "hands-on", discovery science, investigative science, or exploratory science, are often applied to active inquiry.

Antecedents of attitudes. An antecedent of an attitude is a particular preceding or prior factor influencing a specific emotional reaction. Antecedents of attitudes are "conditional elements or characteristics of previous events, or situations which affect a person's subsequent feelings" (Wareing, 1990, p. 373). Beliefs are "determinants or antecedents of attitudes" (Wareing, 1990, p. 373).

Attitudes. An attitude is a spontaneous feeling or emotional response toward something, which is caused by previously related experiences. Attitudes are the "learned predispositions to respond or behave in certain ways" (Wareing, 1990, p.374). Therefore, attitudes, assessed by self-reporting methods, "will allow the person's behavior to be predicted" and explained by social psychologists (Schibeci, 1983, p. 596). Attitudes "are difficult to distinguish from such affective attributes of personality as interests, appreciation, likes, dislikes, opinions, values, ideals, and character traits" (Haney, 1964, p. 33). Attitudes toward science are associated with science education and laboratory work (Schibeci, 1983). They are "tendencies or inclinations to respond fairly consistently, in an unfavorable or favorable manner to a given object, namely, science" (Wareing, 1990, p. 373). Individuals develop emotional responses to science, based on their past experiences with science (Hasan & Billeh, 1975). Because attitudes are a reflection of a person's basic beliefs about science, "they help others predict the kinds of science related behaviors we are likely to engage in more accurately than almost anything else we can tell them" (Koballa & Crawley, 1985, p. 226).

CTL. CTL is the Center for Teaching and Learning (College of Education) at the University of North Dakota.

In-service teachers. In-service teachers are those teachers already in the teaching profession.

Pre-service teachers. Pre-service teachers are education majors still in college training.

Science content courses. Science content courses are those science classes that stress science information. Examples are courses generally called: anatomy, astronomy, biology, chemistry, ecology, entomology, geography, geology, physics, physiology, and zoology.

Science methods courses. Science methods classes are those classes which convey the effective methods of teaching science in the classroom.

Scientific attitudes. Scientific attitudes are the procedures and mental processes used by scientists while conducting an objective scientific investigation. Scientific attitudes have a primarily cognitive orientation (Wareing, 1990), which includes objectivity, critical and analytical thinking, curiosity, honesty and open-mindedness

(Schibeci, 1983), and "may be aptly labeled scientific attributes (e.g., suspended judgment and critical thinking)" (Koballa & Crawley, 1985, p. 223). Scientific attitudes are characteristics of scientists at work so they are considered to be an objective of the science curriculum. (Krynowsky, 1988)

Scientific literacy. Scientific literacy does not mean the retention of extensive scientific knowledge or a multitude of specific facts about a particular science. Instead it involves understanding and appreciating scientific processes and the general laws of nature, which govern and enrich our daily lives. Scientific literacy is the ability "to demonstrate long-term recall of scientific skills and principles, the ability to apply previous scientific training toward understanding current issues, and the ability to use scientific principles in arriving at responsible and supportable opinions on scientific issues" (Pestel, 1988, p. 26).

Scientific processes. The scientific method uses science process skills. These processes of inquiry, such as observation, classification, measurement, computation, experimentation, and prediction, are basic to all scientific disciplines (McNairy, 1985). Process skills are sometimes referred to as inquiry skills, such as using number relationships, classification, using space/time relationships, observing, inferring, measuring, communicating, and predicting (Riley, 1979).

UND. UND refers to the University of North Dakota.

## Limitations

The population for the six interviews consisted of the first six students from one of the two classes enrolled in the elementary science education methods classes who volunteered for the interviews.

The population for the two surveys was not randomly selected. Instead, all 57 students enrolled in the two undergraduate elementary science education methods classes offered during the fall semester at the University of North Dakota, and who were present at the time the surveys were administered, were asked to respond to the two questionnaires. The results of the research apply only to the one setting where the research was conducted, and may not be transferable to other students at other universities.

# CHAPTER II

# A REVIEW OF RELATED LITERATURE

## Introduction

A review of the literature related to the attitudes of pre-service elementary teachers toward science is complex. In the present study it includes the importance of attitudes toward science for elementary teachers and students, the importance of elementary science according to teachers and students, reasons for many elementary teachers' avoidance of teaching science or a particular science, the factors involved in the formation of pre-service teachers' attitudes toward science, and attempts at designing courses for pre-service elementary teachers to cultivate positive attitudes toward science.

When studying the formation of pre-service elementary teachers' attitudes toward science, it is necessary to research and review the literature about not only pre-service teachers' attitudes toward science, but also in-service elementary teachers' attitudes. Attitudinal information about science and science teaching gathered about in-service elementary teachers reflects the current attitudes and beliefs about science and future attitudes about science teaching that pre-service teachers also possess (Cunningham & Blankenship, 1979; Gerlovich, Downs, & Magrane, 1981; Manning, Esler, & Baird, 1982; Westerback, 1984). One reason for this is that the prior elementary/junior high/high school/college educational experiences may have been similar for the two groups and contributed to their present attitudes and behaviors (Begley, 1990; Manning et al., 1982; National Opinion Poll, 1990). Also, while student teaching, future teachers may become aware of the attitudes of in-service teachers in the classroom and may model those attitudes when they themselves teach. After all, student teaching is supposed to be a learning experience for the pre-service teacher, an experience which at the present time appears to include a lack of commitment to elementary science education (Manning et al., 1982; Mittlefehldt, 1985; National Opinion Poll, 1990).

In summary, the attitudes of in-service elementary teachers toward science may not only be a reflection of the present and future attitudes of pre-service elementary teachers, but also may be unconsciously transmitted to fledgling teachers during their student teaching experiences.

Because the research literature (Gabel & Rubba, 1979; Lucas & Dooley, 1982; Riley, 1979; Shrigley, 1978; Shrigley, 1983; Westerback, 1984) seems to indicate that designing courses to change pre-service elementary teachers' negative attitudes toward science have not been very successful, the prevention of negative attitudes toward science is probably the most effective way of insuring positive attitudes of elementary teachers toward science and science teaching. It is necessary to review the reasons suggested why many elementary teachers avoid science. Also, it is important to investigate the antecedents that have contributed to the formation of their attitudes toward science and the present factors that influence their current attitudes toward science.

## The Importance of Attitudes toward Science for Elementary Teachers and Students

Research indicates (Hasan & Billeh, 1975; Koballa & Crawley, 1985; Schibeci, 1983) that it is very important for elementary teachers to possess and be able to transfer positive attitudes toward science. A teacher's attitude toward science influences his/her classroom behavior toward science, which is sometimes referred to as "attitudinal behavior".

It is important for teachers to consciously promote positive attitudes about science in young children. Mittlefehldt (1985) warns, "The attitudes we form on the elementary level directly affect science achievement at the secondary level and beyond" (p. 67). In fact, research indicates that the attitudes of even elementary-age students about science may affect their cognitive ability in science (Plimmer, 1981).

Attitudinal behavior is "the ability of attitudinal characteristics to influence behavioral outcomes" (Wareing, 1990, p. 371). Koballa and Crawley (1985) suggest several purposes for attitudinal research in science. One is, "A person's attitude toward science conveniently summarizes his or her emotional response to basic beliefs about science" (p. 226). Another reason for attitudinal research in science is that attitudes toward science affect learning, career choices, and abilities to deal with technological changes. The authors note that people's attitudes are thought to "fulfill basic psychological needs, such as the need to know and the need to succeed" (p. 224). According to the authors, attitudes toward science effect behaviors about science, such as "purchasing science magazines, attending a science fair or museum, signing a petition to ban certain science books from use in public schools, and watching NOVA on television. Behavior, like beliefs, may also have positive, negative, or no evaluative implications for the study of science" (p. 223-224).

Because attitudes are often formed or altered in the elementary grades, negative attitudes toward science can be unknowingly conveyed to young children by their elementary teachers. The elementary teacher's lack of interest and confidence in science may be transmitted non-verbally in the elementary classroom in many ways (Begley, Springen, Hager, Barrett & Joseph, 1990):

1. By deliberately not spending much class time on science.
2. By not developing and conducting an appealing and complete science curriculum.
3. By avoiding the handling of science equipment.
4. By not permitting active hands-on science exploration.
5. By not promoting innovative and creative thinking through additional classroom science projects.
6. By not encouraging and replying to questions from students about all science topics.
7. By not initiating class discussions about the unexpected results from science activities.
8. By not focusing on the understanding of science concepts rather than the memorization of unnecessary facts.
9. By not displaying extensive general science knowledge, insatiable curiosity, or positive attitudinal behaviors toward science.
10. By relying solely on information and activities suggested in a textbook.
11. By not seeking answers to questions for which the answers are not known or understood.
12. By not consciously relating science to the personal lives of students.
13. By not encouraging discoveries and initiatives in science by students outside of school.
14. By not enthusiastically presenting new knowledge about the continuous advances in all of the sciences.

Koballa and Crawley (1985) believe that negative attitudes toward science may have complex origins. For example, negative attitudes toward science may serve as a defense mechanism for the ego because of feelings of low self-worth, resulting from low achievement. The authors note that students may even pretend to change attitudes in order to impress the teacher and get a good grade. In addition, attitudes toward science may be affected by social interactions or peer groups, parental attitudes and beliefs, personal involvement outside the classroom, personal interests, community and school support, necessity, the culture, images of scientists in society, technological and medical advances, and environmental concerns.

Achievement in science is more school dependent than other subjects (Zuzovsky & Tamir, 1989). The classroom environment and teachers' attitudes are significant factors in the formation of students' attitudes toward science (Haladyna, Olsen, & Shaughnessy, 1982, 1983; Talton & Simpson, 1986). A teacher's negative attitude may be directed to all sciences (Holden, 1987; Manning et al., 1982; National Opinion Poll, 1990; Shrigley & Johnson, 1974), or a particular science or science topic (Baird, Lazarowitz & Allman, 1984; Schibeci, 1983; Tamir, 1988; Wandersee, 1986). Science taught in the elementary grades should provide a foundation on which to build additional knowledge in later grades. However, some science topics are deliberately avoided by teachers in elementary school (Begley, 1990; Glasgow, 1983).

## The Importance of Science According to Teachers and Students

For at least a decade national attention has been focused on the disinterest in teaching science in the elementary school as compared to other subjects (Cunningham & Blankenship, 1979; Manning et al, 1982; National Opinion Poll, 1990). Some elementary teachers do not show an interest in science education.

In a 1990 National Opinion Poll, prepared by Instructor magazine, elementary teachers display their lack of interest in science by the scant amount of science teaching time, which reflects, in a sense, the value that the teacher places on the subject. The poll found that less time was spent teaching elementary science than math and reading, and the average time spent on science in the elementary classroom was 45 minutes per lesson for one to five days per week. Math, on the other hand, was taught daily on an average of 54 minutes per lesson, and reading was taught daily for an average of 95 minutes per lesson. The average length of homework assignments per week was 44 minutes for science while for math the average was 71 minutes and for reading 68 minutes.

Manning et al. (1982) found only four percent of elementary teachers preferred teaching science to teaching reading, math, social studies, or language arts. This survey may indicate a lack of interest in science by elementary teachers or their lack of confidence about teaching the subject competently. Nearly 25 percent of the elementary teachers responding to the 1982 survey claimed that they did not teach science, and more than 75 percent spent only two hours or less per week on science. It is reported that over half of the elementary teachers rank science as fourth or fifth out of five subjects in importance (Gerlovich et al, 1981; Manning et al., 1982; Westerback, 1984).

The lack of importance placed on science teaching was reflected in a study of 96 pre-service elementary teachers by Cunningham and Blankenship (1979). They found that the concern for self as a teacher and the concern for self as a reading teacher were equal and/or higher than the levels of concern for self as a science teacher.

There appears to be a difference between teachers and students in their interest in science. According to Jaus (1981), more intermediate-grade students than teachers express an interest in learning science and hearing about science careers. He reports in his poll of 5,152 students and 224 teachers in kindergarten through sixth grades in Indiana that none of the primary teachers or students indicates an interest in science or science-related careers. However, 27% of the intermediate-grade students want more science, with girls showing an equal interest to boys, while only two of their 128 teachers indicate an interest in science. In the survey no intermediate-level teacher suggests learning about careers in science while 30% of the students express such a desire.

In a survey of 2,000 ninth grade students by Jacobson and Doran (1986), although 30% believe science to be necessary for a successful career, 72% want to learn more about the world we live in, and 50% feel working in a science laboratory would be an interesting way to earn a living. While 74% believe all students could learn science if taught properly, only 49% feel science at school is taught interestingly. In addition, many students believe that there may be a need to study science. For example, 86% consider science to be related to a country's development; 80% think scientific discoveries aid the standard of living; 74% disagree that science has ruined our environment, and 55% want the government to allocate money for scientific research. However, only 30% consider public money to have been spent wisely on science in the past.

One excuse for not teaching science in the elementary classroom may be a reflection of the public's concerns about science, according to Plimmer (1981). He feels that science continually receives criticism for the problems created by a modern society, sometimes without justification, such as depicting scientists in cartoons and movies as lunatics deliberately trying to destroy the world. Some people do not focus as much attention on the positive contributions of science, such as the relief of pain and suffering, the increase in leisure time, the ease of communications, and the advancement of knowledge. Plimmer says, "There is a tendency to blame science for all the ills of a technological society without giving any emphasis to benefits deriving from science" (p. 644). Plimmer mentions some specific public concerns that have damaged the image of science and have been emphasized by the media, such as nuclear emissions, pollution, depletion of natural resources, and safety of drugs.

## Background Knowledge as a Factor in Attitudes toward Elementary Science Teaching

There are many reasons suggested and excuses given for many elementary teachers avoiding or spending a minimal amount of time teaching science, but the main concern of teachers appears to be their inadequate science background, knowledge, education and confidence (Horn & James, 1981; Hove, 1970; Mittlefehldt, 1985; National Opinion Poll, 1990; Plimmer, 1981; Weiss, 1977).

Over twenty-one years ago, Hove (1970) offered three reasons for avoiding science: (1) inadequate teacher background in science, (2) inadequate science equipment, and (3) inadequate time and space for science. More recently, Mittlefehldt (1985) suggests five similar reasons why science teaching has not offered effective and cognitive stimulation in the elementary classroom. He cites inadequate teacher education, lack of equipment, under-utilization of community resources, over-reliance on textbooks, and time constraints.

Plimmer (1981) believes that some prior knowledge or understanding of science is one prerequisite to being able to teach science successfully even in the primary grades. He noticed that elementary teachers were "asked [by science curriculum developers] to use skills and apply knowledge of which they had no basic understanding themselves" (p. 641).

Unfortunately, the confidence of elementary teachers in their ability to teach science may not have changed much for more than a decade. In a national survey, Weiss (1977) found only 22% of the K-6 teachers believed they were well-qualified to teach science, while 63% of those teachers felt well-qualified to teach reading. A survey of K-6 Kansas teachers, conducted by Horn and James (1981), revealed that only 9% felt qualified to assist colleagues in teaching science.

More recently, in the 1990 National Opinion Poll on Science Teaching by <u>Instructor</u>, many elementary teachers indicated they still did not feel as well-prepared to teach the sciences as they did to teach math, social studies and reading. The percentages of elementary teachers in the poll who felt very well-prepared to teach the following subjects were: life sciences, 33%; physical sciences, 20%; earth/space sciences, 25%; math, 51%; social studies, 46%; and reading 71%. Percentages of those who conceded that they were really unqualified to teach those subjects were: life sciences, 16%; physical sciences, 28%; earth/space sciences, 24%; math, 6%; social studies, 10%; and reading, 5%.

Many teachers escape sufficient training in teaching science because the requirements for elementary teacher certification in science differ widely from state to state. Recent data proved difficult to find, but in 1982, Mechling, Stedman, and Donnellan received 46 replies to a questionnaire sent to 50 states and the District of Columbia, which shows the preparation of teachers who are currently teaching. In 1982 all Southeastern states and 10 of 14 Western states required some kind of science for elementary certification, but the science requirements that existed were often vague and inadequate. For example, in 1982, only seven states required a course in biology or physical science for elementary teachers, while no state demanded earth science. Also, only one-fourth of the states required a science methods course. In addition, as a consequence of the fact that 18 states certified elementary teachers through the eighth grade in 1982, it is possible that some teachers, who are not trained in science, may actually be teaching junior high science courses.

Because some states do not require an adequate amount of science preparation, many teachers are simply unprepared to teach even elementary school science. Frequently elementary teachers expose their lack of commitment to science as well as their insecurity in teaching science by the number of hours of science elected in college. In a survey of elementary school teachers in central Florida it was reported that 12 percent of the responding teachers admitted taking no college-level science content courses, 20 percent confessed never having had any science methods course, and 65 percent never attended any in-service science teaching program. The results showed that 12 percent of those teachers surveyed did not have any preparation to teach elementary science (Manning et al., 1982).

Frequently the feelings regarding science insecurity may be traced back to the insufficient or frustrating junior high/high school science preparation of pre-service and in-service elementary teachers. Research shows that pre-service teachers have more positive attitudes toward science if they have taken four or more junior high/high school science classes. Of course, those high school students who already have positive attitudes toward science are more likely to take additional science classes (Shrigley, 1974b).

Begley, in the Newsweek Special Issue on Education (1990), mentioned the lack of science experiences for many high school students:

> Only 7% of 17-year-old high school students have the advanced science skills they need to perform well in college-level courses. Most 11th graders have used a microscope, but just 46% have used a barometer and 33% have operated a meter for electricity. Although 90% of high school students take biology by graduation, only 20% take even one year of physics. Only 59% of 11th graders have taken a science course that requires them to write up the results of experiments; a mere 20% have ever gone on science field trips. (p. 28)

Fear and lack of confidence in science due to teachers' own insufficient knowledge about science and inadequate experiences with science equipment may contribute to negative attitudes about teaching science among future undergraduate elementary education majors even before entering college.

## Sex, Age, Education, and Outside Support as Factors in Influencing Attitudes of Pre-service Elementary Teachers toward the Sciences

In addition to insufficient background knowledge, there are several other factors which influence the attitudes of pre-service elementary teachers toward the sciences. One factor is the teacher's sex, which the research literature shows has an effect on preference for science (Akpan, 1986; Holden, 1987; Plimmer, 1981; Schibeci, 1983; Shrigley & Johnson, 1974; Tamir, 1988), or a particular science (Baird et al., 1984; Schibeci, 1983; Tamir, 1988; Wandersee, 1986). Other factors include the teacher's age in conjunction with the amount of science taken, and the type of educational institution the teacher attended (Schwirian, 1969). Also, when student teaching, pre-service teachers become aware of the amount of school and community support for science, which may influence their attitudes.

Traditionally most elementary teachers have been female. Thus, differences in achievement, interests and attitudes about all the sciences and toward particular topics in science between the sexes have been investigated. Elementary teachers will probably teach and certainly stress what is interesting and important to them. Pre-service teachers will not only eventually carry their learned prejudices into their classroom, but probably reflect similar attitudes as current in-service teachers.

There appears to be in the literature a difference between the sexes in their attitudes toward the sciences and particular topics in science. In both single-sex schools and mixed schools, males are attracted to science more than females (Plimmer, 1981).

During their research, Shrigley and Johnson (1974) found that male in-service elementary teachers had significantly more positive attitudes toward science than female elementary teachers. Since most elementary student teaching is done under female teachers because many more women than men teach elementary school, this is an important point.

Achievement, a reflection of ability, motivation, interest and appropriate opportunities, also seems to differ between the two genders. Holden (1987) cites several research articles which indicate males do better than females on standardized achievement tests in math and science, although females apparently are overall better students from kindergarten through graduate school and do better on course-related exams than on standardized tests.

An investigation of 2,153 Israeli 12th grade students shows that more boys than girls perceive themselves as high achievers in science and math, prefer math and science more than other subjects, aspire for college science courses, plan on more engineering and science research careers, have more positive attitudes toward science, and have a better understanding of the nature of science. Girls express more positive general attitudes toward school and homework, but are less interested in studying science (Tamir, 1988). Other studies point to similar findings in science. In a Nigerian study boys were more likely to study science than girls although attitudes and intelligence were more often predictors (Akpan, 1986).

There is also a difference between the sexes in achievement level in particular sciences. Boys achieved better in physics and the earth sciences than girls, according to Tamir (1988), though he notes that the achievement level of girls in biology and chemistry was similar to boys, and girls were more likely to be interested in medical careers.

A preference for a specific subject is an indication of personal interest. The sex of a student appears to influence his/her preference for a particular science or science topic. Schibeci (1983) finds that boys not only generally possess more favorable attitudes toward science than girls, but among those favoring science a larger fraction of the boys as compared with the girls prefer the physical sciences to the biological sciences.

These gender differences in preference for a particular science were confirmed in a study of 1855 junior and senior high school students in Utah. Girls preferred zoology, health and botany, while more boys than girls preferred astronomy, chemistry and physics (Baird et al., 1984).

Similar gender-related preferences within science were revealed in another research project. It was found in an investigation of 136 students, equally divided between boys and girls, that most junior high school students, especially girls, prefer to study biological topics. Also, most students, but especially girls, show more interest in the study of animals than in the study of plants. Interviews indicate that students relate animals more directly with their own experiences, such as eating, moving, seeing, feeling and learning. However, it is suggested by the researchers that the interests of students in science should be intentionally broadened by educators as students progress through the educational system in order to alleviate gender biases in science (Wandersee, 1986).

From the foregoing studies it appears that girls prefer the life sciences while more boys prefer the physical sciences. Gender-related preferences for particular topics in science probably are reflected in which types of science are currently being presented by in-service teachers and which will be taught in the future by present pre-service teachers in most elementary classrooms, where female teachers dominate. If only particular science topics are introduced with enthusiasm and confidence into the elementary curriculum, negative attitudes toward other sciences may be conveyed to young students by their teachers. The selection of science topics taught may affect student attitudes, especially the attitudes of female students, who unknowingly may imitate their female teachers. Thus, it is possible that attitudes toward certain sciences unintentionally learned from elementary teachers may subconsciously be carried by students into the higher grades.

These findings may change in the future as girls become aware of the opportunities for women in science and science teaching. Females may see a need for science education and cultivate interests in all sciences.

Gender-related preferences toward particular topics are important since elementary teachers largely follow their own preferences in the science topics taught, a contention supported by research (Glasgow, 1983). Most school districts attempt to have a logical sequence of concepts and topics taught in their science curriculum determined by the science textbook series that the school or local school curriculum committee adopts. However, often the "ideal curriculum" is not being taught in the classroom, according to a 1983 report of elementary school classrooms in Arkansas by Glasgow. Because some teachers do not follow the curriculum guide, many students never study some topics, while other subjects are repeated in every grade level. In fact, Glasgow reports:

> It was extremely rare for 80% of the teachers at a given grade level to teach a concept that the scope and sequence chart identified as belonging to their level. Sometimes the percentage was as low as 10%. Teachers in the upper grades were more likely to cover the concepts at the prescribed level. (p.57)

As might be expected, Glasgow finds that life sciences were taught most frequently, followed by earth science; the physical sciences were a distant third. Because of the small amount of time spent on science instruction in the elementary school, it is not surprising that a large percentage of concepts and topics in science that are expected to be taught are admittedly not being taught. Consequently many essential topics and concepts in elementary science are being omitted, which may be a contributing factor toward science attitudes in the later grades. Then unfamiliar science topics may be intimidating, not selected, and consequently never learned. Furthermore, the next generation of elementary teachers may continue to reflect these preferences because of their own incomplete science education and experiences.

There are other characteristics of a teacher, besides inadequate scientific knowledge and gender differences, which appear to contribute to a teacher's attitude about science. Statistical research has yielded information about the characteristics and experiences of elementary teachers with positive attitudes toward science. As suggested previously, not only do the findings about attitudes of in-service teachers reflect attitudes of current pre-service teachers as well, but also the attitudes of in-service teachers are being exposed during student teaching, and modeled.

Research by Schwirian (1969) shows that some factors, such as the teacher's age and type of educational institution attended, appear to be related to the formation of positive attitudes toward science among elementary teachers. For example, the teachers most likely to have positive attitudes toward science were those under 40 who have graduated from a state institution. By administering a 60-item Science Support Scale to over 200 elementary teachers in a midwest city, Schwirian found that teachers under forty were more likely to be flexible, adaptable, and open-minded to suggestions and change after taking any number of science courses. Younger teachers also expressed more positive attitudes toward science. It appears that teachers over forty years old must have experienced over 10 hours of science courses in order to have achieved positive attitudes toward science. Also, it appears that teachers who graduated from state schools have more positive attitudes about science than those who came from private, liberal arts institutions. Schwirian notes that this may be attributed to the fact that state institutions, which generally are larger, have more course selections and more stringent requirements. Negative attitudes attributed to age can be modified by the type of institution attended and the number of hours taken in college science courses, according to Schwirian. Differences in religious preference, even after controlling for the age variable, do not appear to be significantly correlated with attitudes toward science. Neither does there appear to be an association between the amount of higher education attained, between years of teaching experience, or between elementary grade level taught and positive attitudes toward science (Schwirian, 1969).

Contrary evidence about the importance of age was found in research by Cunningham and Blankenship (1979). They report that pre-service elementary teachers older than twenty-five years of age had significantly lower levels of concerns about all subject areas than did younger pre-service teachers. According to the investigators, this may reflect the importance of experience in interpersonal situations.

Shrigley and Johnson (1974) find no significant relation between the attitudes toward science of in-service elementary teachers and grade level taught, school size, classroom organization [self-contained classroom or cooperative teaching], or type of program [conventional or innovative in-service programs].

There are additional factors that may affect the attitude toward science of in-service teachers, and consequently future teachers as a result of student teaching. During their student teaching, pre-service elementary teachers may not witness any outside support or encouragement given to the classroom teacher for science from school officials or the community (Mechling & Oliver, 1983; Mittlefehldt, 1985; Roy, 1985; Shrigley, 1977). This is unfortunate because the in-service teacher's behavior is observed and emulated by the pre-service teacher. Thus, pre-service teachers may notice that the positive attitudes of current elementary teachers toward science are sometimes neither stimulated, nor maintained. It is possible that student teachers may subconsciously infer that this apparent lack of outside commitment for science means elementary science is obviously not worth teaching.

Research shows that support and encouragement from school officials and the community appear to be important prerequisites for an honest commitment to a good elementary science curriculum. If support in the form of incentives, such as money for science teaching materials and equipment, space for conducting active inquiry science, re-education opportunities for updating methods of teaching science, and the use of professional consultants and community resources, is not given, positive attitudes toward science may not be maintained (Shrigley, 1977). A lack of these resources and support has been suggested as one of the reasons why science education is neglected by teachers in the elementary schools (Hove, 1970; Mittlefehldt, 1985). Thus, while they are student teaching, pre-service teachers probably become aware of the lack of availability of outside support and enthusiasm for elementary science, which in turn influences their own commitment and attitude toward science, especially if it is not already strongly positive.

Shrigley (1977) found that frequently the improvement of attitudes of elementary teachers depends on the support of science from school officials and the community. This support, Shrigley found, can be accomplished through the use of professional consultants, the accessibility of appropriate teaching materials and equipment, the teaching of strategies for effective investigative science, and the placing of science as an essential subject in the school curriculum.

It appears important for acquiring positive attitudes toward science among student teachers to experience a well organized elementary school science program, according to

Shrigley (1974b). He finds that a meaningfully designed elementary science program rather than an incidental one positively effects the science attitudes of pre-service teachers. Shrigley comments, "This could mean that the science attitude of each generation of elementary teachers will become more positive as more elementary schools organize a science curriculum" (p. 249).

In their article, "The Principals' Project: Promoting Science among Elementary School Principals," Mechling and Oliver (1983) point out that support must come from principals for an effective science program by offering training programs, budgeting science needs, ordering supplies, leading programs, and promoting science.

Mittlefehldt (1985) suggests offering teachers rewards and incentives for receiving additional helpful instruction, even in the form of take-home videocassettes. Other possibilities include building a network of donated equipment and utilizing the expertise of knowledgeable community science-oriented professionals.

Roy (1985) also discusses important features in a committed, budgeted, coordinated, and constantly evaluated elementary science program for promoting teachers' positive attitudes toward science. The program should include physical, life, earth and space sciences. These should be taught in a hands-on approach, involving observation, classification, and experimentation, but not the memorization of facts. Science content should slowly be expanded as the grade level increases.

In summary, in order for student teachers to believe that science is an important subject in the elementary school curriculum, they need to witness school officials seriously dedicated to up-dating the education of in-service teachers in science and providing classroom teachers with adequate science equipment and professional science resources. Such actions would influence the formation of positive attitudes toward science for pre-service teachers.

## Past Experience as a Factor in Influencing the Attitudes of Pre-service Elementary Teachers toward Science

The effect of past experiences on the formation of pre-service elementary teachers' attitudes toward science needs to be included in this discussion. Some predictors of attitudes toward science appear to be the classroom or learning environment, self-assessment of one's ability, motivation, achievement, home environment, peers, interest and curiosity. These antecedents have been studied extensively, and many significant and complex relationships have been found.

An example of a complex interrelationship was found by Uguroglu and Walberg (1979), who showed the importance of ability, quality of instruction, time spent in learning, sociopsychological characteristics of the classroom group, and home environment on achievement.

In a fifteen year (1964-1979) science education literature search of 20 attitudinal studies, Kremer and Walberg (1981) concluded that student motivation (self-concept, persistence, need-achievement, test anxiety), home environment (parent occupation, presence of science-related equipment and documents in the home, parent involvement in school work), and peer environment (ability tracking between classes, extra-curricular school activities, instructional groups within classes, social associations) appear to be important correlates of achievement in science. The most important predictors of positive attitudes toward science will be described separately below.

As substantiated frequently in science attitudinal research, the classroom environment appears to be the most important predictor of positive attitudes toward science. The classroom environment, which is sometimes referred to as the learning or school environment, includes the teacher's role, such as the teacher's knowledge about science, the teacher's attitude toward science, and the teaching technique or the teacher's ability to teach science effectively. Also included in the school environment is the time spent on science and the science curriculum.

Talton and Simpson (1986) realize the importance of the classroom or learning environment. They include seven subscales in the school science environment: "emotional climate of the science classroom, science curriculum, physical environment of the science classroom, science teacher, other students in the science classroom, friends' attitudes toward science, and school" p. 366- 367). In a study of all grades in North Carolina, they found that the classroom environment is 46%-73% of the variance in the prediction of students' attitudes toward science.

A similar conclusion is expressed by Haladyna et al. (1982), who show significant relationships among teacher variables and students' attitudes toward science among students in ninth grade. They specifically mention teacher enthusiasm, respect for the teacher's knowledge, teacher support for students, teacher praise, teacher commitment to learning, and fairness toward students. Variables concerning the learning environment that show a moderate association with the attitudes of students in the ninth grade are satisfaction, enjoyment of classmates, classroom environment, organization, and attentiveness.

In addition, Haladyna et al., (1983) report in their research that overall teacher quality was the strongest contributor to variance of students' attitudes toward science scores in a study of fourth, seventh, and ninth grades.

Another verification of importance of the teacher was made when Wareing (1990) found a significant relationship between achievement in science and attitude toward science as measured by report card grades in a survey of nearly 2000 high school science students. According to the perception of students, a qualified and knowledgeable teacher is an important ingredient for achievement, and consequent attitudes. For example, Wareing states, "Students from the same school district exhibiting unfavorable attitudes toward science tended to agree that their teachers had not been terribly knowledgeable in the sciences" (p. 383). Other important contributing factors on attitudes found by Wareing were the perceived structure of the course, degree of stress, degree of rewards and reinforcements, and the number of tests.

Zuzovsky and Tamir (1989) report from a study of over 2500 elementary students in Israel that achievement in science is more clearly school dependent than home dependent as compared to achievement in reading comprehension. This means science is more related to the school curriculum and the learning environment.

A high school student's perception of the classroom learning environment is shown to account for about 30% of the variance in scores on a science attitude survey, according to Lawrenz (1976). The researcher notes that a learning environment where there is little internal conflict (cooperative class projects) is shown to be more important in biology and chemistry classes for fostering positive attitudes toward science than in physics classes. Challenging classes in chemistry and physics do not often threaten a positive attitude. The reason may be that those students already with stable and strong positive attitudes toward science may be the ones to elect more difficult classes, such as chemistry and physics. These results may also reflect that more heterogeneous students take biology than take chemistry or physics.

Talton and Simpson (1986) report that the second most important predictor of positive attitudes toward science after classroom environment is the self-concept or self-assessment of one's ability to learn science (between 38%-55% of the variance). A student's level of science self-confidence contributes to the student's motivation. Sometimes self-confidence and motivation are measured in terms of achievement. In other words, how a student perceives himself/herself as a student of science appears to influence and contribute to his/her motivation and achievement in science. Student motivation is "any measured intrinsic drive or extrinsic reward that influences student performance during an instructional treatment or test situation," and is measured by "self-concept, persistence, need-achievement and test anxiety" (Kremer & Walberg, 1981, p. 13). Achievement contributes to the student's attitude toward science and the student's perception of the importance of science.

For example, Haladyna et al. (1982) conclude that especially by ninth grade there is a significant positive correlation between students' attitudes toward science and their self-confidence in their ability to learn, a positive relationship between students' attitudes toward science and their concept of the importance of science, and a negative association between student attitudes toward science and their sense of fatalism, or in ability to control their success in science.

Also, Bloom (1976) reports a strong correlation between how successful one perceives oneself in a particular subject and one's attitude toward that subject. Therefore, success or non-success in science over an extended period of time apparently figures prominently in responses to later encounters with science. In fact, Bloom indicates that at least 25% of students' variance in achievement can be predicted by their self-evaluation as science students, and this relationship appears to increase with grade level.

Simpson (1979) contends that a negative attitude may be reinforced by general negative self-esteem, unsupportive home life, inaccurate stereotypes and negative images about scientists, the perceived unimportance of science in students' personal lives, and lack of control of students' own lives (fatalism). Simpson believes that a positive self-concept fosters achievement, which may result in an interest in science and a positive attitude toward science.

Vitrogan (1967) found that among high school students significant relationships exist between achievement levels in science and attitudes toward science. Positive significant relationships between high school science achievement and positive attitudes toward science were also found by Hough and Piper (1982).

Talton and Simpson (1986) found that the third most important predictor of attitudes toward science, after classroom environment and self-concept of one's ability in science, was the home environment (13%-39% of the variance). In fact, these three variables, according to the investigators, explain 62%-82% of the variance in attitudes toward science.

Home environment is the environment "over which a parent or guardian exerts direct control as opposed to classroom or peer group environment." It was measured in this study by "parent occupation, presence of science-related equipment and documents in the home, and parent involvement in school work" (Kremer & Walberg, 1981, p. 13).

Another important predictor is the peer group, which may indirectly influence a students' attitude toward science. The peer environment consists of the students' beliefs, practices, and social activities associated with peer group beliefs and practices. It was measured in this study by "ability tracking (between classes), school activities (extra curricular), instructional grouping (within classes), and social associations" (Kremer & Walberg, 1981, p. 13).

Students may react to the attitudes of their friends and classmates, and peers may expect certain behaviors to be displayed for acceptance into their social group. Koballa and Crawley (1985) note not only the importance of the classroom and the teacher, but the peer group as well, in the formation of attitude. They claim, "Teachers, facilities, and peers determine the context and therefore the consistency between attitude and behavior" (p. 224). Therefore, conceivably students may exhibit a positive attitude toward science at one specific time, in one certain situation, or in one classroom, but not in another.

The importance of peer association is shown by Schibeci (1989), who found that hours of homework reported by a child's nominated three best friends is related to the child's inquiry skills, attentiveness in science, self-confidence, school motivation, and the child's general and science-related attitudes.

In his analysis of the relationships between home, school and peers, and achievement in mathematics and science in Australian classrooms, Keeves (1975) concludes that where more educative environments are established in the home (greater parental interest), the classroom (better teachers, better pupil-teacher relationships), and the peer group (interests of friends), "the cumulative effects may be substantial" (p. 459).

An inquisitiveness about science is also a predictor of positive attitudes toward science. There is evidence that achievement in science, interest in science, curiosity levels, and attitudes toward science are interrelated. The importance of connecting with the student's present interests in science and in arousing a student's curiosity to cultivate new interests about science or specific science topics appears to be also an important antecedent for developing a student's positive attitude toward science (Harty, Beall & Scharmann, 1985; Harty, Samuel, Beall, 1986; Koran & Longino, 1982).

If success in science is more related to the school curriculum than success in other subjects (Zuzovsky & Tamir, 1989), the affective aspects, which are the interests, values or attitudes, may need to be considered when developing the science curriculum. Therefore, teachers should be aware that an interest in and curiosity about science or a particular science topic may be necessary for success in science and the formation of positive attitudes toward science.

Harty, Andersen, and Enochs (1984) showed a relationship between active student involvement in science among fifth graders and greater interest in science, positive attitudes toward science, and increased curiosity.

According to Harty et al. (1985), their study of fifth grade students confirmed significant positive correlations among the variables (achievement in science, interest in science, reactive curiosity and general scholastic aptitude) with attitudes toward science. They summarize, "There is a need for classroom interaction which focuses on cognitive development directly linked to such factors as attitudes toward science, interest in science and curiosity" (p. 478). They believe that attempts at simply improving attitudes toward science may not necessarily result in higher science achievement or scholastic aptitude. Nevertheless, they continue to feel that if students develop more interests in science, positive attitudes toward science and a higher level of curiosity may result.

Harty et al. (1986) studied 228 sixth-grade students and found significant positive correlations between interest in science, science curiosity and self-concept of science ability, and attitudes toward science. Also, positive significant correlations were found between science curiosity and self-concept of science ability, and interest in science. In addition, a positive correlation was found between curiosity and self-concept of science ability. The researchers inferred from a factor analysis "that attitudes toward science, interest in science, and science curiosity may be similar and highly related attributes" (p.58). According to the authors, students may be attracted to science by "creating classroom learning environments that encourage student participation and focus on the development of more positive attitudes toward science, a greater interest in science, and higher levels of science curiosity" (p. 59).

Koran and Longino (1982) relate curiosity to science achievement. They note that curiosity is stimulated by "objects or events that are novel, complex, or incongruous" (p. 18). It appears that curiosity influences learning, concept formation, achievement and performance. They suggest that curiosity should be encouraged in elementary school science by offering students opportunities for manipulating objects and seeking answers to questions in a non-threatening classroom situation.

Koelsche and Newberry (1971) show the importance of constructing a valid and reliable instrument to determine children's interests in science, which would, thereby, contribute to their achievement. The researchers developed and administered an interest inventory, "What I Like to Do Science Interest Inventory," and found significant differences in the science interests of children in Atlanta, Georgia, according to grade level (the fourth and sixth grade), the sex, and teaching approach (students in the Process Approach, and those not).

Thus, a program in science that relates to students' interests and arouses students' curiosity may be a necessary ingredient for achieving positive attitudes. Alvord (1972) in a study of fourth, seventh and twelfth grade Iowa children noticed that a relationship between achievement in most subjects and attitude toward school existed regardless of grade, sex, and the level of education of a pupil's parents. However, only about 4% of the variability in science achievement could be explained by the measure of a pupil's attitude toward school, which indicates achievement in science is determined by factors other than attitude toward school. Alvord, therefore, concludes that concentrating on improving attitudes towards school alone will not result in higher achievement in science. However, he believes that by incorporating not just the cognitive objectives, but also the affective objectives, such as the interests, values, and attitudes of students, the science curriculum will be responding to the needs and the personal lives of the students.

In summary, the most important predictors of positive attitudes are the classroom environment, self-concept of one's ability, motivation, achievement, home environment, peer group, interest and curiosity. As the above literature search indicates, the role of the teachers and how science is taught from elementary school through high school appear to have a direct effect on students' attitudes toward science. In other words, the classroom environment appears to be the major predictor or antecedent to a positive attitude toward science.

## The Importance of Teaching Methods in the Formation of Attitudes toward Science

The research previously reviewed shows that the classroom environment is the most important antecedent to the formation of attitudes toward science. At the same time, it will be shown that the literature indicates that many students in science do not feel actively involved in the learning process and cannot relate to the material taught in science class. Many students do not understand or never experience the thrill enjoyed by professional scientists as they discover unexpected results and gather interesting information through the scientific processes. Instead many students believe that science is dull and boring because science to them consists mainly of passively memorizing factual information out of a textbook that is unrelated to their personal lives.

It cannot be over-emphasized that the way that science is taught in elementary/junior high/high school may be the most important factor in cultivating a positive attitude toward science, according to the research in the literature. Consequently it is necessary to review the literature on both how science is frequently being taught and how it should be taught in order to understand the formation of the attitudes toward science of current pre-service teachers.

Students' negative attitudes toward science increase with age (Cowley, Springen, Barrett & Hager, 1990; Yager & Penick, 1986). The reason for this may be that younger students are naturally curious, more likely to participate in science exploration and be involved in hands-on discoveries.

In a survey, 64% of students in third grade perceived science classes as fun, compared to 40% in seventh grade, 25% in eleventh grade, and only 2% of adults. Science classes were thought to be interesting by 84% of third grades, 51% of seventh graders, 46% of eleventh graders, and 21% of adults. Science classes were considered exciting by 51% of third graders, 43% of seventh graders, 40% of eleventh graders, and 29% of adults. Surveys in 1977 and 1982 offered similar statistical results. Although the belief that their science teacher is knowledgeable increases with grade level, the belief that their school science experiences are meaningful and useful decreases (Yager & Penick, 1986).

Dislike of science appears to be increasing. Cowley et al. (1990) report recently that half of all third graders admit a dislike for science. This increases to 80% by eighth grade.

Science education is frequently not responsive to a student's needs. The research indicates that if only teachers would consult students, they would realize that students might be able to offer helpful advice about how science education could be made more interesting and relevant to their needs (Jacobson & Doran, 1986; Lazarowitz et al., 1985; Watts & Ebbutt, 1988). Students in all grade levels express concerns about the inappropriateness of much science teaching. These concerns certainly contribute to long-lasting negative attitudes toward science and negative attitudinal behavior.

There are many reasons suggested for why students dislike science. A study of approximately 2000 students from grade six to grade twelve in Utah revealed their reasons for liking or disliking science, which included the teacher's personality, reliance on the textbook, emphasis on memorization, lack of understanding or comprehension, difficulties with related math problems, activities not challenging or interesting, and subjects unrelated to personal life (Lazarowitz et al., 1985).

In a similar survey by Jacobson and Doran (1986), 2000 ninth grade students expressed the desire to help plan lessons and choose science topics, go on field trips, and have worthwhile personal science experiences. Most students unfortunately find science education to be a boring collection of traditional tasks, such as hearing lectures, copying notes from the board, reading the textbook, and taking written tests.

Interviews with sixty 17-year old British students in five groups about their memories and feelings about their science educational experiences between ages 11-16 years, revealed that most were dissatisfied with their previous science education. They desire more coherence or continuity of topics in science classes, more attempts to relate the content of the course to the scientific world around them, less emphasis on learning uninteresting and unnecessary facts, more practical applications of concepts to everyday life, more challenging opportunities for self-inquiry and discovery, a greater degree of self-direction in the learning of science, student input into selected activities, and discussions about students' career objectives. In addition, many students feel the need to combine topics in physics, chemistry and biology rather than taking them as parallel and unrelated subjects (Watts & Ebbutt, 1988).

Just as students elect to study science for numerous reasons, they also prefer particular topics in science. The research literature shows the importance of connecting science lessons with the student's interests for promoting curiosity about science and fostering positive attitudes (Harty et al., 1985; Harty et al., 1986; Koelsche & Newberry, 1971; Koran & Longino, 1982).

Rowe (1980) notes that many elementary students do not have a sustained interest in science that is able to carry them into tenth grade. According to Miller, Suchner and Voelker (1980), the number of students with a high level of interest in science decreases as they progress through high school.

Lazarowitz et al. (1985) found 43% of sixth through twelfth grade students chose a particular science for affective objectives, 37% for pragmatic needs, and 20% for cognitive objectives. Students offered reasons for selecting a science subject: enjoying the outdoors (90%), seeing things live and grow (71%), insuring the survival of life on earth (70%), solving a personal problem or question (61%), preparing for a good job in the future (59%), understanding the beauty of the subject (48%), manipulating experimental equipment (46%), making interpretations and drawing conclusions (33%), helping other people (30%), working with hands 30%, and being self-confident in the subject (30%).

The preferences of individual students may be ignored as school requirements increase in the higher grades. These individual preferences for particular sciences by students may also be a reflection of their past experiences, on which they can comfortably build knowledge and relate to their personal life. Thus, by electing preferred science courses and topics students may cultivate positive attitudes.

Research conducted with over 13,000 students from grade 1-8 in ten states confirmed that there was a decline in affective reaction to all specific science topics as grade level increased. However, students showed preferences for particular topics that are studied in science. For example, most favor earth/space science and life science activities, rather than physical science/mechanics. Thus, it is not simply a matter of how science is taught, but what topics are taught (Sullivan, 1979).

According to a survey of 1855 junior high/high school students conducted by Baird et al. (1984), most preferred science subjects relating to zoology, human anatomy and physiology, rather than chemistry, physics, botany and ecology. Rural students especially prefer zoology and earth science over the physical sciences, such as chemistry and physics.

Important factors affecting 1240 Nigerian secondary students' choice of science subjects were reported by Akpan (1986). Akpan finds factors that are important for studying science include social implications, image of a scientist, high spatial and numerical ability, and particular personality characteristics, such as determination and stability. Attitudes and intelligence are most often predictors of who will study science, according to Akpan. Although the researcher feels students with more favorable attitudes are more likely to study science, physics is not as likely to be studied even as a career choice because it is perceived as being difficult.

In the United States it appears that the schools must not be teaching even the preferred sciences adequately. According to Cowley et al. (1990), the International Association for the Evaluation of Educational Achievement reports that in biology the American students rank last out of 13 countries on achievement tests. American students rank eleventh in chemistry, and ninth for those who have taken two years of physics.

Many teachers do not teach investigative science (Jacobson & Doran, 1986; Watts & Ebbutt, 1988), which is teaching students to ask their own questions, seek their own answers, interpret their findings, and discover their own misconceptions about science through the exploratory process of the scientific method. It appears that frequently teachers do not reflect students' purposes for taking science (Lazarowitz et al., 1985). Teachers' responses are more cognitive than affective (Zeitler, 1984). Thus, misguided philosophies about the purposes of science education may contribute to incorrect teaching techniques by teachers, cause students' negative attitudes toward many science topics, and ultimately lead to graduates with life-long negative attitudinal behavior toward science.

Another reason suggested why teachers do not conduct investigative science may be a reflection of their insecurity about their general science knowledge (Hove, 1970; Mittlefehldt, 1985). Teachers may resort to teaching science very methodically and uninterestingly by requiring that students read a chapter in the textbook, define the vocabulary, answer questions at the end of the chapter, and recall factual information on a test. Many elementary teachers perceive that science education means only memorizing information and terminology (Manning et al., 1982), and many topics in the science curriculum are neglected (Glasgow, 1983).

This belief is supported by the findings of Zeitler (1984). He finds 58% of elementary teachers believe that their most important task is to teach science information. In fact, only 23% feel the importance of problem solving, only 10% feel the need for teaching science processes, only 7% have the notion that they should be developing a positive attitude toward science for their students, and only 5% believe they should be developing a student's curiosity. However, Zeitler finds that 38% of elementary teachers feel they should develop an awareness of the world. These percentages probably reflect the attitude with which and the way in which elementary science is presently taught.

Consequently many teachers perceive teaching science as simply dispensing scientific facts, as noted by Manning et al. (1982). For example, they point out that 70% of teachers report allowing students one hour or less per week for engaging in science activities which teach science processes and relate science to personal life.

As explained earlier, frequently teachers themselves have not been taught the ways elementary children learn science best which, according to the interpretations of Piaget (Campbell, 1976), would be through concrete methods rather than abstract approaches. Future elementary teachers who were themselves taught passively by lecture, textbook reading, note taking, demonstrations, and abstract conceptual verbalization may, in turn, teach young children in familiar and similar methods instead of involving them as active participants in hands-on activities.

Research has been conducted on how science should be taught in order to foster positive attitudes. Especially elementary children discover knowledge about physical objects through their direct actions on the objects, their observation of the reactions of the object to those actions, and their own mental activity. Instead schools unfortunately attempt to make children into passive learners who rely heavily on verbal instructions and remain unresponsive in their seats rather than first-hand discoverers of physical knowledge and mental constructors of logical knowledge (McNairy, 1985).

Stedman (1974) proposes a model of active experiences in science for pre-service elementary teachers. Included in the model are experiences for developing an understanding of the nature of science and learning certain basic concepts, principles, laws and theories essential for understanding on the elementary school level. Opportunities for pre-service elementary teachers to practice the scientific method or scientific processes of observing, classifying, measuring, recording, questioning, interpreting, experimenting, predicting, inferring, analyzing, hypothesizing, and communicating data may be necessary rather than simply telling future teachers what they should do with young children in the classroom.

Currently many in-service teachers are frequently incapable of modeling effective teaching techniques for student teachers. This belief is confirmed in a study that showed professional elementary school teachers feel a need to be taught how to create realistic and first-hand science experiences for their students. Teachers want to learn basic science process skills and methods of self-discovery and investigation, which they may be able to transmit to their students to make science more meaningful, and they also express a need to be able to relate science to society (Moore & Blankenship, 1977).

There is much criticism about the overuse of textbooks. Rowe (1980) notes that many students cannot read well enough to even understand the textbooks. Sometimes teachers even complain that the books are not written on the reading level of the student so that too much time is wasted in class explaining what the book means. In making these comments, Rowe assumes that in-service and pre-service teachers are capable of explaining all the information in science textbooks, but many are not.

The importance of the role of the teacher in science teaching cannot be overemphasized. The positive attitudes toward science that elementary teachers successfully transmit throughout the student's elementary educational experience appear to be more important than the amount of knowledge any elementary teacher may be able to convey about science. Yager and Penick (1986) report that a less knowledgeable teacher permitting exploratory experiences with open-investigation in elementary science and avoiding lectures provides a more success-oriented atmosphere than a well-informed instructor with demands of perfection in a regulated program.

Science programs especially designed to change students' attitudes towards science may be beneficial. After studying the literature and research on attitudes of elementary and secondary students toward science, Haladyna and Shaughnessy (1982) conclude that effective science programs designed to change attitudes generally have a positive effect on attitudes. However, they claim, "The evidence is not yet conclusive as to which of these teacher and learning environment variables are most predictive" (p. 558).

The importance of first-hand knowledge gained by personal experience rather than through textbooks would help to keep science a lifelong interest. Science activities and references books, especially those produced locally, would help students explore their natural surroundings and understand how scientists themselves work (Rutherford, 1987).

The fact that science is a way of thinking which involves exploring, searching, answering questions, solving problems, and understanding principles and processes, rather than an accumulation of facts and terms, should be reflected in the way science is taught (Tilgner, 1990). Rather than being passive listeners and note-takers, students should be active participants in smaller classes, acquire broad understandings and develop higher cognitive skills. They should be taught how to ask the right questions and develop possible solutions (Journet, 1985).

Memorizing factual information in science class without understanding concepts may result instead in negative attitudes toward science, according to Koballa and Crawley (1985). They write, "The assumption that students will acquire positive attitudes toward science as they learn more science facts is no longer valid" (p. 222). They further emphasize, "Attitudes toward science are not inherited traits, but are learned predispositions acquired over a period of time, perhaps years" (p.225). The researchers conclude, "A person's attitude toward science conveniently summarizes his or her emotional response to basic beliefs about science" (p. 226).

Halkitis (1989) suggests applying the scientific method to the elementary science curriculum. In this investigative approach the teacher may need to research basic information on scientific subjects and be creative in setting up simple experiments.

The American Association for the Advancement of Science (1990) suggests not only giving students time for exploring and observing, but for retesting ideas, questioning results, and correcting mistakes. In a science program where students are actively engaged in the gathering of information, students learn to think like scientists.

Utilizing the scientific method through teaching discovery science may lead to positive attitudes being acquired. Haney (1990) explains:

> To be scientific means that one has such attitudes as curiosity, rationality, suspended judgment, open-mindedness, critical-mindedness, objectivity, honesty, and humility...If these and other attitudes are to be fostered, they must be planned for and not simply accepted as concomitant to cognitive outcomes...Pupils cannot learn attitudes that their teachers don't have. (p. 33)

Kyle, Bonnstetter, McCloskey, and Fults (1985) report on a discovery approach, called the "Science Curriculum Improvement Study", in which teachers' knowledge of science is broadened while at the same time teachers develop more positive attitudes toward science. In the program the elementary students ask questions, record data, discuss experiments, devise new experiments for testing answers, and explain their results. Teachers in the program feel more qualified to teach science and have fewer needs for assistance.

Although most children enter school with innate curiosity and desire to ask questions, they find instead that the teacher asks most questions. Allison and Shrigley (1986) note that these "non-operational" questions, which "are those that cannot be easily answered by first-hand evidence of the type that young students can generate" (p. 73), can be answered only by using books and teacher-directed information. After a research investigation of fifth and sixth graders, Allison and Shrigley suggest that students should be encouraged to write operational questions, in which inquiry science teaching experiences are utilized.

Vargas-Gomez and Yager (1987) find positive attitudes toward the science teachers of third, seventh, and eleventh grade students in "exemplary programs," where both teachers and students ask questions in science class, where students can express their own ideas, where teachers enjoy, are well-informed, and are enthusiastic about science, and where teachers meet the personal needs of their students.

Pestel (1988) makes a distinction between preaching, teaching, and training in science classes. According to her, teaching science should not be preaching in an attempt to force ideas and solutions on students, nor training students to mechanically do tasks. Instead Pestel believes teaching should focus "on cultivating the ability to solve future problems" (p.29). She explains the purpose of teaching: "Our teaching style should center around the processes involved in the responsible collection of facts and the use of these facts in the synthesis of ideas" (p.26). In other words, teachers should encourage students to ask questions while discovering their answers.

Many articles about investigative and hands-on classroom science are appearing in popular magazines. Examples of effective discovery approaches were recently offered by Begley (1990), who reports "scratch 'n' sniff" science has been taught successfully in some classrooms in Arizona for 16 years, and Burroughs (1990), who describes students actively engaged in classroom science projects in four different states, Pennsylvania, Ohio, Texas and Alabama.

Herron (1979), in his article on the research findings about attitude and interest, points out the importance of making students want to learn, creating a stimulating environment to change the minds of those who may not want to learn, teaching concepts and ideas in science logically and sequentially, offering explanations that make sense whenever possible, teaching in meaningful contexts through discovery learning techniques, leading students in their self-discovery of errors, outlining expectations and goals of teachers, and giving frequent feedback concerning progress.

Although most educators agree that science should incorporate asking questions, forming theories, testing hypotheses, observing results, and drawing conclusions, many teachers are still perplexed about how to teach investigative science. The American Association for the Advancement of Science (1990) offers suggestions for alleviating their concerns. In general, science students should be kept actively engaged in the investigative process, be taught to ask questions, be encouraged to suggest alternative methods to answer questions, be permitted to offer their own interpretations of the evidence found, be informed about the growth of science from historical perspectives, be taught effective oral and written communication, learn to cooperate in a team approach, understand concepts rather than memorize, be encouraged to be creative, be provided with time to work, be provided with many opportunities to use scientific equipment, and be allowed to correct their mistakes.

An interdisciplinary elementary science program which incorporates science into other classroom subjects is one method for solving the scarcity of time available for science in the elementary school, for making science more related to the personal lives of students, and ultimately for improving students' attitudes toward science. Mittlefehldt (1985) thinks that elementary science must become more interdisciplinary and creatively incorporated into activities in English, social studies, art, math, music, and physical education. Examples he gives are plays dramatizing the observation of one-celled animals, poems describing objects in nature, biographies of scientists, and dances showing the movement of the solar system.

There are exemplary elementary science programs designed for creating positive attitudes toward science among students. Japanese science educators now advocate teaching science in the early years with approaches that foster "hands-on" experimentation, reasoning, problem solving, open-ended questions, argumentation and less emphasis on memorization of facts. Ironically this philosophy in teaching science was copied by the Japanese when it was being considered in the United States during the 1960's and 1970's. In a study of over 7500 seventh, eighth, and ninth grade students in Japan and the state of North Carolina by Lawson (1990), the Japanese students in all grades outperformed their American counterparts. Lawson says:

> In Japan they have been able to put this philosophy and methodology into the schools. In the United States, due I think, to our lack of a central educational authority, and due to a lack of effective teacher training, we have not been able to put these programs into the majority of schools. In other words, the Japanese seem to be beating us at our own game. (p. 500)

Lawson suggests additional reasons for the better performance of Japanese students compared to American students, such as more Japanese parental involvement in education, higher Japanese expectations for their children, and longer Japanese school years.

In summary, although the issues involved in improving the learning environment for students in science are very complex, some concrete suggestions have been offered from the research literature for improving all students' attitudes toward science. The formation of attitudes toward science of pre-service elementary teachers can be traced to their own prior educational experiences in science.

## Attempts at Designing Courses for Pre-service Elementary Teachers to Cultivate Positive Attitudes toward Science

One way to further discover the positive and negative influences on attitudes toward science is to examine the attempts at designing courses for pre-service teachers to cultivate the desire for and to gain confidence in teaching investigative elementary science. A variety of methods have been used in these courses for encouraging positive attitudes toward science and dispelling negative attitudes already formed from prior life and educational experiences in science. However, there is currently a debate as to whether any amount of science, any particular course, or any re-educational technique can permanently and completely eliminate pre-service teachers' negative attitudes toward science that have already been formed prior to college. In other words, the research literature shows the difficulty, and maybe the impossibility, in designing courses to change negative attitudes and to give pre-service elementary teachers confidence in teaching scientific processes and handling science equipment. As discussed earlier, attitudinal research implies the importance of preventing negative attitudes from forming earlier in life and identifying which factors are the most significant antecedents in the formation of attitudes toward science. A review of some of the attempts, suggestions and controversies about influencing the previously formed pre-service teachers' attitudes toward science through re-training courses and educational methods will follow.

In 1980, an analysis of science education needs was conducted by the National Science Foundation, which supports the notion that providing good pre-service programs before elementary teachers are certified is a better assurance of qualified teachers than surmounting the task of correcting deficiencies at a later time through in-service programs (Mechling et al. (1982).

There is a controversy among teacher educators as to whether requiring science content classes or science methods classes best increases confidence in general science knowledge and improves attitudes toward science and science teaching (Mechling et al., 1982). Science methods courses deal with laboratory experiences and activities for developing science process skills, methods of teaching science and general teaching techniques, while the purpose of science content courses is to transfer science information and to promote understanding of science concepts.

According to Mechling et al. (1982), more emphasis is being placed on science methods courses for pre-service elementary teachers than on science content courses. In his 1982 national survey, most institutions did not require more credits in science content courses for elementary teachers than the general requirement for all students. Of the top 45 teacher-producing colleges and universities in the United States who responded, 44 institutions required elementary teacher candidates to complete some science courses, but only eight colleges specifically required biological, physical and earth science content courses for elementary education majors. Some schools accepted a physical geography class for fulfilling the science content requirement rather than a more rigorous and useful biological, physical, space or earth science class. Forty-two institutions replied that they required only one science methods course, two schools reported that they required both a science methods course and a general methods course, and two universities responded that they required only a general methods course. Thirty-three universities required courses designed to teach science process skills through active laboratory experiences and activities. However, most deans at the responding institutions believed in the need to provide additional science content courses, more science methods courses and more laboratory science courses specially designed for elementary teachers.

When a science option is offered, many pre-service elementary teachers simply elect the easiest science class rather than the most useful. A survey conducted by Zeitler (1984) shows that geography is chosen more often in college by pre-service elementary teachers for fulfilling a science requirement than physics, chemistry, geology or space science. Zeitler believes this deliberate selection may result from the perception that geography is less difficult or that it is considered a major curriculum area in elementary school. However, geography has little use as a science in the elementary classroom. Geography does not teach hands-on investigative and manipulative laboratory skills, the scientific processes, and the scientific method. Zeitler concludes that especially the physical sciences are often considered difficult and outside the realm of previous life experiences so they tend to be avoided by pre-service elementary teachers. Consequently the physical sciences may not frequently be taught in the elementary school.

The method by which scientific knowledge is presented to pre-service elementary teachers may be an important ingredient in acquiring long-term positive attitudes toward science (Shrigley, 1974a). Unfortunately the way in which many pre-service science courses are taught actually seems to foster or maintain negative attitudes toward science. Shrigley finds that "pre-service elementary teachers with higher test scores on science achievement tests do not necessarily have a more positive attitude toward science than teachers with lower scores" (p. 148). Shrigley concludes that large lecture sessions taught uninterestingly from textbooks rather than through personal involvement by discovering answers and manipulating laboratory materials may actually cause negative attitudes about science teaching. Thus, simply requiring more science classes for pre-service teachers may not be the solution for cultivating positive attitudes toward science. Shrigley (1974b) says that it is important for acquiring positive attitudes to have a well-organized pre-service science program. He finds that an organized elementary science education program has a positive effect on the science attitudes of pre-service teachers.

Many pre-service elementary teachers apparently perceive that their ability to teach science competently and confidently is based on their ability to accumulate numerous miscellaneous science facts. This is the finding of Perkes (1975), who surveyed 52 prospective elementary teachers enrolled in a teacher education program at the University of California, Davis. His research indicates that those pre-service teachers with feelings of inadequacy about their ability to teach science are least likely to enroll in any science class and probably most likely to avoid teaching science as an in-service elementary teacher. It is Perkes' belief that those insecure pre-service teachers feel that they simply do not have sufficient background knowledge to be successful in science courses. Based on this assessment, Perkes remarks:

> Attitudes towards teaching of science are shaped by experiences other than personality

> characteristics--a view supported by the relationships between reported difficulty and other background factors. Those going into elementary teaching do not view science as an enticing intellectual enterprise (p. 87).

Perkes believes that science and science methods classes in universities need to provide future elementary teachers with successful experiences in science for achieving science confidence and improving their attitudinal behavior.

Thus, it is suggested by some researchers that pre-service courses, which emphasize science processes and active hands-on exploration rather than the memorization of science facts, may possibly help pre-service teachers acquire positive attitudes toward science and reduce their anxiety about the importance of accumulating factual knowledge for successfully teaching elementary science. In such a program, more emphasis is placed on learning and experiencing first-hand effective and appropriate teaching methods for elementary exploratory or discovery science. Therefore, an appropriate approach would appear to be to place the science methods courses before the content courses, and have the content courses taught by science education faculty sympathetic to the needs and backgrounds of most elementary education majors (Duschl, 1983).

In reality it may be necessary to teach many pre-service teachers in hands-on or concrete methods for another reason. Although it has been assumed that most individuals reach Piaget's cognitive Formal Operational Stage by 16 years of age, Chiappetta (1976) reports research by Juraschek that 52% of prospective elementary teachers in college are still at Piaget's Concrete Operational Stage of cognitive development. An investigation shows that a large percentage of pre-service teachers actually perform on the concrete operational level when tested on their understanding of physical science subject matter. In other words, many pre-service teachers do not understand underlying concepts and principles, but are only capable of solving physical science problems by substitution.

In addition, if the information and teaching techniques presented in science or science education courses do not seem interesting nor applicable to the needs of the pre-service teacher, it can be assumed that the course material will be ignored and never be utilized in his/her elementary classroom. This may also be ultimately reflected in the elementary teacher's confidence about teaching science and general attitude toward science. Thus, it is argued that pre-service teachers need to be taught science themselves in the ways elementary children learn science best, which is through inquiry experiences or individual hands-on investigation.

The pre-service college science professor has the ultimate responsibility for devising ways of involving education students in the scientific processes for improving their attitudes. This notion is expressed by Shrigley (1976), who feels that the credible science methods college instructor for pre-service elementary teachers should offer practical elementary classroom activities, be experienced in teaching science to children, be able to model teaching methods appropriate for children, design useful science content courses for elementary teachers, and be available for assistance and reassurance.

With these beliefs in mind there have been many attempts by universities to develop useful and practical pre-service hands-on science methods courses for pre-service teachers. For example, in an attempt to reduce the anxiety of pre-service teachers about science at Purdue University in 1972, an integrated National Science Foundation science pilot program for pre-service elementary teachers was offered in which the goal was to provide practical and useful experiences during which scientific knowledge was taught as an imaginative and creative inquiry process rather than by the memorization of facts and vocabulary (Nordland & DeVito, 1974).

Many other researchers also suggest that pre-service elementary teachers be exposed to more actual science activities in order to increase their confidence and improve their attitudes before actually teaching children as professionals. Koballa and Coble (1979) at East Carolina University find that the attitudes toward science of undergraduate education students improve when the students are exposed to additional activities, demonstrations and discussions in their biological and environmental science laboratory classes before actually teaching children.

There is contradictory research about whether or not attitudes of pre-service teachers toward science improves after field experiences. Sunal (1980) finds that field experiences do not modify attitudes of pre-service teachers toward science, but possibly help elementary education students in activity-oriented science teaching. On the other hand, other research by Strawitz and Malone (1986) indicates that attitudes toward science by pre-service teachers improve after field experiences. However, the field experiences apparently do not alleviate the teachers' concerns about self, teaching tasks, and the impact of inquiry science on pupils.

Some course designers suggest that in order to reduce the science anxiety of pre-service teachers, the focus should be placed on the impact or results of their science teaching rather than on their own questionable competence in science. In an attempt to reduce the anxiety levels and improve the science education of undergraduate elementary teachers, the University of Houston successfully tried a program which did not focus on science content, but on science as an important inquiry experience. The pre-service teacher's concerns about being a knowledgeable science teacher were not emphasized. Instead the learning impact on children while engaging in discovery science was stressed at the same time that the knowledge and skills needed to be an effective teacher were acquired. Time was spent with children in student-centered, low-ratio teaching experiences working with lesson planning for inquiry hands-on science that involved questioning, reinforcement, and non-verbal communication (Roberts, Chiappetta, & Jones, 1974).

With related information obtained from confidential hour-long interviews with 100 elementary education students, a developmental concerns model for pre-service teacher education is proposed by Fuller (1969). Fuller finds that during the pre-teaching phase students focus on their own past experiences as students rather than on any future concerns and worries about their role as future teachers. When they begin student teaching, education students are mainly concerned about their competency as a teacher as evaluated by other professionals. Later their concerns mainly focus on their own critical self-evaluation of student improvement, as the result of their teaching. Thus, Fuller suggests that pre-service course content should be constructed with these developmental phases of concerns in mind. He thinks that students might profit from being placed in student teaching positions earlier in their education and offered individual counseling at the same time. Instructors of science classes for pre-service teachers should be aware of Fuller's suggestions because it appears that before elementary education majors begin their student teaching experiences they probably focus more on their past experiences and previous perceptions about science than on how and what children are learning.

Furthermore, some researchers find a relationship between pre-service teachers being receptive to new teaching techniques in science and having positive attitudes toward science and science teaching. As it has been previously explained, open-minded teaching involves letting children learn by manipulating materials and teachers asking questions not in an authoritarian manner. However, the study does not clarify causality, that is, whether open-mindedness is the result of positive attitudes about teaching science or if positive attitudes about teaching science result from open-mindedness (Strawitz, 1977).

Some researchers believe that attitudes toward science should be consciously and openly addressed in science education courses for pre-service elementary teachers. Frequently the two expressions, attitudes toward science and scientific attitudes, are incorrectly interchanged. Schibeci (1983) warns about the danger of treating attitudes toward science, which are the affective aspects of science, such as feelings, opinions, beliefs, interests and values, in the same way as scientific attitudes, which are in the "cognitive objectives," such as objectivity, critical and analytical thinking, curiosity, honesty and open-mindedness. Schibeci feels that too often the "attitudinal objectives," or affective aspects, are neglected in the science curriculum (p. 601).

Some researchers believe that it may be possible to modify attitudes toward teaching science of pre-service teachers in spite of the difficulty in changing their attitudes toward science. For example, after using a variety of teaching strategies with the objective of improving pre-service elementary teachers' attitudes toward science and science teaching, Lucas and Dooley (1982) in Australia found that pre-service teachers' attitudes toward science are resistant to change although attitudes toward teaching science improve.

Nevertheless, other research points to the difficulty in changing or improving not only the attitudes toward science, but also the attitudes toward teaching science simply by taking science methods classes. However, effective methods for improving science process skills may be developed. Such results are shown in research conducted by Riley (1979) at the University of Georgia while determining which of three different teaching methods was most effective for improving science process skills and for changing the attitudes toward science and science teaching of pre-service elementary teachers. He found that both an active-inquiry approach, in which education students use hands-on or manipulative experiences, and a vicarious-inquiry approach, in which process skills are demonstrated by an instructor, are significantly more effective for improving science process skills of pre-service teachers than a non-manipulative method, in which science films with topics encompassing geology, meteorology and physical sciences are viewed. The science process skills of pre-service teachers measured were number relationships, classification, use of space/time relationships, observing, inferring, measuring, communicating and predicting. Classifying and using space/time relationships are the process skills that are most effectively taught by the active-inquiry and the vicarious-inquiry approaches. However, there was no difference among any of the three methods in the improvement of the pre-service teachers' attitudes toward science and science teaching. Riley concludes, "A final implication for science education is that, if improved student attitudes toward science and science teaching are a valued objective of instruction, then something more than student exposure to process skills through hands-on experience may be required" (p. 383).

There has been other attitudinal research which indicates that it may be very difficult to alleviate the science anxiety experienced by many pre-service elementary teachers. Westerback (1984) finds that increasing the amount of instructional time for pre-service teachers does not reduce anxiety at C. W. Post, Long Island University. This is true in spite of the fact that the instruction involved hands-on activities and understanding the scientific processes rather than the memorization of factual information. Westerback reports that changes in faculty during a course, class competition for grades, comprehensive exams, difficult concepts and uninteresting topics relate to increased anxiety. According to Westerback, it appears that the most effective means of reducing anxiety in pre-service science classes is to have the science material presented in a sequential order.

Gabel and Rubba (1979) make several significant findings about teachers' attitudes toward science, which may be disappointing to science educators. They find teachers' attitudes, which have been developed over long periods of time, do not remain permanently changed by short-term workshops. Thus, there is an implication that it may be necessary for teachers to have formed positive attitudes toward science throughout their earlier educational experiences. According to their study, there was no difference in attitudes toward science between teachers who acted as role "model teachers" for other teachers "by teaching science in their presence" and those who did not (p. 23).

Because negative in-service and pre-service teachers' attitudes appear to be very resistant to change, it may be necessary for in-service and pre-service elementary teachers to be convinced that science is very important, and hence that it should be taught in the elementary school. This approach is suggested by Shrigley (1978), who believes the science educator may need to use "persuasive communication" or the learning theory approach in an attempt to convince future elementary teachers about the need for science education. Shrigley says:

> the learning theory approach assumes that man is rational, and that confronting him with a formal communication having pertinent information implying the need for an attitude change should result in learning a new attitude in much the same way that one learns to read or compute (p. 335).

Six components derived from the responses to a questionnaire conducted by Shrigley for his persuasive communication model for future teachers are:

1. Science develops logical and critical thought, a means to independent learning.
2. Science provides the active, hands-on experiences necessary for children to practice inquiry skills.
3. Science is motivating; it enhances the curiosity among children.
4. Science supports and enriches other areas of the elementary school curriculum.

> 5. Science learnings are necessary for coping with the crises expected in our technological world.
>
> 6. Science provides the child a necessary conceptual understanding to the physical and natural world. (p. 338)

All researchers in science education seem to agree that attitudes are not innate, but learned from prior experiences. Shrigley (1983) says, "Unlike intelligence, the attitude concept has escaped the nature-nurture controversy" (p. 427). Since attitudes are learned, cognition or thought processes must be involved. New information and convincing experiences are necessary for any change in attitudes. Shrigley says, "Information openly sought by individuals because of an immediate need, be it diabetes, inflation, or life after death, seems to directly affect attitudes" (p. 427). Another motivation for changing attitudes is cognitive dissonance, which requires a recipient to make "two inconsistent pieces of information held simultaneously" compatible (p. 427). Shrigley notes that attitudes toward science predict a teacher's behavior. He cautions, "It is doubtful, however, that the content of a science course is critical enough to a recipient for it to function universally as an attitude modifier" (p. 429). Instead Shrigley feels that some teachers may need to be persuaded to teach investigative science. Behavior can be changed, according to Shrigley, through the group dynamics approach, which incorporates social pressure or the need to conform and be accepted by society.

The Complexity of Science Attitudinal Research

In summary, the research in the literature shows the importance of elementary teachers' attitudes toward science, the reasons why elementary teachers avoid science, the factors involved in the formation of pre-service teachers' attitudes toward science, the importance of previous educational and life experiences on the formation of pre-service teachers attitudes, and attempts at changing negative attitudes of pre-service teachers.

Attitudes are learned and influence behaviors (Schibeci, 1983; Shrigley, 1983), and elementary teachers' attitudes toward science and science teaching are important because they may permanently affect the attitudes of students and student teachers. Teachers transmit their negative attitudes in many ways (Koballa & Crawley, 1985; Mittlefehldt, 1985; Plimmer, 1981, Shrigley, 1983; Strawitz, 1977).

It has been shown that many factors, experiences and antecedents may contribute to a positive attitude toward science and science teaching in pre-service elementary teachers. Some of these factors include their perceptions of the role of science in society, their knowledge about science and scientific processes, their perception of school and community support for science, their gender, their age in conjunction with amount of science taken, the type of teacher training institution attended, and their past educational and life experiences, such as their prior science classroom environments, their self-concept about their ability in science, their peers, their home environment, their interests and their curiosity about science and all science topics. Interest in science appears to decrease with age (Cowley et al., 1990; Yager & Penick, 1986). Some studies show the previous science classroom environments, especially the teacher and the teaching techniques used, are the most significant antecedents of attitudes toward science (Haladyna et al., 1983; Talton & Simpson, 1986; Wareing, 1990).

Research has also shown that negative attitudes about science and science teaching among pre-service elementary teachers may be difficult to alter. Certainly it appears to be easier and more desirable to have prevented negative attitudes toward science from forming than to modify them later through pre-service classes or in-service re-education (Gabel & Rubba, 1979; Lucas & Dooley, 1982; Riley, 1979; Shrigley, 1978; Westerback, 1984). Also, research indicates that elementary teachers' experiences, confidence and attitudes about science and science teaching affect their teaching methods and what they teach in science.

The literature shows that many pre-service elementary teachers feel insecure about their general science knowledge and their ability to teach science effectively because of their negative past educational and life experiences. Hence, some pre-service teachers may avoid teaching science, or some science topics, or may teach science ineffectively in the future, which would continue the cycle of another generation with negative attitudes. Physical sciences are especially perceived as difficult based on previous unsuccessful school-related experiences (Akpan, 1986; Glasgow, 1983; Lawrenz, 1976; Zuzovsky & Tamir, 1989).

Without attitudinal research, the experiences, antecedents and conditions that may have affected teachers' attitudes toward science will not be understood and, therefore, improved. The following research exposes the relationships in the past experiences with science of pre-service elementary teachers that may have contributed to their current attitudes toward science and science teaching.

# CHAPTER III

# METHODOLOGY

## Research Design

The research design for this study incorporated both qualitative and quantitative methods. Briefly, based on the themes and ideas obtained from interviews with six pre-service teachers enrolled in the science methods classes, a survey (Sampson Survey I) was designed and given to all pre-service teachers enrolled in science methods classes in an elementary teacher education program. Also, Survey II (Shrigley's Science Attitude Scale) was given, and the results compared with those obtained by Stefanich and Kelsey (1989) at two mid-western universities that used different methods for educating pre-service elementary teachers. All of the quantitative and qualitative results were analyzed.

## Selection of Subjects

The subjects for this study were all undergraduates enrolled in the two elementary science methods classes during the Fall semester, 1990, in the Center of Teaching and Learning, the College of Education at the University of North Dakota. At the time of the research, Fall, 1990, 62.42% of UND students came from North Dakota, 1.77% came from the Grand Forks Air Force Base, and 23.57% came from Minnesota. However, the students have a wide variety of backgrounds. That is, some students grew up in rural settings of very low population, while others come from small towns or cities of 25,000, or more.

The first six pre-service teachers from one of the pre-service elementary education science methods class who volunteered were selected for taped private interviews. Those six students were all female, but, as it turned out, had different experiences, opportunities and backgrounds.

Two of the six students grew up on farms, one spent summers on a farm and winters in a small town, and three grew up in cities with populations larger than 25,000 people. However, the three growing up in these larger cities had parents who grew up on farms so they had grandparents or other relatives in rural settings whom they frequently visited. One of the six had attended a parochial elementary school.

In high school two of the six students had only biology courses in high school, three had both biology and chemistry courses, and only one had taken biology, chemistry and physics.

Two quantitative surveys were given to all of the 57 undergraduate students who were present in the two science methods classes. The students enrolled in those classes were mostly female, but there were also three males.

## Instruments Used

The data from the first phase of the research were analyzed qualitatively. The interviews of approximately one-and-a-half hour duration were taped in a room with only the interviewer and interviewee present. No names or any other revealing personal attributes were mentioned so the interviewees could not be identified.

From the interviews no quantitative or numerical data were expected. In fact, these interviews were exploratory and inductive in nature. No theories had been formulated before the interviews, and no prior hypotheses were under consideration.

The reason for conducting the interviews in a discovery-oriented approach was for the interviewer to better understand the previous life and school experiences in science and the attitudes about science of some students enrolled in the pre-service elementary teaching program at the University of North Dakota. Thus, no checklist was used, but rather the researcher listened to the experiences, perceptions and concerns about science and science teaching of those being interviewed. The eight general categories selected for discussion by the interviewer included a definition of science, school learning experiences in science, non-school learning experiences in science, influences regarding science, the teaching of science, the importance of science, confidence in science knowledge and teaching, and the understanding of scientific processes. It was the intention of the interviewer to design a quantitative survey based on the information gathered from the real-life experiences, concerns and feelings about science of the pre-service teachers who were interviewed.

The interviews were conducted in the following exploratory format. Three initial probes were submitted at least 24 hours prior to the interview so that the interviewees could think about their replies. The first probe was an orientation question, or definition of science. It was, "What do you think of when you think of 'science'?"

The second probe was a series of open-ended questions dealing with previous school learning experiences in science. The topics covered were perceptions about effective methods for learning science, a self-analysis as a student of science, recollections of previous science courses, and earliest memories of science in school.

The third probe dealt with non-school learning experiences in science. Thus, two of these three initial probes required the students to think about and recollect their earliest science experiences inside and outside of school.

The remaining open-ended questions were asked spontaneously by the interviewer during the taped interview and required no prior consideration by the student.

The first open-ended question included recalling people, events and experiences that may have influenced their attitudes toward science, as well as the reasons. Another probe involved inquiring about perceptions of the science curriculum in elementary school and about methods for teaching science. Then there was a series of open-ended questions dealing with the importance of science in one's personal life, with perceived utility of science, and with perceptions of science in society. Still another question probed their confidence about general science knowledge and ability to teach science. The last probe considered their understanding of science and the scientific processes, and their image of a professional scientist. (An outline of the open-ended questions in the eight categories used during the interviews is included in Appendix A.)

These pre-designed inquiry questions given to the six pre-service teachers were used as a skeleton outline for additional probes. Follow-up open-ended questions based on the replies from the initial questions were then sometimes asked by the investigator to help clarify and understand what the interviewees meant by their comments.

By using this interactive format the researcher hoped to avoid misinterpretations, unconscious biases, deceptions, inaccurate judgments and selective perceptions. For example, the interviewees were urged by the interviewer to offer any specific examples and recall situations from their memories, which would clarify, explain, confirm, and illustrate their replies and comments. This interactive approach was conducted in a discussion format, as recommended by Mishler (1986) in "Research Interviewing."

After the taped interviews were completed they were transcribed by the interviewer and, from these written interviews, codes for subject categories were developed. It was the intention of the interviewer to find interrelationships, or "patterns."

These categories or themes emerged and were included:

1) Memories of science inside and outside of schools (vivid, vague, spotty); differences in teachers; differences in schools; types of experiences; specific examples, and why remembered.

2) Active and inactive methods of science teaching used in both elementary school and high school (active hands-on, exploratory or discovery approach, questioning by teachers and/or students, class discussions, explanations, small group cooperative learning, teacher demonstrations, lab exercises, lectures, textbooks, textbook questions, formulas for solving problems, worksheets, scientific processes).

3) Inside and outside school support given for science, specific examples (family, teacher, siblings, peer group, another person, role model).

4) Important teacher characteristics (enthusiasm, interest, patience, understanding, open-mindedness, ability to explain on students' level, availability for questioning, role model, knowledge, teaching techniques).

5) Processes used now and in the past for the internalization of science information (investigative or discovery, additional explorations, self-correction of mistakes, understanding concepts, memorization of facts, substitutions in formulas).

6) Seeking answers and the truth now and in the past (sources of information, means taught, encouragement, curiosity stimulated, information questioned, problems solved logically, search for patterns and meanings, higher levels of thinking, scientific processes).

7) Examples of the utilization of knowledge about science (relationship and application to personal life, staying informed about science, reading science literature, listening to science programs).

8) Knowledge about science (general confidence, specific science topics and subjects, math-related science).

9) Positive attitudes displayed about science (interest, utilization, desire to learn more science, take more science classes).

10) Negative attitudes displayed about science in anxieties and concerns (inadequate science background, too difficult and confusing, unrelated to life, presentation, problems in the classroom, science equipment, making incorrect statements, children's questions, need for professional support, differences in science topics).

11) Image of a scientist (ability, personality, insensitivity, scientific method).

The initial research information, gathered qualitatively in the six personal interviews, was used by the researcher to design one of the quantitative surveys, Sampson Survey I. The other quantitative survey, Shrigley Science Attitude Scale or Survey II, was found in the research literature on science education. Therefore, the final quantitative results were obtained from the two surveys, Survey I and Survey II. Finally the quantitative results of the surveys and qualitative information of the interviews were compared.

## Surveys

### Survey I: Sampson Survey

From the reoccurring topics that appeared in the interviews, a survey of attitudes regarding science was designed by the researcher to yield quantitative information (see Appendix A for Sampson Survey I). This survey with 44 statements was given to all 57 pre-service teachers present in the two science methods classes at the University of North Dakota in the Fall semester, 1990. A Likert-type scale was used in responding to those 44 items. The possible responses were strongly disagree, disagree, undecided, agree, and agree strongly.

The last two statements on the survey, 45 and 46, required written responses. The statements were expected to be completed by the students. These were:

45) In general, the way I feel about science is...

46) I think I feel as I do about science because...

### Survey II: Shrigley Science Attitude Scale

In addition to Survey I, another quantitative survey was administered to the 57 students, Survey II or the Shrigley Science Attitude Scale for Pre-service Elementary

Teachers. Version II of this scale (Shrigley, 1974b) consists of 20 statements, 12 positive and 8 negative, designed to measure attitudes toward science. (See Appendix A for Survey II, Shrigley Science Attitude Scale.)

Results of Survey II obtained from 57 pre-service elementary education students at the University of North Dakota were compared with those obtained by Stefanich and Kelsey (1989), who administered the survey to 318 pre-service elementary teachers in two mid-western universities of similar size and history, University A and University B.

Students at University A had a prerequisite for enrollment in the elementary science methods course of two general education science courses, each of three semesters credits. The selection could be made from a wide variety of courses ranging from specific topics, such as weather and human origins, to ones of broader scope, such as environmental relationships and the physical sciences. With 400 students enrolled, the classes involved lectures-recitation with optional laboratory for some classes.

Students at University B were asked to complete not only comparable general education courses in science before enrollment, but also two basic science courses, which were Physical Science for Elementary Teachers and Biology for Elementary Teachers. There were not more than 30 students in these basic classes. Hands-on science experiences ideal for school settings were selected, materials usually available to elementary teachers were used, appropriate teaching techniques for elementary school were modeled, and instructors encouraged students' questions and responses. The courses were constructed to reflect the typical elementary science curriculum.

The results obtained by Stefanich and Kelsey (1989) indicated that University B had higher positive attitudes toward science in all four categories than students in University A: attitudes toward science content, attitudes toward handling science equipment, attitudes toward science teaching, and antipathy toward science teaching. The conclusion was that pre-service teachers are more likely to improve their attitudes toward science in small success-oriented classes when they can readily consult with the instructor and practice hands-on investigation and techniques useful in their future elementary teaching.

These attitudinal findings by Stefanich and Kelsey were compared with the pre-service teachers at the University of North Dakota.

## Survey I: Sampson Survey

### Reliability Analysis for Survey I

A reliability analysis was conducted on Survey I. A reliability procedure from SPSSX was used to generate a Cronbach's Alpha coefficient, which is used as a measure of homogeneity of response or variance. Items or statements on the survey were removed during the analysis in a sequence that attempted to achieve a high value for Cronbach's Alpha, and consequently maximize the internal reliability for the entire survey. Cronbach's Alpha indicates whether most of the respondents taking the survey consistently answered a particular question in the same way.

Thus, the least consistently answered item or statement on the survey, or the one with the lowest inter-correlations contributing to heterogeneity, was eliminated first. Therefore, the Alpha for the remaining statements in the survey increased as each inconsistent or unreliable statement was withdrawn. This procedure is executed in a stepwise manner similar to the backward elimination procedure used in multiple linear regression analysis.

Cronbach's Alpha is frequently used for Likert-type attitude scales. The reliability analysis considers how the surveyed group as a whole answers one particular question compared with the other questions, which shows if the items in the survey measure similar content. Thus, the Cronbach Alpha coefficient reflects the relationship or correlation between the responses of one specific question and the replies to all of the other questions. The coefficient discloses if any relationship actually exists between that question and the rest of the survey, or if other reasons or factors are involved in answering a particular item or statement. If there is not much relationship between one question and the rest of the survey, there would be a low correlation for that item. Consequently there would be a big increase in Cronbach's Alpha and, therefore, the reliability coefficient for the rest of the survey when that item was eliminated.

The Alpha is the probability or level of significance of not rejecting a null hypothesis which is in fact true, or not arriving at an erroneous conclusion. It is the goal of statistics to achieve the highest possible Alpha or level of significance. Thus, it is desirable to attempt to achieve an Alpha value as high as possible, preferably at least .80. A low value for Alpha or level of significance is an indication that no relationship concerning this item (or statement) may exist in the population under study.

Before any of the 44 items were dropped in Sampson Survey I, the Alpha or reliability coefficient was .8693, which indicated a reasonably high internal consistency for the survey. Thus, the original survey could be considered internally reliable, that each item was usually consistently answered in relation with the other items in the survey.

After 14 items were dropped, Cronbach's Alpha or the reliability coefficient was raised to .9111. Table 10 in Appendix B shows the order in which the questions were dropped (Questions 37, 36, 35, 11, 38, 20, 32, 22, 39, 31, 23, 26, 25, and 18), which indicates progressively which items in the survey were least consistently answered. Table 10 in Appendix B also shows the progressive increase in Cronbach's Alpha or the reliability coefficient for the remaining items as each item was eliminated.

Item Analysis Using Cronbach's Alpha for Survey I

An item analysis (Table 11 in Appendix B) using Cronbach's Alpha shows the total correlation after correction was done on the remaining items that were not dropped.

The correlation measures how a particular item influences the overall reliability of the test. As mentioned, the higher the correlation the more meaningful the item. Thus, when that particular item is included in the survey, a higher Alpha for the entire survey will be achieved because apparently more people answered that statement in the same way. This helps achieve a single scale of homogeneous items that presumably measures the construct under investigation.

In other words, Table 11 in Appendix B is an exploratory analysis of the Pearson correlation, in which correlations are compared with others on the scale. It is not testing a direct hypothesis, but relationships among data. The approximate significances shown are appropriate for hypothesis testing situations. Their usage is only for comparative purposes. Those correlations that are not significant are clearly non-significant relationships. The significant correlations may have their probability grossly underestimated because of multiple correlations.

Therefore, those items with the lowest zero-order correlations with the total, a measure of how a particular item influences the overall reliability, were dropped, as demonstrated in Table 10 in Appendix B. This procedure increased the Alpha factor and resulted in a more homogeneous survey. The 14 items dropped from the survey as shown in Table 11 in Appendix B are: Questions 11, 18, 20, 22, 23, 25, 26, 31, 32, 35, 36, 37, 38, and 39. The questions remaining in the survey are also given.

This procedure continued until a value of .9111 for Alpha was obtained. Question 24, which has the lowest correlation, .253, in Table 11 in Appendix B, would have been the next question removed if the procedure had been continued. If this question had been dropped, the value for Alpha would have increased to only .9116, according to Table 11 in Appendix B, which would have been a very small increase.

The scale mean, which is the arithmetic average of responses for the other items, if a particular item were deleted, was also obtained.

Factor Analysis for Survey I

A factor analysis is shown in Table 12 in Appendix B. The factor matrix, a more factor-pure scale, was completed to discover the intercorrelations among items. Thus, this analysis of factor loadings was compiled to show which statements in Survey I were related. The items with the highest values in each factor were answered more consistently in the same way by the student population surveyed.

Factor 1 in Table 12 in Appendix B appears to give the highest numbers to items (or questions) which show attitudes toward teaching classroom science by cutting out less important unrelated items, which are mainly those items dealing with cognitive processes, general attitudes about science, or aspects of science outside the classroom. The items with the highest values in Factor 1 are answered most consistently in the same way by the student population surveyed. These items address the most school-related questions, such as the most important skills and techniques in the teaching of science within the classroom. The results for Factor 1 also indicate the necessity of support for learning science. The literature also confirms the findings of the factor analysis that the physical sciences are more school-related than the other sciences. In addition, the analysis shows that having confidence in general science knowledge and math ability for science is also school-related.

Factor 2 in Table 12 in Appendix B principally gives the highest numbers to items (or questions) which show attitudes about science gathered outside the classroom. These items are answered less consistently the same way by the population surveyed because they tap or address other aspects of everyday life rather than the way science is presented in the classroom. For example, included in Factor 2 are items dealing with cognitive processes, general attitudes about science, or aspects of science outside the classroom. Most students have not taken geology, astronomy and ecology in school, and their understandings of those subjects may be possibly limited even though they might not realize it. Their knowledge about those science topics and biology was probably acquired mainly outside of school.

Were the third factor to be interpreted, it would be based on only four items, Questions 26, 27, 28, and 31. These four items appear to address a scientific attitude in general, rather than experience necessarily in a science classroom. Given the few number of items loading on Factor 3, no scales were developed to measure this factor. Also, no additional factors were interpreted.

The items with the highest values in each factor above are separated after Table 12 in Appendix B. That is, the questions with the highest values in each factor are given explicitly after the table. The survey indicates that each factor loading has related items.

## Survey II: Shrigley Science Attitude Scale

### Item Analysis Using Cronbach's Alpha for Survey II

An item analysis, Table 13 in Appendix B, using Cronbach's Alpha was also completed on all of the results of Survey II, the Shrigley Science Attitude Scale, to determine if the items were consistently answered by the group surveyed. Again similar information was obtained as with Survey I, such as the scale mean if the item was deleted, the corrected correlation with the total correlation, the squared multiple correlation, and the Cronbach's Alpha if the item were deleted.

Again the higher the Alpha calculated if the item were deleted, the more people answered the question the same way. The Alpha obtained for all the questions was .9111. This Alpha, or the level of significance, was high, showing that the items in Survey II were consistently answered by the respondents as a group.

Then a similar item analysis using Cronbach's Alpha was done separately on the four categories of the Shrigley Science Attitude Scale, which were attitudes toward science content (Table 14 in Appendix B), attitudes toward handling science equipment (Table 15 in Appendix B), attitudes toward science teaching (Table 16 in Appendix B), and antipathy toward science teaching (Table 17 in Appendix B).

All of the analyses of the Shrigley Science Attitude Scale showed that the scale and subscales are fairly reliable or homogeneous. It appears that they are measuring the same thing.

## Data Compilation and Statistical Procedures for Survey I and Survey II

Both quantitative surveys, Sampson's and the Shrigley Science Attitude Scale, were arranged so that the answers could be marked according to the Likert-scale with numerical values (5 for agree strongly, 4 for agree mildly, 3 for undecided, 2 for disagree mildly, and 1 for disagree strongly)

The frequencies and percentages of respondents answering each question in a given way, and the means and standard deviations of responses to each statement in the two surveys, were calculated.

The frequency is the total number of students who gave the same response to each of the five choices available: disagreed strongly, disagreed mildly, undecided, agreed mildly, agreed strongly.

The mean is the arithmetic average of responses for an item. It is obtained by adding together the numerical values of all the responses for one item: 1 (disagreed strongly), 2 (disagreed mildly), 3 (undecided), 4 (agreed mildly), 5 (agreed strongly), then dividing the total by the number of responses for that item.

The standard deviation is the square root of the variance. It is a descriptive measure of dispersion in that it is expressed in the same units as the original measure. It shows the spread of values in the responses.

The Pearson Correlation and Approximate Significance of each correlation for every other question in Survey I to seven of the questions were calculated. The seven questions were chosen for determining the correlations because they appear to indicate general attitudes toward science. The seven questions were:

1. (Q21) I have confidence about my general science knowledge.
2. (Q23) I feel I want to learn more science.
3. (Q40) It will be easy for me to teach life sciences (biology) in the elementary school.
4. (Q41) It will be easy for me to teach physical sciences (physics, chemistry) in the elementary school.
5. (Q42) It will be easy for me to teach earth sciences in the elementary school.
6. (Q43) It will be easy for me to teach space sciences (astronomy) in the elementary school.
7. (Q44) It will be easy for me to teach ecology in the elementary school.

The Pearson Correlation Coefficient may indicate the possibility of a relationship between the responses of a student to two particular questions. The higher the correlation, the more meaningful the relationship; that is, the more bearing the response of a student to one question has on the student's response to the other question. Correlations higher than .30 are considered to be meaningful. A high positive correlation indicates that a direct relationship may exist; that is, if a high response is given for one question, a high response can be expected for the other question. A high negative correlation indicates an inverse relationship may exist. This means if a high response is given for one question, a low response will probably be given for the other question.

The Approximate Significance, or Level of Significance, is the probability of rejecting a hypothesis which is in fact true and arriving at an erroneous conclusion, that is claiming a relationship exists between an independent and dependent variable when no such relationship actually does. Therefore, the lower the numerical value for the approximate significance the better. A value of .01 (which means not rejecting one relationship in one hundred that should have been rejected) is considered desirable. A numerical value even lower indicates a more statistically significant relationship. However, levels of .05 are often acceptable and may indicate some meaningful relationship exists.

# CHAPTER IV

## RESULTS OF SURVEYS

There were two survey instruments used in this research. Survey I (Sampson Survey), consisting of 46 questions, was designed by the researcher and constructed from information gathered in the oral interviews with six pre-service teachers about their past educational and life experiences with science and their attitudes toward science.

Survey II (Shrigley Science Attitude Scale), consisting of 20 questions, was given to assess the attitudes toward science of the same group of 57 pre-service teachers. The results of Survey II were compared with pre-service teachers at two other mid-western institutions.

Table 18 in Appendix B shows the valid frequencies and percentages of respondents answering each question in Survey I, and the means and standard deviations of responses.

Table 19 in Appendix B gives the frequencies and percentages of respondents answering each question, and the means and standard deviations of responses to each question in Survey II, Shrigley's Science Attitude Scale.

## Survey I: Sampson Survey

Forty-one percent of pre-service teachers claimed in Survey I that they had confidence in their general science knowledge. Table 20 in Appendix B shows the exploratory analysis of the Pearson Correlation and Approximate Significance of each correlation for every other question in Survey I by Question 21, "I have confidence in my general science knowledge."

Table 1 shows the questions in Survey I that are meaningfully correlated with Question 21, "I have confidence in my general science knowledge." The correlation and approximate significance of each of those questions are also given.

Table 1

Sampson Survey: Meaningful Correlations with Question 21

| | r | p | Question |
|---|---|---|---|
| Q1 | .339 | .005 | I remember science being taught in an exciting hands-on approach in elementary school. |
| Q2 | -.361 | .003 | I remember almost nothing about science in elementary school. |
| Q4 | .342 | .005 | My science classes in junior high/high school were taught in an interesting fashion. |
| Q6 | .479 | .001 | My parents were supportive in establishing an interest in science in their children (examples: purchased dissecting kits or telescopes, pointed out aspects of nature, went on trips to museums or on nature walks, initiated discussions). |

| | r | p | Question |
|---|---|---|---|
| Q7 | .489 | .001 | I found somebody who would answer my questions about science (teacher, parent, sibling, or another person). |
| Q9 | .307 | .011 | My junior high/high school teachers could explain science on my level. |
| Q12 | .484 | .001 | The educational instruction in science classes stimulated my present curiosity. |
| Q13 | .532 | .001 | I could relate my science education in school to my personal life and apply it. |
| Q15 | .356 | .004 | I had opportunities for making unexpected new discoveries and for exploring new ideas in science class. |
| Q19 | .471 | .001 | I was comfortable asking questions of the teacher. |
| Q29 | .368 | .003 | I am confident I would be successful taking non-CTL science classes. |
| Q30 | .338 | .005 | I have confidence about my mathematical ability for non-CTL science classes. |
| Q31 | .305 | .011 | Anybody can be a scientist. |
| Q33 | -.304 | .011 | I fear that I will make incorrect statements about science when I teach. |
| Q40 | .538 | .001 | It will be easy for me to teach life sciences (biology) in the elementary school. |
| Q41 | .513 | .001 | It will be easy for me to teach physical sciences (physics, chemistry) in the elementary school. |
| Q42 | .427 | .001 | It will be easy for me to teach earth sciences (geology) in the elementary school. |
| Q43 | .350 | .004 | It will be easy for me to teach space sciences (astronomy) in the elementary school. |
| Q44 | .429 | .001 | It will be easy for me to teach ecology in the elementary school. |

Ninety-eight percent of pre-service teachers claimed in Survey I that they wanted to learn more science. Table 21 in Appendix B gives the exploratory analysis of the Pearson Correlation and Approximate Significance of each correlation for every other question in Survey I with Question 23, "I feel I want to learn more science."

Table 2 shows the question in Survey I that is meaningfully correlated with Question 23, "I feel I want to learn more science." The correlation and approximate significance of that question are also given.

Table 2

Sampson Survey: Meaningful Correlation with Question 23

| | r | p | Question |
|---|---|---|---|
| Q25 | .316 | .009 | I seek answers to my questions about science (examples: from teachers, library, news magazines, science journals). |

Seventy percent of pre-service teachers claimed in Survey I that they had the confidence to teach life sciences (biology) in the elementary school. Table 22 in Appendix B gives the exploratory analysis of the Pearson Correlation and Approximate Significance of each correlation for every other question in Survey I with Question 40, "It will be easy for me to teach the life sciences (biology) in the elementary school."

Table 3 shows the questions in Survey I that are meaningfully correlated with Question 40, "It will be easy for me to teach life sciences (biology) in the elementary school." The correlation and approximate significance of each of those questions are also given.

Table 3

Sampson Survey: Meaningful Correlations with Question 40

| | r | p | Question |
|---|---|---|---|
| Q6 | .340 | .005 | My parents were supportive in establishing an interest in science in their children (examples: purchased dissecting kits or telescopes, pointed out aspects of nature, went on trips to museums or on nature walks, initiated discussions). |
| Q7 | .301 | .012 | I found somebody who would answer my questions about science (teacher, parent, sibling, or another person). |
| Q19 | .335 | .006 | I was comfortable asking questions of the teacher. |
| Q21 | .538 | .001 | I have confidence about my general science knowledge. |
| Q24 | .398 | .001 | I read articles about science and deliberately try to stay informed about advances in science. |
| Q25 | .417 | .001 | I seek answers to my questions about science (examples: from teachers, library, news magazines, science journals). |
| Q29 | .362 | .003 | I am confident I would be successful taking non-CTL science classes. |
| Q31 | .520 | .001 | Anybody can be a scientist. |
| Q41 | .485 | .001 | It will be easy for me to teach physical sciences (physics, chemistry) in the elementary school. |
| Q42 | .650 | <.001 | It will be easy for me to teach earth sciences (geology) in the elementary school. |
| Q43 | .476 | .001 | It will be easy for me to teach space sciences (astronomy) in the elementary school. |
| Q44 | .648 | <.001 | It will be easy for me to teach ecology in the elementary school. |

Twenty-eight percent of pre-service teachers claimed in Survey I that they had confidence to teach the physical sciences (physics, chemistry) in the elementary school. Table 23 in Appendix B gives the exploratory analysis of the Pearson Correlation and Approximate Significance of each correlation for every other question in Survey I with Question 41, "It will be easy for me to teach the physical sciences (physics, chemistry) in the elementary school."

Table 4 shows the questions in Survey I that are meaningfully correlated with Question 41, "It will be easy for me to teach the physical sciences (physics, chemistry) in the elementary school." The correlation and approximate significance of each of those questions are also given.

Table 4

Sampson Survey: Meaningful Correlations with Question 41

| | r | p | Question |
|---|---|---|---|
| Q2 | -.317 | .008 | I remember almost nothing about science in elementary school. |
| Q6 | .373 | .002 | My parents were supportive in establishing an interest in science in their children (examples: purchased dissecting kits or telescopes, pointed out aspects of nature, went on trips to museums or on nature walks, initiated discussions). |
| Q7 | .424 | .001 | I found somebody who would answer my questions about science (teacher, parent, sibling, or another person). |
| Q9 | .449 | .001 | My junior high/high school science teachers could explain science on my level. |
| Q10 | .455 | .001 | My junior high/high school science teachers were patient and understanding. |
| Q12 | .402 | .001 | The educational instruction in science classes stimulated my present curiosity. |
| Q13 | .536 | .001 | I could relate my science education in school to my personal life and apply it. |
| Q15 | .411 | .001 | I had opportunities for making unexpected new discoveries and for exploring new ideas in science class. |
| Q19 | .501 | .001 | I was comfortable asking questions of the teacher. |
| Q21 | .513 | .001 | I have confidence about my general science knowledge. |

| | r | p | Question |
|---|---|---|---|
| Q24 | .366 | .003 | I read articles about science and deliberately try to stay informed about advances in science. |
| Q28 | .302 | .011 | I have cultivated a desire to search for patterns and meanings. |
| Q29 | .519 | .001 | I am confident I would be successful taking non-CTL science classes. |
| Q30 | .397 | .001 | I have confidence about my mathematical ability for non-CTL science classes. |
| Q31 | .363 | .003 | Anybody can be a scientist. |
| Q35 | -.323 | .007 | It will be easy for me to teach reading in the elementary school. |
| Q40 | .485 | .001 | It will be easy for me to teach life sciences (biology) in the elementary school. |
| Q42 | .523 | .001 | It will be easy for me to teach earth sciences (geology) in the elementary school. |
| Q43 | .536 | .001 | It will be easy for me to teach space sciences (astronomy) in the elementary school. |
| Q44 | .429 | .001 | It will be easy for me to teach ecology in the elementary school. |

Fifty-three percent of pre-service elementary teachers claimed in Survey I that they had the confidence to teach the earth sciences (geology) in the elementary school. Table 24 in Appendix B gives the exploratory analysis of the Pearson Correlation and Approximate Significance of each correlation for every other question in Survey I with Question 42, "It will be easy for me to teach the earth sciences (geology) in the elementary school."

Table 5 shows the questions in Survey I that are meaningfully correlated with Question 42, "It will be easy for me to teach the earth sciences (geology) in the elementary school." The correlation and approximate significance of each of those questions are also given.

Table 5

Sampson Survey: Meaningful Correlations with Question 42

| | r | p | Question |
|---|---|---|---|
| Q21 | .427 | .001 | I have confidence in my general science knowledge. |
| Q24 | .486 | .001 | I read articles about science and deliberately try to stay informed about advances in science. |
| Q28 | .309 | .010 | I have cultivated a desire to search for patterns and meanings. |
| Q29 | .443 | .001 | I am confident I would be successful taking non-CTL science classes. |
| Q31 | .379 | .002 | Anybody can be a scientist. |
| Q33 | -.360 | .003 | I fear that I will make incorrect statements about science when I teach. |
| Q34 | -.467 | .001 | I feel that I may need some support from other professionals when I teach. |
| Q40 | .650 | <.001 | It will be easy for me to teach life sciences (biology) in the elementary school. |
| Q41 | .523 | .001 | It will be easy for me to teach physical sciences (physics, chemistry) in the elementary school. |
| Q43 | .701 | <.001 | It will be easy for me to teach space sciences (astronomy) in the elementary school. |
| Q44 | .560 | <.001 | It will be easy for me to teach ecology in the elementary school. |

Forty-six percent of pre-service teachers claimed in Survey I that they had the confidence to teach the space sciences (astronomy) in the elementary school. Table 25 in Appendix B gives the exploratory analysis of the Pearson Correlation and Approximate Significance of each correlation for every other question in Survey I with Question 43, "It will be easy for me to teach the space sciences (astronomy) in the elementary school."

Table 6 shows the questions in Survey I that are meaningfully correlated with Question 43, "It will be easy for me to teach the space sciences (astronomy) in the elementary school." The correlation and approximate significance of each of those questions are also given.

Table 6

Sampson Survey: Meaningful Correlations with Question 43

| | r | p | Question |
|---|---|---|---|
| Q1 | .346 | .004 | I remember science being taught in an exciting hands-on approach in elementary school. |
| Q21 | .350 | .004 | I have confidence about my general science knowledge. |
| Q24 | .517 | .001 | I read articles about science and deliberately try to stay informed about advances in science. |
| Q29 | .492 | .001 | I am confident I would be successful taking non-CTL science classes. |
| Q31 | .395 | .001 | Anybody can be a scientist. |
| Q34 | -.336 | .005 | I feel I may need some support from other professionals when I teach science. |
| Q40 | .476 | .001 | It will be easy for me to teach life science (biology) in the elementary school. |
| Q41 | .536 | .001 | It will be easy for me to teach physical sciences (physics, chemistry) in the elementary school. |
| Q42 | .701 | <.001 | It will be easy for me to teach earth sciences (geology) in the elementary school. |
| Q44 | .630 | <.001 | It will be easy for me to teach ecology in the elementary school. |

Fifty-eight percent of the pre-service elementary teachers claimed in Survey I that they had the confidence to teach ecology in the elementary school. Table 26 in Appendix B gives the exploratory analysis of the Pearson

Correlation and Approximate Significance of each correlation for every other question in Survey I with Question 44, "It will be easy for me to teach ecology in the elementary school."

Table 7 shows the questions in Survey I that are meaningfully correlated with Question 44, "It will be easy for me to teach ecology in the elementary school." The correlation and approximate significance of each of those questions are also given.

Table 7

Sampson Survey: Meaningful Correlations with Question 44

| | r | p | Question |
|---|---|---|---|
| Q10 | .312 | .009 | My junior high/high school science teachers were patient and understanding. |
| Q15 | .303 | .012 | I had opportunities for making unexpected new discoveries and for exploring new ideas in science class. |
| Q21 | .429 | .001 | I have confidence about my general science knowledge. |
| Q24 | .362 | .003 | I read articles about science and deliberately try to stay informed about advances in science. |
| Q25 | .316 | .008 | I seek answers to my questions about science (examples: from teachers, library, news magazines, science journals). |
| Q28 | .311 | .009 | I have cultivated a desire to search for patterns and meanings. |
| Q29 | .346 | .004 | I am confident I would be successful taking non-CTL science classes. |
| Q31 | .377 | .002 | Anybody can be a scientist. |
| Q34 | -.336 | .005 | I feel I may need some support from other professionals when I teach science. |

| | r | p | Question |
|---|---|---|---|
| Q40 | .648 | <.001 | It will be easy for me to teach the life sciences (biology) in the elementary school. |
| Q41 | .429 | .001 | It will be easy for me to teach the physical sciences (physics, chemistry) in the elementary school. |
| Q42 | .560 | <.001 | It will be easy for me to teach the earth sciences (geology) in the elementary school. |
| Q43 | .630 | <.001 | It will be easy for me to teach the space sciences (astronomy) in the elementary school. |

Table 8 is a summary of correlations of the above seven questions in Survey I. For a question to be placed in Table 8 there had to be at least one significant correlation with one of the above seven questions.

Table 8

Sampson Survey: Summary of Correlations

| | Question | GSK | W | LS | PS | ES | SS | EC |
|---|---|---|---|---|---|---|---|---|
| Q1 | Remember hands-on elem science | .34 | -.08 | .09 | .25 | .26 | .35 | .28 |
| Q2 | Remember nothing about elem science | -.36 | .03 | -.05 | -.32 | -.08 | .01 | -.03 |
| Q4 | Science taught interestingly | .34 | -.05 | .12 | .26 | .02 | -.03 | .02 |
| Q6 | Parents supportive | .48 | -.11 | .34 | .37 | .07 | .06 | .16 |
| Q7 | Somebody to answer questions | .49 | .10 | .30 | .42 | .16 | .13 | .16 |
| Q9 | Explained on my level | .31 | -.09 | .05 | .45 | .12 | .03 | <.00 |
| Q10 | Patient & under-standing teachers | .28 | .16 | .21 | .46 | .28 | .13 | .31 |
| Q12 | Curiosity stimulated by teachers | .48 | -.02 | .23 | .40 | .21 | .19 | .20 |
| Q13 | Related to life | .53 | -.05 | .22 | .54 | .29 | .22 | .27 |
| Q15 | Opportunities for exploration | .36 | -.05 | .26 | .41 | .24 | .18 | .30 |

| Question | GSK | W | LS | PS | ES | SS | EC |
|---|---|---|---|---|---|---|---|
| Q19 Able to ask teacher questions | .47 | -.13 | .34 | .50 | .12 | -.02 | .20 |
| Q21 General science confidence | X | -.06 | .54 | .51 | .43 | .35 | .43 |
| Q24 Try to stay informed | .21 | .08 | .40 | .37 | .49 | .52 | .36 |
| Q25 Seek answers to questions | .03 | .32 | .42 | .20 | .28 | .25 | .32 |
| Q28 Search for patterns & meanings | .17 | .27 | .28 | .30 | .31 | .18 | .31 |
| Q29 Willing to take non-CTL science courses | .37 | .19 | .36 | .52 | .44 | .49 | .35 |
| Q30 Math confidence | .34 | .09 | .10 | .40 | .17 | .19 | .12 |
| Q31 Anybody can be a scientist | .31 | .18 | .52 | .36 | .38 | .40 | .38 |
| Q33 Fear making in-correct statements | -.30 | -.17 | -.27 | -.23 | -.36 | -.23 | -.28 |
| Q34 Need professional support | -.24 | .01 | -.27 | -.26 | -.47 | -.34 | -.34 |
| Q35 Confidence to teach reading | -.11 | .13 | .01 | -.32 | -.01 | -.12 | -.05 |
| Q40 Confidence to teach life sciences | .54 | .29 | X | .49 | .65 | .48 | .65 |
| Q41 Confidence to teach physical sciences | .51 | .10 | .49 | X | .52 | .54 | .43 |
| Q42 Confidence to teach earth sciences | .43 | .23 | .65 | .52 | X | .70 | .56 |
| Q43 Confidence to teach space sciences | .35 | .16 | .48 | .54 | .70 | X | .63 |
| Q44 Confidence to teach ecology | .43 | .22 | .65 | .43 | .56 | .63 | X |

Note.
Correlations of .22 or greater are significant at the .05 level.
Correlations of .30 or greater are significant at the .01 level

GSK= Q21 Confidence about general science knowledge
W = Q23 Want to learn more science
LS = Q40 Confidence about teaching life sciences
PS = Q41 Confidence about teaching physical sciences
ES = Q42 Confidence about teaching earth sciences
SS = Q43 Confidence about teaching space sciences
EC = Q44 Confidence about teaching ecology

Question 45 and question 46 required narrative replies. Question 45 was, "In general, the way I feel about science is...." Question 46 was suggesting an explanation for Question 45, "I think I feel as I do about science because...."

A tally of the written responses from questions 44 and 45 indicated that there were three times more pre-service elementary teachers (43) who lacked confidence in their general science knowledge or their ability to teach all the sciences than the number of pre-service teachers (14) who expressed confidence in teaching all the sciences.

There appeared to be several themes within the explanations of the pre-service teachers for their negative attitudes about science and science teaching. The general categories and some examples of comments follow:

One theme was a repeatedly expressed concern about having inadequate science knowledge and having had too few science classes. There were many variations of this theme: "worried if I have enough background knowledge," "never learned much science growing up and don't understand it," "never had a good science curriculum," "don't have ... knowledge to explain 'why'," and "so much to learn about the world we live in."

A second category consisted of memories of negative past experiences in science class and the way science was taught to them. Examples of remarks within this category were: "past experiences left negative feelings," "never had a good science teacher," "never had hands-on experiences," "just read and took a little test," "no emphasis on understanding science concepts," and "not applied to real life situations."

A third category indicated inner feelings of many pre-service teachers about their low science or mathematical ability: "incompetent which led to disinterest," "always found science difficult and confusing," and "problems with mathematics in science."

A fourth general theme appeared to be a lack of confidence about future ability to teach science. Within this category was: "worried about science teaching," "not very confident about teaching science," "concern about teaching hands-on," "not sure how to teach children science," and "many things fascinate me, don't know how to use them."

In a fifth category some pre-service teachers expressed the need for role models by stating: "more positive role models needed," and "nobody stressing its importance."

Some pre-service teachers expressed mixed feelings about their past science experiences: "had good and bad science teachers so can tell the difference," and "so much to learn; some interesting, then know; some not, then know less."

Nevertheless, some pre-service teachers expressed their confidence in science, the importance of science to them, and the utilization of their knowledge about science: "have basic understanding of it," "love it, it's interesting and fun," "with math teaches how to think, understand life, and solve problems," and "it's a large part of our life and explains it."

Curiosity was an aspect revealed by some pre-service teachers, who were positive about science. Examples were: "important to know why, questions lead to more questions," "have a need to know why things act, work as they do," and "like explanations for why things happen."

Some mentioned the importance of quality teachers and teaching methods: "had really positive experiences with science, which I want to pass on," "early experiences creative, allowed to explore, find answers," " it's interesting, fun and valuable if taught correctly," and "had good experiences even if I never excelled in it."

Some recalled supportive teachers or family, who stimulated their current positive attitudes: "Chemistry teacher had us teach concepts to elementary students," "had support from teachers, parents and grandparents, father taught earth science," and "had a good life-science teacher in high and grew up on a farm."

Some pre-service teachers said they were more comfortable with biology: "active in nature so involved in that aspect of science", "taken more biology than any other science", and "enjoy learning more about life sciences." On the other hand, chemistry and physics were occasionally preferred to geology and biology.

Some pre-service teachers offered their own solution to their inadequate science background: "will learn with my students," and "hope to learn as I go."

Thus, it appears from Questions 45 and 46 that about 75% of pre-service teachers do not have confidence in their general science knowledge or in their ability to teach elementary science. Some blame their teachers for their insecurity, inadequate science experiences and poor attitudes. Many revealed that they had none or only a few hands-on or investigative science experiences, and science was not related to their personal life. In fact, some say that they don't understand science concepts because they were taught by lecture, textbook and memorization. Many claim that they have had poor role models in science. It appeared that more had positive experiences in biology than in chemistry and physics.

## Survey II: Shrigley Science Attitude Scale

Table 9 compares the means obtained from Survey II (Shrigley Science Attitude Scale) at the University of North Dakota with the means obtained by Stefanich and Kelsey (1989) from two other midwestern universities, University A and University B. Those two universities had different prerequisites prior to enrolling in the elementary science methods. Students at University A were required to complete

Table 9

Shrigley Science Attitude Scale Survey: Comparison of Means

| Category | | | University A | University B | University of ND |
|---|---|---|---|---|---|
| Q1 | III | Neg | 3.13 | 2.35 | 2.49 |
| Q2 | I | | 2.09 | 2.70 | 2.56 |
| Q3 | I | Neg | 3.01 | 2.03 | 2.09 |
| Q4 | II | Neg | 3.07 | 2.35 | 2.67 |
| Q5 | II | | 3.40 | 3.86 | 3.86 |
| Q6 | IV | Neg | 3.42 | 2.91 | 3.46 |
| Q7 | II | | 3.51 | 4.21 | 4.14 |
| Q8 | I | | 1.88 | 2.58 | 2.75 |
| Q9 | I | | 2.05 | 2.72 | 2.74 |
| Q10 | I | Neg | 3.25 | 2.38 | 2.72 |
| Q11 | II | | 3.23 | 3.76 | 3.91 |
| Q12 | IV | Neg | 3.67 | 3.45 | 2.72 |
| Q13 | I | | 2.33 | 3.41 | 3.30 |
| Q14 | II | Neg | 3.35 | 2.96 | 2.97 |
| Q15 | II | | 3.02 | 3.64 | 3.84 |
| Q16 | III | | 2.38 | 3.09 | 3.14 |
| Q17 | IV | Neg | 3.26 | 2.40 | 2.77 |
| Q18 | III | | 3.46 | 4.01 | 3.93 |
| Q19 | III | | 2.68 | 3.36 | 3.25 |
| Q20 | III | | 3.02 | 3.58 | 3.72 |

Note.
Category I - Attitude toward science content
Category II - Attitude toward handling science equipment
Category III - Attitude toward science teaching
Category IV - Antipathy toward science teaching
Neg - Negative statement

two general education science courses of 3 semester credits, which have up to 400 students enrolled in a lecture-recitation class with optional laboratory registration offered for some. In addition to comparable general education courses in science, students at University B were required to complete two basic hands-on science methods courses (Physical Science for Elementary Teachers and Biology for Elementary Teachers), which maintained levels of only 30 students.

# CHAPTER V

# DISCUSSION AND INTERPRETATIONS OF THE SURVEY DATA

## Survey I: Sampson Survey

Frequencies and percentages of respondents answering each question in Sampson Survey I were calculated. (Refer to Chapter III, Methodology, Data Compilation and Statistical Procedures, and also Appendix B, Table 18.)

According to the percentages obtained from Sampson Survey I, most pre-service teachers do not remember much science in elementary school. For example, 63% remember almost nothing about elementary science, and 70% do not remember science being taught in an exciting hands-on approach in elementary school. Sixty percent remember only a few hands-on experiences.

As a group, the pre-service teachers have mixed feelings about whether their junior high/high school classes were taught in an interesting fashion. Fifty-four percent agreed their science classes had been interesting.

However, it appears that most students have a lower regard for the way the physical sciences were taught than for the way the life sciences were taught. For example, the survey revealed that only 16% thought their physical science classes (chemistry, physics) were taught more interestingly than their life science classes (biology), and only 5% could relate their physical science classes more to their personal life than their life science classes.

The students were critical about their science teachers. Only about half of the pre-service teachers (53%) found that their junior high/high school science teachers could explain science on their level; 52% were comfortable asking their science teachers questions; and only 47% had found their science teachers were patient and understanding.

In response to questions about the teaching methods used by their previous science teachers, considerably less than half of the students (25%) reported that they were encouraged to discover their own mistakes and misconceptions in science; 34% had opportunities for making unexpected new discoveries and for exploring new ideas in science class; 35% were taught to find answers themselves to science questions; 38% could relate their science education to their personal life; and 41% thought the instruction had stimulated their present curiosity. While 45% of students had understanding of concepts stressed in some classes, 89% had memorizing science terminology stressed in some classes. It was revealed that 29% believed that they had learned as much about teaching science from their bad science teachers as from their good science teachers.

Most (91%) claimed that their non-school experiences stimulated their present curiosity more than their science classes in school. There were almost equal responses as to whether or not they had parents who supported their science activities (agreed 46%, disagreed 40%). In fact, only 51% found somebody (teacher, parent, sibling, another person) who would answer questions about science.

While 41% have confidence in their general science knowledge, 98% want to learn more science. Nevertheless, only 75% believe that taking more science classes outside of the College of Education would make them a better teacher of science. This may be because only 47% are confident about being successful in science courses outside the College of Education, and only 44% feel they have the mathematical ability for these science courses.

Their current lack of interest in science is apparent when only 40% seek answers to their science questions, and only 42% claim that they read articles about science and deliberately try to stay informed about the advances in science in spite of the frequency of science television programs and news about science.

Most of these pre-service teachers (67%) claim that they have acquired the habit of questioning information; 54% claim that they logically and methodically approach the solution of problems, and 53% claim that they have cultivated a desire to search for patterns and meanings. However, only 44% think anybody can be a scientist, and 35% think a scientist acts and thinks differently than other people.

The survey shows definite differences in confidence levels across the subject matter areas. Most of these pre-service elementary teachers have confidence that they will be able to teach reading (82%), to teach elementary art (84%), to teach elementary math (74%), and to teach elementary social studies (70%). However, fewer pre-service teachers have the confidence to teach most sciences in the elementary school, especially the physical sciences, chemistry and physics. For example, 70% say they have confidence to teach life sciences (biology), 58% to teach ecology, 53% to teach earth sciences (geology), and 46% to teach space sciences (astronomy) while only 28% believe that they will be able to teach physical sciences in the elementary school.

Forty-five percent of pre-service elementary teachers realistically fear that they will make incorrect statements about science, while 23% are undecided whether they will make incorrect statements. In fact, 74% feel that they may need support from other professionals when teaching science.

Pearson Correlation and approximate significance were also calculated for every other question (seven questions) in Sampson Survey I. (Refer to Chapter III, Methodology, Data Compilation and Statistical Procedures, and also Chapter IV, Tables 1, 2, 3, 4, 5, 6, 7, and 8, and Appendix B, Tables 20, 21, 22, 23, 24, 25, and 26.

Correlations above .30 with approximate significance of at least .01 may be considered significant in the sense that they show at least a 9% ($r^2$) overlap in shared variance. Those with correlations above .22 may indicate that a relationship exists because the approximate significance is at least .05. These correlations may bear interesting relationships, even if they are not strong.

There are several relationships that appear to be highly significant with correlations above .30 and with an approximate significance of at least .01. High significant relationships exist between those pre-service elementary teachers with confidence to teach one branch of elementary school science, such as life, physical, earth and space sciences, and ecology, and those who have confidence to teach all elementary school sciences.

Also, high significant relationships ($p<.01$) appear to exist between confidence to teach all branches of elementary science and the deliberate practice of reading articles to stay informed about advances in science. There are high significant relationships ($p<.01$) between those elementary education students who already have the confidence to teach all branches of science and those who have confidence in their general science knowledge.

In addition, those students who have confidence that they would be successful taking non-CTL science classes (classes outside of the Center for Teaching and Learning), which are typically not methods classes, also have confidence in their general science knowledge and in their ability to teach all branches of science ($p<.01$). Also, both having confidence to teach all branches of elementary science and having confidence in general science knowledge are very significantly related to believing that anybody can be a scientist ($p<.01$). It may imply that those pre-service elementary teachers with confidence to teach all sciences also feel that any student can learn science.

It appears that having had early rich discovery experiences, support from others, and models in science inside and outside of school are important in acquiring confidence in the physical sciences (physics, chemistry) and in general science knowledge. Many common school-related antecedents appear for those pre-service teachers who have confidence to teach the physical sciences and those who have confidence in their general science knowledge. The higher correlations show that confidence in the physical sciences may be more school-oriented than confidence in the other branches of science, such as biology, geology, ecology, and space science. It indicates that prior quality instruction may be the most important antecedent for those who have confidence in the physical sciences and in their general science knowledge. There was a high correlation ($p<.01$) between students confident in teaching the physical sciences and in having general science knowledge, and students remembering elementary school science, having had opportunities for exploration in science class, and having had science education related to their personal life. Both groups, those with confidence in teaching physical science and those with confidence in their general science knowledge, had teachers who explained on their level, stimulated their curiosity, and willingly answered questions in a non-threatening manner ($p<.01$). Both groups express confidence in their math ability for science, feel anybody can be a scientist, and believe they can teach any elementary school science ($p<.01$). In addition, those pre-service teachers with confidence to teach the physical sciences report having patient and understanding science teachers ($p<.01$). Those with confidence to teach the physical and earth sciences have acquired the ability to search for patterns and meanings ($p<.01$).

Having had opportunities in science class for making unexpected new discoveries and for exploring new ideas was not only significantly related ($p<.01$) to having general science confidence and confidence to teach the physical sciences, but also to having confidence to teach ecology.

Highly significant relationships ($p<.01$) also exist between having confidence about general science knowledge and the confidence to teach both life and physical sciences, and items that deal with students being able to find answers to their questions, such as having supportive parents, having somebody around to answer questions and being able to ask teachers questions. The fact that these significant relationships do not exist for earth science, space science and ecology may reflect the fact that in school most pre-service elementary teachers have only taken life or physical sciences, and not earth and space sciences, or ecology. Also, it may indicate that parents are generally more aware and supportive of life and physical sciences than they are of earth and space sciences, or ecology.

In fact, the generally lower correlations of school-oriented items in the survey with earth science, space science and ecology may simply show that they have not been intensely taught in school, but some knowledge and confidence about those subjects has been acquired outside the classroom, especially by those who try to stay informed about the advances in science, those who have confidence in other branches of science, and those who have confidence in their general science knowledge. If those branches of science were taught thoroughly in school, they might be perceived to be as school-oriented as the physical sciences by many students.

Although a highly significant relationship ($p<.01$) exists between elementary education students wanting to learn more science and those attempting to seek answers to their science questions, this research shows that there is no relationship between those who want to learn more science and those who try to stay informed about the advances in science. Neither is there any relationship between those wanting to learn more science and those having confidence in their general science knowledge and confidence to teach any branch of science. This may indicate that many elementary teachers simply hope somehow to learn enough to teach elementary science, but are not really interested in the current advances in science or taking more science classes.

There are high significant relationships ($p<.01$) between those remembering science being taught in an exciting hands-on approach in elementary school and those with confidence in general science knowledge and confidence to teach space science. In addition, several interesting, though not strong, relationships (with correlations at least above .22 and approximate exploratory significance above .05) exist between those who remember science being taught in an exciting hands-on approach in elementary school and those who have confidence in their ability to teach physical science, earth science and ecology. It may indicate the importance of teaching discovery methods in elementary school science.

However, there appears to be no relationship between those who have confidence in their ability to teach life sciences and those who remember exciting hands-on approaches in science in elementary school. It may be that students can relate early hands-on life science experiences outside the classroom to their personal life more than early hands-on experiences in physical, earth and space sciences, and ecology.

As mentioned previously, there appears to be a highly significant relationship ($p<.01$) between those who had classroom discovery opportunities and those with confidence in physical science, ecology and general science knowledge. There are also interesting relationships ($p<.05$) between those who had opportunities for exploration in science class and those who have confidence to teach life and earth sciences. This seems to show the importance of teaching hands-on science.

Also, highly significant relationships ($p<.01$) were found between those students who could relate their science education to their own life and those with confidence in general science knowledge and physical science. In addition, interesting relationships ($p<.05$) appear between those students who could relate science education to their own life and those with confidence to teach life, earth and space sciences, and ecology.

It is not surprising that those students who do not fear making incorrect statements about science in the classroom have confidence in their general science knowledge ($p<.01$) and their ability to teach life ($p<.05$), physical ($p<.05$), earth ($p<.01$) and space ($p<.05$) sciences, and ecology ($p<.05$). Those who do not feel they will need the support from other professionals appear to have confidence in their general science knowledge ($p<.05$) and also their ability to teach all sciences in the elementary school, that is life ($p<.05$), physical ($p<.05$), earth ($p<.01$) and space ($p<.01$) sciences, and ecology ($p<.01$).

In summary, it appears from the quantitative analysis of the Sampson Survey responses that in order for pre-service teachers to have acquired the confidence to teach all the sciences in the elementary school, it is necessary to have had early, useful and relevant science experiences, especially in school, such as hands-on elementary science classes, opportunities in science for exploration and discovery, and science classes that were interesting and made applicable to their personal lives. It is important to have had patient and understanding science teachers who explained on the student's level, stimulated curiosity, and created a non-threatening atmosphere where students did not fear asking questions. Another antecedent was self-confidence in math ability necessary for science, which may also be school-related. Also, outside-school support was important, such as parents who encouraged an interest in science and somebody available who answered questions about science.

It appears that if pre-service teachers have confidence to teach all sciences in the elementary school, they have confidence in their general science knowledge, are willing to take science classes outside their science methods classes, do not fear making incorrect statements when teaching, and try to stay informed about the advances in science. Those with confidence believe that any student could become a scientist.

One of the most important implications of the research may be that having confidence in general science knowledge, especially having confidence to teach the physical sciences, appears to be related to previous school experiences.

In conclusion, this survey shows that a relationship exists between past experiences in science and current attitudes toward science among pre-service elementary teachers. It indicates that it may be necessary to have had rich positive experiences, especially educational experiences, in discovery science in order to acquire positive attitudes towards science later in life.

## Survey II: Shrigley Science Attitude Scale

Survey II, the Shrigley Science Attitude Scale (Shrigley, 1974b) is an instrument on which students respond to 12 positive and 8 negative statements concerning their attitudes toward science and science teaching.

There were four general categories:

1) six statements dealing with attitude toward science content.
2) six statements dealing with the handling of science equipment.
3) five statements dealing with science teaching.
4) three statements involving antipathy for the teaching of science.

A higher mean score on a desirable behavior indicates a positive attitude toward science, while a higher mean score on an undesirable behavior reflects a negative attitude toward science.

The means obtained by Stefanich and Kelsey (1989) in their survey of 318 pre-service elementary teachers on the Shrigley Science Attitude Scale indicated that those students at University B had higher positive attitudes toward science in all four categories than students in University A. The conclusion, suggested by Stefanich and Kelsey, was that the pre-service teachers are more likely to improve their attitudes toward science in small success-oriented classes where they can readily consult with the instructor and practice hands-on investigation and techniques useful in their future elementary teaching.

The 57 pre-service teachers at the University of North Dakota had mean scores very close to University B, or generally between University A and B but closer to University B than University A, as seen in Chapter IV, Results of Surveys, and in Table 9. Such was the case with the following questions:

Q 1: I daydream during science class.
Q 2: I would like to have chosen science as a minor in my elementary education program.
Q 3: I dread science classes.
Q 5: I enjoy manipulating science equipment.
Q 7: In science classes, I enjoy lab periods.
Q 9: If given the choice in student teaching, I would prefer teaching science over another subject in the elementary school.
Q13: I enjoy college science courses.
Q14: I prefer that the instructor of a science class demonstrate equipment instead of expecting me to manipulate it.
Q18: I expect to be able to excite students about science.
Q19: I frequently use science ideas or facts in my personal life.

The means of the following questions were higher at UND than at Universities A and B so reflect more positive attitudes:

Q 8: Science is my favorite subject.
Q11: I would enjoy helping children construct science equipment.
Q15: I would be interested working in an experimental elementary science curriculum project.
Q16: I enjoy discussing science topics with my friends.
Q20: I believe that I have the same scientific curiosity as a young child.

These results may be a reflection that at the University of North Dakota the classes in elementary science education are fairly small so individual attention can be given to a student by the teacher. Also, the classes are generally geared toward demonstrations by the instructor or hands-on manipulation of science materials by the students. However, the question remains whether these attitudes toward science reflected in Shrigley Survey II are more an indication of short-term attitudinal changes from positive experiences for two months in the UND science methods class where the acquisition of specific scientific knowledge is not stressed and tested than of long-term attitudes formed from previous inappropriate instructional methods and negative experiences in elementary/junior high/high school science classes, as the Sampson Survey I suggests.

The greatest differences in means between the University of North Dakota students and University B occurred in the following five statements:

> Statement 4, "Science lab equipment confuses me," received 33% agreement from UND students. 56% disagreed, and 11 % were undecided. The UND mean (2.67) was between University A (3.07) and B (2.35).
>
> Statement 6, "I am afraid young students will ask me science questions I cannot understand," received 60% agreement from UND students. 26% disagreed, and 14% were undecided. The UND mean (3.46) was higher than the means at both Universities A (3.42) and B (2.91).

Statement 10, "My science classes have been boring," received 33% agreement from UND students. 56% disagreed, and 11% were undecided. The UND mean (2.72) was approximately between University A (3.25) and B (2.38).

Statement 12, "When I become a teacher I fear that science demonstrations will not work in class," received 35% agreement from UND students. 51% disagreed, and 14% were undecided. The UND mean (2.72) was lower than the means at both Universities A (3.67) and B (3.45).

Statement 17, "Science is very difficult for me to understand," received 32% agreement from UND students. 51% disagreed, and 18% were undecided. The mean at UND (2.77) was between University A (3.26) and B (2.40).

At UND more students agreed or strongly agreed than disagreed or strongly disagreed on the following statements:

Q 5: I enjoy manipulating science equipment.
Q 6: I am afraid young students will ask me science questions I cannot answer.
Q 7: In science classes, I enjoy lab periods.
Q11: I would enjoy helping children construct science equipment.
Q13: I enjoy college science courses.
Q14: I prefer that the instructor of a science class demonstrate equipment instead of expecting me to manipulate it.
Q15: I would be interested working in an experimental elementary science curriculum project.
Q16: I enjoy discussing science topics with my friends.

Q18: I expect to be able to excite students about science.
Q19: I frequently use science ideas or facts in my personal life.
Q20: I believe that I have the same scientific curiosity as a young child.

At UND more students disagreed or strongly disagreed than agreed or strongly agreed on the following statements:

Q 1: I daydream during science class.
Q 2: I would like to have chosen science as a minor in my elementary education program.
Q 3: I dread science classes.
Q 4: Science lab equipment confuses me.
Q 8: Science is my favorite subject.
Q 9: If given the choice in student teaching, I would prefer teaching science over another subject in the elementary school.
Q10: My science classes have been boring.
Q12: When I become a teacher, I fear that science demonstrations will not work in class.
Q17: Science is very difficult for me to understand.

# CHAPTER VI

# INTERVIEWS

The students selected for the interviews were the first six students who volunteered from the two elementary science methods class. The interviews provided insights into the previous life and school experiences in science of these pre-service elementary teachers. Using open-ended probes and follow-up questions, the researcher urged the students to provide examples of memories and situations that supported their replies. After categorizing the comments and finding patterns, the researcher constructed the Sampson Survey. Without the information obtained from the interviews, the researcher could not have developed an instrument that accurately reflected the concerns, experiences and attitudes of the population that was to be surveyed. After analyzing the survey, it appears the interviews support the results obtained from the survey, which will be shown in the Conclusions (Chapter VII). Information from the interviews may explain more completely the results of the survey.

According to the six pre-service teachers, the interviews helped them reflect on how their past science experiences influenced the way they now feel about science and how science should be taught.

Five students expressed negative attitudes toward the physical sciences. One of those students mentioned that she had suffered from math anxiety in chemistry rather than from a dislike of science. The one student who had taken biology, chemistry and physics in high school was enthusiastic about all science, saying she remembered only good past experiences in science.

The information that emerged from the interviews indicates that it is not just the amount and kinds of science that a student has had that is important, but also how the science was taught. The following excerpts from students' interviews reveal that science classes taught with teacher-centered methods, such as memorization of facts rather than understanding concepts, lectures by teachers, and reliance on textbooks and routine questions on worksheets, appear to produce negative attitudes toward science and doubts about the ability to teach even elementary science. This belief is supported in the literature (Gabel & Rubba, 1979; Journet, 1985; Koballa & Coble, 1979; Koballa & Crawley, 1985; Moore & Blankenship, 1977; Riley, 1979; Rutherford, 1987; Shrigley, 1974a; Tilgner, 1990; Yager & Penick, 1986).

The order of reporting the interviews is based on the amount of science remembered from elementary school and the number of science courses taken later. The reporting starts with the student who took the most science classes and remembers the most elementary science, and ends with the student who took and remembers the least. The names used here are pseudonyms to conceal identity.

## Carol

Carol, who had many good experiences throughout her schooling in biology, chemistry and physics, felt very confident about teaching all sciences in the elementary school and correspondingly expressed a very positive attitude toward all sciences. Science will probably be a central subject in the elementary curriculum in Carol's classroom. She claimed, "I guess with everything I would do, I can think of a science project [related] with it." Carol represents 70% of the UND elementary education students with confidence in the life sciences, 28% with confidence in the physical sciences, 53% with confidence in the earth sciences, 46% with confidence in the space sciences, 58% with confidence in ecology, and 41% with confidence in their general science knowledge.

Before college Carol had taken physical and earth science in junior high, and chemistry, physics, biology and advanced biology in high school. In college she took biology, chemistry, and physics. She also took North Dakota botany and geology. She grew up in a city of 30,000 in western Minnesota, but her grandparents and other relatives lived on a farm, which she often visited. She was also fortunate to have had a supportive family, who constantly stimulated her interest and curiosity in science and patiently answered her endless questions. She is part of the 46% of the students who had parents who supported an interest in science in their children.

Carol's past successful hands-on educational experiences in science started in kindergarten and may have contributed to her present enthusiasm:

> I think I really had a good elementary experience. I had some really good teachers. I remember in kindergarten doing evaporation. The teacher was teaching us about evaporation. We had a disk full of water. The next day we came back, and it was gone. It was like a miracle!

Carol represents 25% of the students who remember science being taught in an exciting hands-on approach in elementary school. Throughout her educational career Carol fortunately had patient and understanding teachers, as did 47% of the students. Carol is extremely curious about the world around her, seeks answers to her own science questions, as do 40% of the students, and is not afraid to ask questions even when science courses become more difficult, as do 52% of the students.

According to Carol, all of her science teachers taught on the student's level of understanding, as did the teachers of 53% of the students . For example, she mentioned her high school physics teacher, who was also an instructor at the local university. Occasionally the students needed to remind that particular teacher to come down to their level of comprehension about a concept in physics. In fact, Carol said that the instructor would explain everything in as many ways as needed until everyone understood. Consequently Carol appeared confident about her knowledge of elementary physics. She even elected to take physics in college.

Another time Carol recalled how she satisfied her need to understand a concept in advanced biology in high school:

> In advanced biology we were going through DNA and replication. We were all kind of lost so he [the teacher] would have to go over it a couple of times. I would ask about it. 'Say, can you explain that to me again? I'm kind of lost on this part. Can you go over it one more time?' Usually I wasn't alone. If I didn't understand it then, I would ask someone who sat next to me to explain it to me.

Carol displayed her unremitting curiosity and need to understand concepts rather than only memorizing information in science when she said, "I am very inquisitive. I want to learn. I want to know, and if I don't understand it, I like someone to explain it to me so I do understand it. I don't like feeling confused." Like Carol, 98% of the students claim they want to learn more science. Carol is part of the 45% of the students who had understanding concepts stressed in some junior high/high school science class, and part of the 25% of the students who were encouraged to discover their own mistakes and misconceptions in science.

Teachers stimulated Carol's curiosity by their student-centered teaching methods. In this respect, Carol represents 41% of the students who claim the educational instruction in science classes stimulated their present curiosity. Carol feels that she had many opportunities for making unexpected new discoveries in science classes, as do 34% of the students. Carol recalled, "My seventh grade teacher would bring in things to show us and ask what we thought about it. I like discussions. I like trying to figure it out for myself."

Carol's past personal involvement in inquiry or discovery science was an important aspect in the development of her positive attitudes toward science. She has cultivated a desire to search for patterns and meanings taught through inquiry science, as have 53% of the students. This was apparent in her comments:

> [Science was taught me] to make my own discoveries. Trial and error, try it this way. Maybe it will work, maybe it won't. Try something else. You were more involved with it. It was your ideas that mattered. It made you feel important. Other than, 'Oh, here's the right answer, the wrong answer. Fill in this work sheet.' You were given a problem or a situation, and you had to come up with the answer!

Carol has cultivated an open mind to new ideas and concepts in science. Her on-going curiosity was displayed when Carol said, "Scientific knowledge to me is a lot of explanations. Why do things happen? You use scientific knowledge to explain things." Carol is part of the 35% of the students who were taught to find answers to their own science questions, and the 54% who logically and methodically approach the solution of problems.

Teachers conveyed their enthusiasm for science to Carol. She represents 38% of the students who had teachers who were able to relate science to the lives and interests of their students. Carol believed that she could always apply science to her personal life. Carol remembered, "The teachers I had were all excited about it [science]. They made it interesting. They taught stuff from our view. What would be interesting to us, not what they think is interesting." The teachers of 54% of the students made science interesting.

Carol frequently mentioned the importance of being able to apply her science instruction to her personal life. For example, she recalled one time when the college physics teacher deliberately connected the problems with real life situations of interest to the students:

> In physics we did a lot with boat sailing. He [the teacher] also geared it a lot toward aviation because there were a lot of aviation students. If you're going this air speed, and if you threw something out of an airplane, where would it land? How far behind you?

Many of Carol's recollections revealed that her parents and grandparents also stimulated her interest in science. They all tried to answer her questions. Carol obviously appreciated her parents' stimulation when she said, "If my parents would not have encouraged me to ask questions, it would have made a big difference. For the first five years of my life they were all I had." Thus, she is representative of 51% of the students who found somebody who would answer questions about science.

In fact, Carol's parents went out of their way to seek answers to her questions. Thus, they were good models for her. Again Carol affectionately recognized the extensive support given to her by her parents:

> My mom and dad would explain things to me. I always thought there was an answer for everything. They [Mom and Dad] would look it up if they did not know, or ask someone else. They would tell me the truth. They always answered my questions. They never made me inferior for asking silly questions. They were my strongest influence. They always have been.

Her grandparents also responded to Carol's endless questions. For example, Carol recalled, "I remember wondering how a big tree could grow from a little acorn. The outside of it was so tough. How could it grow out of there? My grandpa would explain things to me, 'Oh, there's a seed inside!'" Carol is part of the 67% of the students who acquired the habit of questioning information.

Carol uses her trained powers of observation while learning. A self-analysis of her study habits revealed:

> I learn best through seeing things and experiencing them. When I study, I usually take notes. I read through it and take notes. Rewriting it usually helps me learn it. Seeing it and duplicating it a real lot to help me learn.

Carol looked forward to being able to encourage children to notice the amazing world around them and seek answers to their own questions. In other words, she planned as a teacher to convey her own insatiable curiosity and interest about the laws in nature to her students. Her positive attitude and enthusiasm toward science teaching were frequently expressed by her revealing comments:

> Positive attitudes [toward science are]---being inquisitive, trying to get children to think it's okay to ask all of these questions. The attitude that science is fun, and you can learn from it, and that it is interesting. It's kind of like a game! A big puzzle!

Science remains a part of Carol's everyday life. She exclaimed, "I like it [science] a lot! I like taking classes in it! I feel like I use it every day!" She represents the 44% of the students who believe that anybody can be a scientist.

Carol apparently continues to renew her interest in science and keeps up with advances in science. She explained, "I do a lot of reading in medical journals. I watch a lot of science programs on TV like 'Discovery.'" She represents the 42% of the students who read articles and try to stay informed about the advances in science.

Carol's thirst for scientific knowledge appears to be never-ending because she said, "I never finished learning about some sciences." She specifically mentioned two sciences, astronomy and geology, both of which she would like to explore further. She said that she would consider taking additional science classes outside of the education department, as do 75% of the students.

Another time Carol spoke about her current environmental concerns in relationship to science. Carol is interested in the preservation of the environment:

> I'm into the ecological part. I'd like to learn about how we can save our earth. The lake and the [grandparents'] farm are side by side so we talk about the [pesticide] run off from there. I want the earth to be around for generations to come.

Carol is scientifically literate about many topics in all of the sciences. She feels the impact and importance of the scientific world on her personally. She stated, "I support research in science a lot. It's a very important field. Science will keep us around."

Carol summarized her generally positive attitude toward science and science teaching by stating, "I like science. To me it's a very important part of everyday life, everybody's life."

## Alice

Alice had many good hands-on experiences when she was young, especially in the life sciences, which motivated her to take physiology in college. She felt very confident about being able to model her own interesting hands-on experiences in biology in her own classroom. Unfortunately, the teaching techniques used in her college physiology class did not renew or stimulate her interest in the life sciences, and she switched from occupational therapy to elementary education. Although she had taken chemistry, she did not enjoy it because she was not able to relate to it. Nevertheless, Alice claimed that she planned to make science in general an important subject in her elementary classroom. She felt that she had gathered sufficient scientific knowledge and effective hands-on teaching techniques for elementary students from her science classes and numerous science experiences.

Before college, Alice had taken earth science in junior high, and chemistry, biology and advanced biology in high school. While in college she took anatomy and physiology. Alice grew up in a fairly large city of 70,000 in Minnesota, but her parents, whom she often visited, came from farms, where she still had relatives.

Alice was enthusiastic as she recalled many good early discovery experiences in the life sciences while in school, on school field trips, with her sister at home, and on camping trips with her family. Her curiosity had been sustained when she was young. Many opportunities were presented to her for exploring her environment and making unexpected new discoveries. She always found somebody who would answer her questions. She explained, "I think we were encouraged to figure out [answers] for ourselves, and if we couldn't, then we were given help from teachers and at home. Mom and Dad would explain it to me."

In college Alice had taken physiology, which involved memorizing many difficult scientific terms and names. During that class her enthusiasm for classroom science was extinguished by the teaching methods, which involved lectures, memorization, and no investigation. She may represent the 29% of students who feel that they learned as much about teaching science from bad science teachers as good ones. She reflected on the changes in the instructional methods used from junior high school to college that caused her to ultimately dislike science classes:

> Memorization was hard for me. I was good in elementary school and junior high science because it was hands-on, but when I got to high school [chemistry] and later on in college [physiology] is when the sciences turned around for me. I was really interested in them. I liked doing them, but when I had to memorize and get a grade attached to it, it was not what I thought so I changed careers.

In addition, Alice's negative feelings about high school chemistry were different from her positive attitudes about high school biology. Chemistry apparently did not initially appear attractive or interesting to her. She remembered, "The reason I took chemistry was because it was a requirement. I would not have taken it because I wanted to." She represents 61% of the students who disagree that physical science classes were more interesting than life science classes.

There were also other reasons for Alice's negative attitudes toward high school chemistry. The chemistry instructor was unable to teach on the students' level of understanding. In addition, she found that she could personally relate to the topics in biology, but not chemistry. Also, apparently her high school biology teacher encouraged students to ask questions, and he initiated discussions, but not her high school chemistry teacher, whose teaching methods fostered memorization rather than understanding:

> If you asked questions [to the chemistry teacher], it was talked down upon although there were a lot of confused people. I know I was not the only one that didn't get it. It was like all of a sudden, 'Okay, now you have to memorize this, plus you have to memorize the chart, plus you have to memorize the formula.' I just liked the biology thing better, the animals and that kind of stuff more than the chemistry. Maybe it's just the way it was taught. I'm sure it probably was.

The teaching techniques used in Alice's chemistry class, which did not incorporate active learning through personal involvement, simply did not inspire her. Thus, she is part of the 89% of the students who felt memorizing science terminology was stressed in junior high/senior high. Discovery science methods were only used in biology where the students were encouraged to make their own discoveries and think through their answers in small groups. Alice compared the difference in the approaches used in the two high school classes:

> In chemistry it was all lecture except for the labs. In biology and advanced biology [in high school] we did a lot in small groups where we would figure out things together and then talk about them in our smaller groups. Then the teacher would get the whole class back together, and he would talk about it and ask us, 'What did your group find?' instead of an individual.

Success and confidence appear to be necessary ingredients for positive attitudes. Students may need to understand the concepts presented in science class in order to achieve confidence and positive attitudes. For example, Alice questioned her innate science ability in chemistry class, which she sometimes did not understand. In this respect Alice may represent the 35% of the students who feel that scientists act and think differently than other people. Alice reflected about this notion in her remark:

> The ones [students] that were really into chemistry had no problem with it so every once in a while I would get help from those people in the class when I was really lost, and I needed to get back into it. I think they just had this special chemistry gene in their body, and they knew how to do it.

Even now Alice cannot connect chemistry with her personal life the way she can the life sciences, just as 49% of the students feel. She constantly renews her interest in the life sciences:

> I like the fact that I know as much as I do about biology and anatomy. Just in articles and whatever I read it makes sense to me now because I know these things like exercise and muscles and different things like that. The chemistry part I don't think I've used. It was taught as a stepping stone to something bigger. 'You need this for college. If you're going into anything, you have to know this. It's a basic thing.' It wasn't, 'Let's try to relate this to what you are trying to do now.'

Whether or not a teacher enjoys a particular science or a science topic is obvious to the students, according to

Alice. The following remark by Alice pointed out how teachers can unknowingly transmit their personal attitudes to their students:

> You could tell who [which teacher], and who didn't [like science], and what part of science they liked. I remember in junior high we had a class about rocks, quartz and all those different kinds of rocks. That teacher really liked rocks so you got more into it because they were into it. They made it interesting whereas there were other classes if we were studying the body, and that teacher didn't enjoy that part of it, we'd skip over that part and get on to what he liked. You could tell which teachers liked which areas.

Unfortunately Alice's curiosity, interest and confidence in other sciences than the life sciences were not maintained, renewed or extended, which was possibly the result of the way some of her science classes were taught. Although teachers may be interested in a subject, they may not be able to convey their interest to their students because of ineffective teaching techniques. For example, although Alice had a junior high teacher who apparently enjoyed geology, the teacher may not have been able to transfer his enthusiasm for rocks to his students.

Also, Alice may have lost confidence in her ability to successfully complete college science classes after her unsuccessful college physiology class. She said that she was not really interested in taking additional science classes to explore some new areas, including geology:

> I have taken the science that I was interested in, and I did not do as well as I thought I would have. I don't think I would go out and take a geology class. It's not where my interests are.

Alice may represent the 11% who do not feel that taking more science classes outside of CTL would make her a better science teacher. Fortunately, Alice's strong life science background, her other previous courses in science, and her early hands-on science experiences permit her to believe that she possesses the confidence to teach most elementary science and the insight to know how to effectively teach science to young students:

> I think on the elementary level I have a wide variety of interests with the hands-on kind of things. I think I could give them [elementary students] a wide variety of experiences with the sciences. I guess I would rate science about third or so...reading, math, science. It's like one of the top ones anyway. I think of it as a major subject. I think if they [students] don't get encouraged to ask questions, they just stop. They will just say everything is the way it is

because... If you encourage them to think about it and want to do more about it, then they will.

## Helen

Although Helen had taken physical, earth and life sciences in junior high, and biology and chemistry in high school, she said that she could never connect science, especially chemistry, with her personal life. In fact, almost half (49%) of the students believe that they could not relate and apply their science education to their personal life.

In college Helen had previously taken a physical science class in the education department and also biology. However, she had few hands-on experiences in most of her science classes and may never have thought science was interesting or fun. Because of her negative experiences in science classes, Helen admitted not desiring to seek answers to her questions about science. She represents 37% of the students who claim that they do not seek answers to questions about science. In fact, Helen lacked confidence in her general science knowledge, as do 36% of the students, and was worried about her ability to teach any elementary science. She may be representative of the 45% of the students who fear making incorrect statements about science when teaching, and of the 74% who feel that they may need some support from other professionals when teaching.

Helen, who had difficulty with the mathematical aspects related to chemistry, feared teaching science, particularly the physical sciences. In fact, she kept repeating her concerns about science and math. For example, Helen acknowledged, "Science was always kind of something that was a little above my head. It was kind of hard. It was for mathematical-type people. It was kind of hard for me, the math parts of it." She may represent the 44% of the students who lack confidence in their math ability for science classes.

The chemistry-math connection distressed Helen. She never clarified why she had trouble with the math in chemistry. She may not have had an adequate foundation, or the math used in chemistry may not have been explained on her level. Anyway she lost her confidence in math. She once commented, "Chemistry was kind of hard because of the math. There is just something about math. There is a little anxiety there that I am not good at it."

Helen sometimes attempted to seek answers to her questions. One comment suggested that chemistry in general was not explained on her level of understanding. She recalled, "If you had a question, you'd ask the teacher, and the teacher couldn't always explain it on your level so you would ask a classmate." However, her remarks about the difficulty she had with chemistry suggest that the help she gained from her teacher and friends was not sufficient for achieving feelings of success and confidence. She may represent the 35% of the students who could not find somebody to answer their questions about science.

In addition, chemistry was taught in a passive format. For example, Helen remembered a frequent command in her high school chemistry science class, as she remarked, "'Here do thirty problems, correct them, and hand them back.' No kind of concepts to relate it to anything. Just a bunch of numbers." Helen described a high school science class: "It was a lecture, and take notes and take a test. I didn't get much out of it [science] for enjoyment."

Helen could frequently not tie concepts in science with her personal life, just like 49% of the students. Helen separated biology from the other sciences:

> Maybe biology had more to do with you, yourself. But as far as to what was going on in my life as a kid, it [science] was kind of a separate thing. It never went home with me. It stayed in the classroom.

Although Helen spent many summers on the farm, she did not remember doing many science activities. There was little family support for science even in her rural setting. The percentage of students with parents who did not support science is 40%. It appears that Helen considers science not to be an important aspect of her life. She claimed, "I remember looking at stars, but I never really went any further with it.

Helen recalled no student involvement in science class and no exploratory science, even in biology. It seems the way science was taught to her made a difference in her attitude. Realizing this possible explanation for her negative attitudes caused Helen to remark, "I remember learning about the different kinds of clouds, but I think I would have remembered it more if the teacher had taken us outside and showed us an example if she could, weather permitting, the different kinds of clouds."

Therefore, in Helen's past she has had to rely mainly on her reading of science from her textbook for her science knowledge. She emphatically recalled, "We never did much of the hands-on things." Also, Helen's memories did not include any elementary school discovery science (63% of the students could not remember any elementary discovery science). She commented, "I don't remember it [in elementary school] because we didn't do it, all those hands-on type things."

Helen's negative attitudes toward science were summarized when she added, "It [science] never really interested me that much. It wasn't presented interestingly. It was kind of boring and kind of the same." Science wasn't taught interestingly to 37% of the students.

However, Helen now realizes the way science should have been taught to her for achieving a life-long interest:

> I am starting to see a different view on it [science], teaching it for kids, and how different that it should be as to how I was taught. If it had been presented differently in school, I might have pursued it differently out of school. It might have seemed more interesting to me, and I would have wanted to find out more things.

When discovery science is taught, students use higher level thinking skills (Journet, 1985). Helen realizes now that she was not actively involved in thinking while in science class. Instead science class was taught mechanically without creative responses from the students. She remarked, "I think we should have been encouraged to think more on our own. The teacher told me 'this', and that was it." Fifty-three percent of the students were not encouraged to discover their own mistakes and misconceptions in science.

Helen understands now how she learns best:

> I learn best by doing. I don't get much out of the textbook. I mean I can, but I would much rather be doing it. Even like at work I am given examples because they teach me things. They would just tell me how to do it, and I couldn't remember how to do it. If I did it, and they told me how

> to do it, I went through it, and I did the motions, then I remembered it. So for me I learn much better by actually doing it and experiencing it and being part of the action. Otherwise you are just getting the sight and the sound, and it's not enough, not for me.

Because of her past frustrating science experiences, Helen does not seek science information, "My science is still in school, really!"

Helen expressed guilt about her present lack of interest in science in spite of having taken several science classes, "I should read more articles and investigate on my own. It is really interesting, I guess, a lot of it, but I just don't take the time to do it. But I guess I would say I like science." Forty-two percent of the students do not try to stay informed about the advances in science.

It appears that Helen's confidence in her science knowledge, in her ability for learning science, and in her success at teaching science has been shattered by her negative and inadequate past experiences. She expressed this herself in her comment:

> I don't think of myself as a strong science teacher. I think I would have to do a lot on my own in order to present it. I probably would be one to be afraid that the kids are going to know more than I do, and I won't know what to say.

In addition, Helen is not anxious to take more science classes. She may be representative of 31% of the students not confident to take additional non-CTL science classes. She revealed her present science insecurity when she said, "I never had physics. I'd probably be poor in that."

Jane

Although Jane had no elementary science in her parochial school, she had a supportive family, who stimulated her curiosity about science. Jane claims she discovered the joys of exploratory science at home rather than in elementary school. She recalled, "Basically in grade school we didn't have any science at all. I can't remember ever having an inspiring [elementary] teacher." Students who remember almost nothing about science in elementary school number 63%, and those who feel their present curiosity about science was stimulated more by non-school experiences than by science classes is 91%.

Even though Jane did not experience any elementary science in school, she had many interesting hands-on science experiences outside of school on the family farm with her brother. Jane remembered her brother's influence and her parents' support in her pleasant recollections about her science activities:

> We [my brother and I] had a little dissecting kit. I mean we did frogs and worms and fish and everything. It was wonderful. And then living on the farm you get to see the "birthing," growing and babies, and we had chicks. We had a telescope, and we would sit outside at night and try to find the constellations with my mom's and father's support. My brother was really into science so he dragged me. I kind of went along with him. My brother went to a different school so obviously they must have done more of it because it was always what he wanted to do, and he would come with these ideas. I guess we were together a lot so observations I made out of school, I made with him.

Jane's experiences with her brother probably contributed to her understanding of discovery science. It appears that Jane was comfortable with hands-on science when she was a young child. Jane still believes that she learns best "by being able to manipulate an object or take things apart and put them back together." She claimed, "To me science is investigating."

Biology was a positive experience to Jane both with her brother at home and in her high school science class. According to her, the instructional techniques used by the biology teacher were conducive to acquiring positive attitudes:

> The [biology] teacher did not stand up and lecture a lot. We did hands-on investigation, and we worked in small groups. She [the teacher] just had a lot of materials available if you had a question. She was right there to help you with it.

Jane's interest in the life sciences has been sustained. In college she had taken biology and biology lab. She remarked, "Areas that interest me are things in nature, biology, or plants and animals, things like that."

Jane's experiences with chemistry in high school were considerably different. Apparently the teaching techniques used in chemistry were not as effective as in biology, and Jane is not able to apply chemistry to her life. Sixty-two percent of the students disagree that they could relate the physical sciences more to their personal life than the life sciences. Jane explained, "I don't consider chemistry as part of science although I know it is, but to me chemistry is just kind of an abstract part of it. Maybe because I am not so interested in it." Later Jane specifically tried to explain why she felt negative about chemistry. She recalled, "I remember in [high] school having this huge chart and having to memorize all those things."

Jane expressed her bitterness about how high school chemistry was taught to her, as she said, "I remember a lot of memorization and advice on how to write out chemical equations and things like that I do not think were necessary." Jane may be typical of 89% of the students who remember memorizing science terminology being stressed in junior/senior high.

Obviously Jane's chemistry teacher did not inspire her as she sat passively in class listening to his lectures. She reflected on the teacher's style of teaching:

> Mostly what I learned was through reading. The textbook was okay. The instructor was not. The teacher was really boring, and his technique was to lecture for at least three-quarters of an hour, and then we did some reading or whatever. I don't know. It was hard for me to learn.

Jane's recall of any chemistry lab was foggy. Certainly it appears that if she had taken chemistry lab, it was conducted in a format which was not designed to stimulate the student. She said, "The chemistry lab was not such that it inspired you enough that you remember it. We must have had one. Maybe I just didn't take it!"

Presently Jane thinks that she has been able to apply her childhood experiences in discovery science to the children in a day care center where she works. She was very enthusiastic about teaching young children who are actively involved in their own learning. She explained, "I've worked in day care, and they're so inquisitive. I'm not fired up about textbooks."

Jane plans to bring nature into the classroom, and apply her understanding of investigative techniques. She admitted a lack of in-depth knowledge about science, but seemed convinced that would not be a problem when she taught science. She proposed a solution:

> I would try to find things that they see, but don't really think about in depth. We would learn together. I rely a lot on being able to look things up. I realize I don't know everything. The biggest thing I would say is not to lecture the entire hour. I need to gain confidence in how to present it [science], or how to get it started.

It appears that Jane is not interested in learning more chemistry or physics maybe because of her negative experiences with classroom chemistry. She claims that she would like to be able to find the constellations, but admitted not being interested in theoretical astronomy, such as learning about the origin of the universe, the formation of the solar system, the composition of the moon or the origin of the moon.

Jane explained that she is more interested in observing astronomy rather than understanding concepts about astronomy. She admitted, "When something is there, I just accept it like that instead of looking to where it comes from. I just take things at face value." She represents the 17% of the students who admit that they have not acquired the habit of questioning information.

Although Jane claimed, "To me science is investigating," she is not convinced that explanations in science are apparently necessary in investigative science. Learning concepts, principles and laws in science do not appear to be important to her.

Jane may not recognize her lack of curiosity. Her experiences were reflected in her philosophy about teaching:

> I think it is really helpful to have those kind of memories [about how science was taught to her], and I don't think I am bitter about it, but yet I know I want to do it differently. So I think it was maybe helpful to know that it wasn't the best because hopefully I'll turn things around and do things better.

Jane expressed a lack of confidence in taking other science courses outside the education department. "Scientists, I just assume, have more brain cells than I do. I think they have to be so inquisitive and hard workers." (37% of the students do not agree that anybody can be a scientist.)

Lois

Lois generally had negative and inadequate experiences in science, except for one biology course in high school. Also, she had to overcome general feelings of inadequacy in school caused by low self-esteem. She admitted that she has a lot of science to learn along with her students. She had previously worked in business for three years before attending college, which had increased her self-confidence.

Lois took general science in junior high, biology in high school, and biology again in college. In addition, she has taken college geography and nutrition, and also Physical Science for Elementary Teachers in the Center for Teaching and Learning.

Lois claimed that earlier she had learning problems in school because she was convinced by her father that she was incapable of scholastic achievement. She noted, "I had a lot of troubles myself in elementary school in my personal life."

Lois' educational difficulties were self-analyzed when she remarked, "When I was in school, school was not important to me. I wasn't a good listener. I was always thinking about something else."

The teachers in junior high/high school did not explain science on Lois' level of comprehension, just as 37% of the students claim. Consequently she lost confidence in learning science. Lois' past failing educational experiences were further explained by her:

> If you can't understand the subject he's [the teacher is] teaching, if he is talking over your head, then you are not going to get a good understanding of it and kind of lose interest because you think, 'Oh!' My attitude was that I'm not going to get this so I didn't listen as well.

Although Lois grew up on a farm, she thinks that she was not a curious child and was unaware of science around her. Neither did she remember doing any exploratory science in elementary school. She claimed, "I don't remember doing hands-on science in elementary school. Otherwise I would remember if we had done it!" Furthermore, she elaborated on how science was passively taught to her. She explained, "It was straight from the book, and there were not a lot of projects or things like that."

Lois remembered her junior high school general science teacher as a boring monotone-voiced lecturer, who demanded a lot of note-taking and a quiet class. Lois' teacher did not even show an interest in the science he was teaching although she felt that he was probably knowledgeable about the subject. She remembered, "Nothing excited him [the teacher]. I don't think anybody was really interested. Nobody cared because to me the teacher seemed like he didn't care. He was just doing his job." Fifty percent of the students feel that the educational instruction in science classes did not stimulate their present curiosity.

Later Lois continued to criticize the attitude of her general science teacher. He apparently talked down to the students. In addition, he was not a patient and understanding teacher, who readily answered questions. She recalled, "Sometimes he [the teacher] made you feel that you did not know very much." Lois represents 40% of the students who claim that they did not have patient and understanding science teachers, and 34% who recall that they were not comfortable asking questions of the teacher. Neither were the teacher's instructional techniques helpful. He apparently did not incorporate exploratory or inquiry science into his classroom. The students were not actively involved in their own learning processes. Lois elaborated, "No encouragement, no discussions, no projects or cooperative learning, or things like that."

However, Lois' tenth grade biology class was more interesting. The teacher had a different approach and was more interested in what was being learned by his students. He apparently was more patient and understanding. In addition, the biology teacher actively involved the students in learning activities. Lois commented, "You could tell he [the teacher] enjoyed his job. He always listened to what the students had to say and seemed to be really interested and challenged us a lot more with his activities."

The subject of biology interested Lois. She realized, "The subject material was different. There were more field experiences." Lois admits that she learns by manipulating materials and practical applications.

Consequently Lois' interest in science is limited to biology. She mentioned, "I have no interest in physics or chemistry. I guess because I don't know anything about it, and the things I hear, mixing chemicals together, just doesn't interest me at all. I don't know how to explain it. More like biology, nutrition, geography interests me."

Lois is not confident about having an adequate background in math for chemistry and physics, the same as 44% of the students. Lois revealed, "I have not had experience with chemistry or physics. There are some things that I've got to have a lot of math background. I know I need to know math."

The physical sciences may be avoided and not explored in Lois' future elementary classroom. She admitted, "I don't have a desire to get into chemistry." She reflects 54% of the students who disagree that it will be easy to teach physical sciences in elementary school. Apparently geology does not interest Lois either. She commented, "I don't think I want to go through a whole semester and study rocks."

Sometimes Lois was more comfortable asking her brother questions than she was her teachers or fellow students. Apparently Lois did not have sufficient achievement necessary for self-confidence in her ability with science. She recalled, "I could ask him [her brother] anything without feeling stupid. He would always tell me. I was always intimidated in school. My attitude was everybody is smarter than me."

For one thing she realized that she needed somebody to explain on her level of understanding without criticism. Her brother played that role. Lois realized, "He [my brother] could tell me at my level of thinking. He always wanted to know how things worked."

In addition, Lois' mother would also attempt to answer Lois' questions if she could. However, frequently her mother was unable to satisfy her inquiries so her curiosity was never cultivated. Lois explained, "If she [her mother] said, 'I don't really know,' I would just take that. I would never go and search. I would never go and read about it or something."

Because of her own experiences Lois realizes that some students need encouragement in science. Lois noted, "Some [students] don't [wonder], but some students just need it to be brought to their attention." Lois believes in "hands-on experiences, activities with a partner, cooperative learning experiences" as methods for teaching science in the elementary school. Her philosophy is, "Let them explore."

In other words, Lois did reflect on how she will personally teach science in spite of her frustrating and insufficient science background. She concedes that she will not know all the answers. Her solution is:

> We'd [Lois and her students] look it up. We'd find out. We'd figure it out together. If we couldn't find it, we ask somebody who did know. Always answer their [the students'] questions. If you can stop them [the students] from thinking about their home life and family, and get them involved in the classroom and make them feel important, then they are going to start learning, and once they can start learning and taking risks in the classroom by asking questions and figuring out things, they will be more confident. Give them a chance to make mistakes and figure out their mistakes and fix them. Provide opportunities for them to get out of the classroom setting and get out into the environment.

Consequently Lois' negative science and personal experiences may actually help Lois to become a better science teacher. She will certainly be more understanding. She admitted, "Because of the difficulties I had when I was in elementary school, I can understand, and I can speak at their level." She represents the 29% of the students who feel that they learned as much about teaching from bad science teachers as good ones.

Lois feels insecure about taking more science in school. However, realizing a lack of confidence about her general science knowledge, Lois conceded, "I've got a long ways to go. I want to learn [now], I can learn with my students."

## Joyce

Joyce was required to take a couple of years of general science in junior high and took biology in high school. In college she took Life Science and Physical Science for Elementary Teachers. Joyce never enjoyed nor was she interested in any science classes, which she felt were mostly inadequate anyway. She has been unable to focus her attention on science. Therefore, science has definitely not been a part of Joyce's life.

Joyce admitted that she has not been "a strong science student" in her past:

> I don't know why, but I never got really interested in it. If it had to do with the teachers I had... I have never been able to figure out why I have never liked science. It was always, 'Oh, we have to go to science. I have to

take a science course.' I was more of a negative student, I guess, than a positive student.

She claimed that science was not an important part of her life except "things out of school, camping out, stuff like that, dealing with nature, things like that. When you don't realize you are doing science, I guess it was when it was more fun rather than okay."

Neither did Joyce remember having much elementary science, as claimed by 63% of the students. Joyce believed that there was no coordinated science curriculum and no science materials in elementary school. She recalled a few animals, some leaves and rocks placed around the classroom by one teacher. Apparently science was not taught in an interesting enough fashion to distract her from her people-oriented focus. She explained that she remembers "more of the people that I was with than the projects that I was doing. Maybe that's why I don't remember because we did not spend a lot of time doing experiments, not a big part of our school day."

However, Joyce conceded that early experiences in science are important for students. In addition, she now realizes that science needs to be taught on the student's level. Her comments probably revealed her past experiences:

> I think it [science] should be taught in elementary school because if it is not taught, then there is six years of school before they

[students] start with science, and then it's going to be a new subject. Some of the things they probably won't comprehend until they get older. If you teach it on their level, they are going to learn. If you talk above their heads, they are not going to try."

In junior high Joyce was required to take a couple of years of general science. Science was not taught interestingly, as with 37% of the students. Instead she found science to be mostly lectures out of a book, just like 89% of the students. She admitted, "It just wasn't fun." Science class made no impact on Joyce because she was not actively involved in learning the subject. Understanding concepts was not stressed, as with 41% of the students. Joyce elaborated, "It [science] never stuck with me. They [the teachers] expected you just to sit down and read and know it. It was a lot of memorizing."

There were no discussions, asking questions, or cooperative learning in science class. Again Joyce explained, "Nobody ever talked in class." She may represent 50% of the students who did not have opportunities for making unexpected new discoveries in science class. According to Joyce, science was not taught through explorations and investigations, but with specific directions from the teacher. She claimed, "I don't remember doing a lot on our own. A lot of it was, 'This is what we will do.'"

However, in high school Joyce's biology teacher was able to relate the subject to her life. She remembered learning to identify birds from slides. Joyce feels the teachers conveyed their attitudes to their students. Joyce explained, "You could tell he [the teacher] really enjoyed it. Whereas in between my seventh and tenth grade years, he [the teacher] was kind of dull."

Now Joyce realizes that she learns through active participation. She concluded, "I learn best by doing. I get bored sitting and listening to someone talk about what we will be doing. I'd rather just jump in and start doing it even if I do it wrong."

Unfortunately Joyce did not learn to question or wonder. It seems that her curiosity may not have been stimulated. She readily admitted, "I never really looked into a lot of it [science] because I see it, I like it, and accept it." Neither was science reinforced by her family. Science has not been a part of her life outside of school. She said, "I have two brothers, one two years older, and one two years younger. None of us were science buffs."

Joyce found that science class required homework outside of school, which she was not willing to do:

> There was that aspect of having to study for it, you know. I wasn't much of a go home and let's

read the book stuff. I'd rather go home and get outside and enjoy the day before it's time to go to bed.

She blamed her teachers for her lack of motivation. She reasoned, "Possibly they [the teachers] just didn't inspire you that much to want to pursue it."

Science is still not an important part of Joyce's life. She admitted that she still does not question or seek answers in science. She represents 39% of the students who were not taught to find answers to their science questions.

About chemistry, she conceded, "It's a lot of that unknown area. I don't know that much about it." Later Joyce displayed her lack of general knowledge about science:

> I'm afraid [of chemistry and physics] because I do not know much about it. I never had much experience in those areas at all. I guess I don't know what research is coming up with, or what research is being done.

Joyce continually revealed her lack of confidence in her general science knowledge, as do 36% of the students. For example, she said, "I think there is still a lot to learn before I can. I don't think I will ever be totally confident that I am teaching the right things."

Neither did Joyce feel confident about handling science equipment because of her insufficient experiences. She timidly said, "That's something [science experiments] I haven't done a lot with."

Commenting on her ability to teach science in elementary school, Joyce admitted that she does not think that she has enough knowledge to teach elementary science. She is worried about her ability to successfully teach any science. Joyce may represent the students who lack confidence to teach life sciences (16%), the physical sciences (54%), the earth sciences (33%), the space sciences (37%), and ecology (25%).

However Joyce tried to rationalize, her timidity about science teaching was revealed:

> In talking with other teachers out there, they thought they knew more than they did. I don't know where I stand in these areas. It scares me because student teaching is only a semester away. How can I teach these kids when I don't know if I know it, but that's something I won't find out until I start teaching.

# CHAPTER VII

# CONCLUSIONS

The University of North Dakota students, based on their responses to the Shrigley Science Attitude Scale, generally had attitudes toward science that were comparable to the research by Stefanich and Kelsey (1989) at University B. The attitudes at University B were more positive than at University A. The classes at University B were smaller than at University A, had more hands-on investigations and were more geared for elementary science teaching. In these ways University B was more like the University of North Dakota.

At the University of North Dakota, according to the Sampson Survey, 70% of the pre-service elementary teachers had the confidence to teach elementary life sciences, 58% had confidence to teach ecology, 53% to teach elementary earth sciences, 46% to teach elementary space sciences, 41% had confidence in their general science knowledge, and 28% to teach elementary physical sciences.

Generally it appears from the interviews that the more science a student has taken, the more positive an attitude toward science he or she is likely to possess, though cause and effect are not directly discernable. Carol, for instance, took the most science classes and had a very positive attitude toward all sciences while Joyce recalled the fewest science experiences and claimed to be insecure about her science knowledge and her ability to teach any science.

However, the interviews showed that although the amount of science may be important, it may not be the most important factor. Instead, the most important antecedent appears to be the student's memories of how a particular science was taught. Although Alice and Helen had taken many science classes, they had negative experiences in some science classes, (Alice in high school chemistry and college physiology, and Helen in high school chemistry), which they emphasized more than any positive ones. Still Alice expressed confidence about teaching most elementary science because of her own early hands-on science experiences in school and with her family, and her strong life science background in school. She said, "I think on the elementary level I have a wide variety of interests with the hands-on kind of things." However, Alice's negative educational experiences in high school and college caused her not to pursue a vocation in science. She analyzed her decision:

> I was good in elementary school and junior high science because it was hands-on, but when I got to high school [chemistry] and later on in college [physiology] is when the sciences turned around

> for me. I was really interested in them. I liked doing them, but when I had to memorize and get a grade attached to it, it was not what I thought so I changed careers.

However, Helen, who experienced no early investigative science and had ineffective science instruction in school, expressed a lack of confidence in her general science knowledge and her ability to teach any elementary science. She forecast, "I probably would be one to be afraid that the kids are going to know more than I do, and I won't know what to say."

It appears that the qualitative and quantitative data show similar patterns and relationships. The interviews support the results from the Sampson Survey. For example, high significant relationships ($p<.01$) were found between those pre-service teachers with confidence to teach any elementary science, such as life, physical, earth and space science, and ecology, and those with confidence to teach any other science. In addition, there were high significant relationships ($p<.01$) between those teachers with confidence in their general science knowledge and those with confidence to teach any of the elementary sciences. This general confidence about science knowledge and about teaching all sciences was frequently verbalized by Carol. For example, Carol exclaimed, "I guess with everything I would do, I can think of a science project with it!"

Also, the Sampson Survey and the interviews indicate that there are particular antecedents and experiences that contribute to the positive attitudes of pre-service elementary teachers toward science and their confidence to teach all elementary sciences. The classroom environment created by the teacher seems to be extremely important in establishing positive attitudes toward science. Both the qualitative and quantitative data show that science classes taught with student-centered methods involving hands-on exploration and inquiry appear to produce students with positive attitudes toward science. According to the comments and memories of all interviewed students, it is important for science teachers to have explained on the students' level of understanding (53% of the students remembered having such teachers), to have been patient and understanding (47% of the students had), to have answered students' questions in a non-threatening manner (52% had), to have taught students to find answers to their own questions (35% had), to have stimulated students' curiosity and interests (41% had), to have provided opportunities for hands-on exploration and new discoveries (34% had), to have related science to the students' lives (38% had), to have helped students discover their own mistakes and misconceptions (25% had), and to have displayed an interest in science themselves and made science class interesting (54% had). The literature also shows the role of the teacher, an aspect of the classroom environment, to be the most important antecedent toward positive attitudes toward science (Haladyna et al., 1982; Haladyna et al., 1983; Talton & Simpson, 1986; Wareing, 1990).

In summary, the results above imply that it is important for pre-service elementary teachers to have successfully taken many interesting and well-taught science courses throughout their educational careers in order for them to have acquired long-term positive attitudes regarding their general science knowledge and ability to teach elementary science. In other words, it appears that continuous positive memories of science classes taught appropriately may be one of the most important ingredients in developing positive attitudes. Carol, who has positive attitudes toward all sciences, remembers science having been taught in an exciting hands-on approach in kindergarten and elementary school (25% of the students remember hands-on elementary science, while 63% remember nothing about science in elementary school).

It was revealed during the interviews that more students had taken life science classes than physical science classes (Jane, Lois and Joyce had not taken any physical science). Jane and Lois found high school biology interesting. Among those who had taken both kinds of science, Alice and Heidi found their life science classes were more interesting and were more related to their personal life than their physical science classes. (The survey showed that 70% of the students have confidence to teach life sciences while 28% had confidence to teach physical sciences. Only 16% of the students thought their physical science classes were more interesting than their life science classes, and only 5% could relate their physical science classes more to their personal life than their life science classes.)

The classroom environment is especially important for confidence in teaching elementary physical sciences (chemistry and physics), which appears to be perceived by pre-service teachers to be more school-related than the other sciences, such as life, earth and space sciences, and ecology. Confidence to teach the physical sciences in elementary school had highly significant correlations above 0.30 ($p<.01$) with the following school-related items: having been comfortable asking questions of the science teachers, having had patient and understanding science teachers, having had teachers who could explain science on their level, having experienced educational instruction that stimulated their curiosity about science, having had science education that was related and applicable to their personal life, having been able to make unexpected new discoveries and explore new ideas in science class, having cultivated a desire to search for patterns and meanings, having acquired the attitude that anybody can be a scientist, and being confident about their mathematical ability for science. In addition, there was also a highly significant negative correlation of -0.32, ($p<.01$) with remembering nothing about elementary science.

Also, interesting relationships, though not strong relationships, with correlations above 0.22 ($p<.05$) were found between having confidence in the physical sciences and remembering hands-on elementary science and having had interesting science classes. During the interviews Carol remembered all her science education had been interesting, satisfying and meaningful. She vividly described many incidents that showed she had teachers who taught investigative science on the student's level, related science to the student's personal life, and answered a student's questions. Carol summarized, "The teachers I had were all excited about it [science]. They made it interesting. They taught stuff from our view." Carol was the only student interviewed who felt that her physical sciences classes, chemistry and physics, had been taught interestingly. It was also shown in the literature search that achievement in the physical sciences is more school-related than in the other sciences (Akpan, 1986; Glasgow, 1983; Lawrenz, 1976; Zuzovsky & Tamir, 1989). It may be that since most students do not take earth or space sciences, or ecology in school, they do not relate them to the classroom environment.

Also, having the confidence to teach physical and life sciences was significantly correlated ($p<.01$) with having parents who were supportive in establishing an interest in science in their children and with having somebody to answer questions about science. In the interview Carol expressed appreciation for the support for science she had always received from her family when she reminisced, "If my parents would not have encouraged me to ask questions, it would have made a big difference." (91% of the students say their non-school experiences stimulated their present curiosity more than their science classes, while 41% say the educational instruction in science classes stimulated their present curiosity, and 38% could relate their science education in school to their personal life. The percentage of students who claim their parents were supportive in establishing an interest in science in their children is 46%, and the percentage of students who found somebody, (teacher, parent, sibling, or another person), to answer questions about science is 51%.)

In fact, science acquired outside of school in an interesting fashion seems to be important because it arouses interest and curiosity in science, especially in the life sciences, as supported by the interviews with Carol, Alice and Jane. Both Carol and Alice had early positive experiences in science in school and with their families. Jane recalled no elementary school science experiences, but her interest and curiosity about science was stimulated by her brother and parents. Jane explained, "My brother was really into science so he dragged me. I kind of went along with him. My brother went to a different school...."

There were significant correlations ($p<.01$) between those with confidence in their general science knowledge and ability to teach all sciences, and those who believe anybody can be a scientist (44% of the students believe anybody can be a scientist, while 35% think a scientist acts and thinks differently than other people). Carol noted with confidence, "I feel like I use it [science] every day," while Helen acknowledged, "Science was always kind of something that was a little above my head," and Jane said, "Scientists, I just assume, have more brain cells than I do."

There are some behaviors acquired through investigative science that were mentioned during the interviews: having the habit of questioning information (67% of the students think they have acquired this scientific attitude), logically and methodically approaching the solution of problems (54% of the students), having cultivated a desire to search for patterns and meanings (53% of the students), and discovering their own mistakes and misconceptions (25% of the students were encouraged to do it).

Examples of ineffective teaching techniques used in science class that were frequently revealed and reported in a negative tone during the interviews were:

1. Stressing the memorization of science facts rather than understanding concepts (89% of the students claim science terminology was stressed in some previous classes, while 45% claim understanding concepts was stressed in some classes). Alice recalled her chemistry teacher stressing memorization by saying, "Okay, now you have to memorize this, plus you have to memorize the chart, plus you have to memorize the formula."

2. Giving unimaginative and uninteresting lectures by teachers rather than addressing the interests and relating science information to the lives of the students in the class. For example, Helen's memories of her chemistry class were, "It was a lecture, take notes and take a test."

3. Relying on textbooks rather than offering personal hands-on and discovery experiences in science. For example, Lois said, "It [science class] was straight from the book, and there were not a lot of projects or things like that."

4. Using routine worksheets and textbook questions rather than questions originating from students' discussions and discoveries in science

investigations. Joyce explained, "Nobody ever talked in class."

Also, a significant correlation ($p<.01$) was found between having confidence to teach all sciences and the deliberate practice of reading articles about science to stay informed about advances in science. Carol claimed, "I do a lot of reading in medical journals. I watch a lot of science programs on TV..." On the other hand, Helen realized, "My science is still in school, really!" During the interviews most students claimed that they wanted to learn more science (98% of students). Still, fewer students claimed during the interviews that they read articles about science and deliberately try to stay informed about advances in science (42% of the students), and seek answers to their own questions about science from teachers, library, magazines and journals (40% of the students). The item, "I feel I want to learn more science" was significantly correlated at the 0.01 level with only one item, "I seek answers to my questions about science."

In the interviews those students who appeared insecure about their abilities in science and had previous unsatisfying experiences appeared hesitant about taking additional science classes and sometimes about exploring more science areas. Confidence in general science knowledge and confidence to teach all sciences was significantly correlated ($p<.01$) with confidence to successfully take non-

CTL science classes. For example, although Lois claimed, "I've got a long ways to go. I want to learn [more science now]," she admitted, "I have no interest in physics or chemistry," and later added, "I don't think I want to go through a whole semester and study rocks." Helen remarked, "Chemistry was kind of hard because of the math," and later said, "I never had physics. I'd probably be poor in that." Joyce conceded, "I'm afraid because I do not know much about it [chemistry and physics]." (While 75% of the students agree that taking more science classes outside of CTL would make them a better science teacher, only 47% believe they would be successful taking non-CTL science classes, and only 44% feel confident about their mathematical ability for non-CTL science classes.)

The interviews supported the belief that those with confidence feel science is very important, relevant to everyone's life, and are convinced that science is fun and exciting. Carol's interest in science appears to be endless. Her enthusiasm for science was reflected by her statement: "I like science. To me it's a very important part of everyday life, everybody's life."

The results from the survey show interesting negative relationships, though sometimes not strong ones ($p<.05$), between those who fear making incorrect statements, and those with confidence in their general science knowledge ($p<.01$) and confidence to teach any science, that is life

($p<.05$), physical ($p<.05$), earth ($p<.01$), space ($p<.05$), and ecology ($p<.05$). The percentage of those who will need professional support was negatively correlated with those with confidence in their general science knowledge ($p<.05$), and those with confidence to teach life science ($p<.05$), physical science ($p<.05$), earth science ($p<.01$), space science ($p<.01$), and ecology ($p<.01$). Fear about teaching science was expressed during the interviews by those with inadequate science experiences. Lois remarked, "I've got a long ways to go." Joyce conceded, "I don't think I will ever be totally confident that I am teaching the right things." (45% of the students fear making incorrect statements about science when teaching, and 74% feel a need for support from other professionals when teaching science.)

Twenty-nine percent of the students say they learned as much about teaching science from bad science teachers as from good ones. For example, Jane believes, "I think it was maybe helpful to know that it [science] wasn't [taught] the best because hopefully I'll turn things around and do things better."

Behavior reflects attitudes, and attitudes reflect experience. Elementary teachers unconsciously transmit their attitudes at an age when their young students are forming their life-long attitudes and beliefs. There is currently a debate in the literature about whether any type of pre-service or in-service educational or retraining program for elementary teachers can alter negative attitudes once formed toward science (Gabel & Rubba, 1979; Koballa & Crawley, 1985; Lucas & Dooley, 1982; Riley, 1979; Shrigley, 1978; Westerback, 1984). Elementary teachers with confidence in their general science knowledge and confidence to teach all sciences, probably will be able to transmit their enthusiasm about science, and the relevance and constant interaction of science in personal lives. They will emphasize science as an important subject in their own classroom and in the lives of their students. From their own prior personal experiences in inquiry or hands-on science they will understand how to use the discovery method for stimulating curiosity, finding answers to questions in science, and dispelling unsubstantiated beliefs. They will consequently produce students with positive attitudes toward science who believe that anybody can be a scientist.

On the other hand, elementary teachers who fear or lack confidence in science usually avoid teaching any science, or they may reluctantly teach science ineffectively as memorizing meaningless terms out of a textbook. This approach tends to result in the next generation of students acquiring similar negative attitudes toward science and not being curious or able to apply scientific concepts in their daily lives. It may also result in subsequent groups of pre-service elementary teachers with a lack of confidence in their general science knowledge and their ability to teach all branches of elementary sciences. We must break out of this cycle because it has been shown that our nation cannot afford to wait to produce technologically scientifically literate graduates (Business-Higher Education Forum, 1983; Hazen & Trefil, 1991; Jacobson & Doran, 1986; Twentieth Century Fund, 1983).

# APPENDICES

# APPENDIX A

# INSTRUMENTS

Open-Ended Probes for Interviews

Questions 1, 2 and 3 will be submitted to the student before the interview.

1. Orientation question (Definition of science):
What do you think of when you think of "science"?

2. Learning (school) experiences:
How do you think you learn best? How would you describe yourself as a student of science? What science courses have you had in high school and college? Starting with your earliest recollections, discuss your experiences with science in school. What is most vivid about those memories, and why?

3. Learning (non-school) experiences:
Starting with your earliest recollections, discuss your experiences outside of school that relate to science.

4. Positive or negative influences:
What kinds of events, people, experiences do you feel have influenced you regarding science?

5. Teaching science:
Should science be taught in elementary school? Why, or why not? Based on your experiences, how do you think science should be taught to make it interesting and meaningful?

6. Importance of science:
In what ways, do you feel that science is an important aspect of your life? How do you demonstrate interest in science? How do you feel that progress in science has helped or harmed mankind? Do you ever seek answers on your own to the questions you have about science? If so, how? Has any recent scientific news interested or excited you?

7. Confidence:
What kind of image do you have of yourself as a science teacher? How confident are you about your general science knowledge? How can you gain more confidence?

8. Understanding:
What does "scientific knowledge" include? What does scientific inquiry or the scientific method mean to you? What characteristics must a scientist possess?

Survey I: Sampson Survey

After you have carefully read each statement, check your response to the statement:

AS) Agree Strongly
AM) Agree Mildly
U) Undecided
DM) Disagree mildly
DS) Disagree strongly.

ES 1) I remember science being taught in an exciting hands-on approach in elementary school.
AS____ AM____ U____ DM____ DS____

ES 2) I remember almost nothing about science in elementary school.
AS____ AM____ U____ DM____ DS____

3) I remember a few hands-on experiences.
AS____ AM____ U____ DM____ DS____

H 4) My science classes in junior high/high school were taught in an interesting fashion.
AS____ AM____ U____ DM____ DS____

5) My physical science classes, such as chemistry and physics, were more interesting than my life science classes, such as biology.
AS____ AM____ U____ DM____ DS____

Ind 6) My parents were supportive in establishing an interest in science in their children. (examples: purchased dissecting kits or telescopes, pointed out aspects of nature, went on trips to museums or on nature walks, initiated discussions)
AS____ AM____ U____ DM____ DS____

7) I found somebody who would answer my questions about science. (teacher, parent, sibling, or another person)
AS____ AM____ U____ DM____ DS____

8) I was taught how to find answers by myself to my questions about science.
AS____ AM____ U____ DM____ DS____

H 9) My junior high/high school teachers could explain science on my level.
AS____ AM____ U____ DM____ DS____

H 10) My junior high/high school science teachers were patient and understanding.
AS____ AM____ U____ DM____ DS____

11) My non-school experiences stimulated my present curiosity more than my science classes. (examples: camping, playing with a sibling, gardening, raising animals and plants, nature walks, collecting items, classifying collections, finding constellations)
AS____ AM____ U____ DM____ DS____

12) The educational instruction in science classes stimulated my present curiosity.
AS____ AM____ U____ DM____ DS____

13) I could relate my science education in school to my personal life and apply it.
AS____ AM____ U____ DM____ DS____

14) I could relate my physical science classes (chemistry, physics) more to my personal life than my life science classes (biology).
AS____ AM____ U____ DM____ DS____

15) I had opportunities for making unexpected new discoveries and for exploring new ideas in science class.
AS____ AM____ U____ DM____ DS____

16) I was encouraged to discover my own mistakes and misconceptions in science.
AS____ AM____ U____ DM____ DS____

17) In my junior high/high school understanding concepts was stressed.
AS____ AM____ U____ DM____ DS____

18) In my junior high/high school memorizing the science terminology was stressed.
AS____ AM____ U____ DM____ DS____

19) I was comfortable asking questions of the teacher.
AS____ AM____ U____ DM____ DS____

20) I learned as much about teaching science from my bad science teachers as from my good science teachers.
AS____ AM____ U____ DM____ DS____

21) I have confidence about my general science knowledge.
AS____ AM____ U____ DM____ DS____

22) I feel that taking more science classes outside of CTL would make me a better teacher of science.
AS____ AM____ U____ DM____ DS____

23) I feel I want to learn more science.
AS____ AM____ U____ DM____ DS____

24) I read articles about science and deliberately try to stay informed about advances in science.
AS____ AM____ U____ DM____ DS____

25) I seek answers to my questions about science. (examples: from teachers, library, news magazines, science journals)
AS____ AM____ U____ DM____ DS____

26) I have acquired the habit of questioning information.
AS____ AM____ U____ DM____ DS____

27) I logically and methodically approach the solution of problems.
AS____ AM____ U____ DM____ DS____

28) I have cultivated a desire to search for patterns and meanings.
AS____ AM____ U____ DM____ DS____

29) I am confident I would be successful taking non-CTL science classes.
AS____ AM____ U____ DM____ DS____

30) I have confidence about my mathematical ability for non-CTL science classes.
AS____ AM____ U____ DM____ DS____

31) Anybody can be a scientist.
AS____ AM____ U____ DM____ DS____

32) A scientist acts and thinks differently than other people.
AS____ AM____ U____ DM____ DS____

33) I fear that I will make incorrect statements about science when I teach.
AS____ AM____ U____ DM____ DS____

34) I feel I may need some support from other professionals when I teach science.
AS____ AM____ U____ DM____ DS____

35) It will be easy for me to teach reading in the elementary school.
AS____ AM____ U____ DM____ DS____

36) It will be easy for me to teach art in the elementary school.
AS____ AM____ U____ DM____ DS____

37) It will be easy for me to teach music in the elementary school.
AS____ AM____ U____ DM____ DS____

38) It will be easy for me to teach social studies in the elementary school.
AS____ AM____ U____ DM____ DS____

39) It will be easy for me to teach math in the elementary school.
AS____ AM____ U____ DM____ DS____

40) It will be easy for me to teach the life sciences (biology) in the elementary school.
AS____ AM____ U____ DM____ DS____

41) It will be easy for me to teach the physical sciences (physics, chemistry) in the elementary school.
AS____ AM____ U____ DM____ DS____

42) It will be easy for me to teach the earth sciences (geology) in the elementary school.
AS____ AM____ U____ DM____ DS____

43) It will be easy for me to teach the space sciences (astronomy) in the elementary school.
AS____ AM____ U____ DM____ DS____

44) It will be easy for me to teach ecology in the elementary school.
AS____ AM____ U____ DM____ DS____

45) In general, the way I feel about science is ______________

46) I think I feel as I do about science because ______________

Survey II: Shrigley Science Attitude Scale

After you have read each statement, check your response to the statement:

AS) Agree Strongly
AM) Agree Mildly
U) Undecided
DM) Disagree Mildly
DS) Disagree Strongly

1. I daydream during science class.
AS____ AM____ U____ DM____ DS____

2. I would like to have chosen science as a minor in my elementary education program.
AS____ AM____ U____ DM____ DS____

3. I dread science classes.
AS____ AM____ U____ DM____ DS____

4. Science lab equipment confuses me.
AS____ AM____ U____ DM____ DS____

5. I enjoy manipulating science equipment.
AS____ AM____ U____ DM____ DS____

6. I am afraid young students will ask me science questions I cannot answer.
AS____ AM____ U____ DM____ DS____

7. In science classes, I enjoy lab periods.
AS____ AM____ U____ DM____ DS____

8. Science is my favorite subject.
AS____ AM____ U____ DM____ DS____

9. If given the choice in student teaching, I would prefer teaching science over another subject in the elementary school.
AS____ AM____ U____ DM____ DS____

10. My science classes have been boring.
AS____ AM____ U____ DM____ DS____

11. I would enjoy helping children construct science equipment.
AS____ AM____ U____ DM____ DS____

12. When I become a teacher, I fear that science demonstrations will not work in class.
AS____ AM____ U____ DM____ DS____

13. I enjoy college science courses.
AS____ AM____ U____ DM____ DS____

14. I prefer that the instructor of a science class demonstrate equipment instead of expecting me to manipulate it.
AS____ AM____ U____ DM____ DS____

15. I would be interested working in an experimental elementary science curriculum project.
AS____ AM____ U____ DM____ DS____

16. I enjoy discussing science topics with my friends.
AS____ AM____ U____ DM____ DS____

17. Science is very difficult for me to understand.
AS____ AM____ U____ DM____ DS____

18. I expect to be able to excite students about science.
AS____ AM____ U____ DM____ DS____

19. I frequently use science ideas or facts in my personal life.
AS____ AM____ U____ DM____ DS____

20. I believe that I have the same scientific curiosity as a young child.
AS____ AM____ U____ DM____ DS____

APPENDIX B

TABLES

Table 10

Sampson Survey: Item Analysis Using Cronbach's Alpha to Measure Attitude toward Science (Education)

Reliability Analysis - Order of Questions Dropped

| Item Removed | Alpha |
|---|---|
| 1. None | .8693 |
| 2. Q37 It will be easy for me to teach music in the elementary school. | .8758 |
| 3. Q36 It will be easy for me to teach art in the elementary school. | .8773 |
| 4. Q35 It will be easy for me to teach reading in the elementary school. | .8835 |
| 5. Q11 My non-school experiences stimulated my present curiosity more than my science classes (examples: camping, playing with a sibling, gardening, raising animals and plants, going on nature walks, collecting items, classifying collections, finding constellations). | .8892 |
| 6. Q38 It will be easy for me to teach social studies in the elementary school. | .8937 |
| 7. Q20 I learned as much about teaching science from my bad science teachers as from my good science teachers. | .8977 |
| 8. Q32 A scientist acts and thinks differently than other people. | .9008 |
| 9. Q22 I feel that taking more science classes outside of CTL would make me a better teacher of science. | .9025 |
| 10. Q39 It will be easy for me to teach math in the elementary school. | .9040 |
| 11. Q31 Anybody can be a scientist. | .9055 |
| 12. Q23 I feel that I want to learn more science. | .9066 |
| 13. Q26 I have acquired the habit of questioning information. | .9084 |
| 14. Q25 I seek answers to my questions about science (examples: from teachers, library, news magazines, science journals). | .9100 |
| 15. Q18 I had opportunities for making unexpected new discoveries and for exploring new ideas in science class. | .9111 |

Table 11

Sampson Survey: Item Analysis Using Cronbach's Alpha to Measure Attitude toward Science (Education)

Total Correlation of Remaining Items

| Item Retained | Scale Mean If Item Deleted | Corrected Item-Total Correlation | Squared Multiple Correlation | Alpha If Item Deleted |
|---|---|---|---|---|
| Q1 | 86.0893 | .517 | .7826 | .9077 |
| Q2 | 85.7857 | .368 | .6803 | .9103 |
| Q3 | 85.0536 | .386 | .5569 | .9101 |
| Q4 | 85.1250 | .529 | .6835 | .9075 |
| Q5 | 85.9286 | .289 | .7196 | .9114 |
| Q6 | 85.2143 | .511 | .7562 | .9079 |
| Q7 | 85.0714 | .570 | .7239 | .9068 |
| Q8 | 85.3571 | .386 | .5646 | .9099 |
| Q9 | 85.1071 | .600 | .7914 | .9063 |
| Q10 | 85.0714 | .671 | .8317 | .9051 |
| Q12 | 85.3571 | .649 | .7283 | .9056 |
| Q13 | 85.4643 | .686 | .7649 | .9048 |
| Q14 | 86.1964 | .328 | .7406 | .9104 |
| Q15 | 85.6071 | .633 | .6515 | .9057 |
| Q16 | 85.7143 | .545 | .6488 | .9073 |
| Q17 | 85.2321 | .461 | .7106 | .9087 |
| Q19 | 85.0893 | .679 | .8013 | .9049 |
| Q21 | 85.2679 | .638 | .6655 | .9059 |
| Q24 | 85.3214 | .253 | .5688 | .9116 |
| Q27 | 84.8750 | .386 | .7244 | .9097 |
| Q28 | 84.8750 | .393 | .6942 | .9096 |
| Q29 | 85.0179 | .446 | .6452 | .9089 |
| Q30 | 85.2500 | .510 | .6310 | .9078 |
| Q33 | 85.4107 | .314 | .6006 | .9109 |
| Q34 | 86.0357 | .344 | .6458 | .9104 |
| Q40 | 84.6071 | .433 | .8076 | .9091 |
| Q41 | 85.6071 | .706 | .7961 | .9049 |
| Q42 | 84.9821 | .416 | .8047 | .9093 |
| Q43 | 85.2500 | .355 | .8458 | .9103 |
| Q44 | 84.8036 | .415 | .7389 | .9093 |

Note. Alpha = .9111

(table continues)

<u>Questions Retained in Table 2</u>:

Q1: I remember science being taught in an exciting hands-on approach in elementary school.
Q2: I remember almost nothing about science in elementary school.
Q3: I remember a few hands-on experiences.
Q4: My science classes in junior high/high school were taught in an interesting fashion.
Q5: My physical science classes, such as chemistry and physics, were more interesting than my life science classes, such as biology.
Q6: My parents were supportive in establishing an interest in science in their children (examples: purchased dissecting kits or telescopes, pointed out aspects of nature, went on trips to museums or on nature walks, initiated discussion).
Q7: I found somebody who would answer my questions about science.
Q8: I was taught how to find answers by myself to my questions about science.
Q9: My junior high/high school teachers could explain science on my level.
Q10: My junior high/high school science teachers were patient and understanding.
Q12: The educational instruction in science classes stimulated my present curiosity.
Q13: I could related my science education in school to my personal life and apply it.
Q14: I could relate my physical science classes (chemistry, physics) more to my personal life than my life science classes (biology).
Q15: I had opportunities for making unexpected new discoveries and for exploring new ideas in science class.
Q16: I was encouraged to discover my own mistakes and misconceptions in science.
Q17: In my junior high/high school understanding concepts was stressed.
Q19: I was comfortable asking questions of the teacher.
Q21: I have confidence about my general science knowledge.
Q24: I read articles about science and deliberately try to stay informed about advances in science.
Q27: I logically and methodically approach the solution of problems.
Q28: I have cultivated a desire to search for patterns and meanings.
Q29: I am confident I would be successful-taking non-CTL science classes.
Q30: I have confidence about my mathematical ability for non-CTL science classes.
Q33: I fear that I will make incorrect statements about science when I teach.
Q34: I feel I may need some support from other professionals when I teach science.
Q40: It will easy for me to teach life science (biology) in the elementary school.
Q41: It will be easy for me to teach physical sciences (physics, chemistry) in the elementary school.

(<u>table continues</u>)

Q42: It will be easy for me to teach earth sciences (geology) in the elementary school.
Q43: It will be easy for me to teach space sciences (astronomy) in the elementary school.
Q44: It will be easy for me to teach ecology in the elementary school.

Table 12

Sampson Survey: Factor Matrix

| Item | Factor 1 | Factor 2 | Factor 3 |
|---|---|---|---|
| Q1 | .56334 | -.12262 | -.06529 |
| Q2 | -.41049 | .29310 | .15272 |
| Q3 | .43849 | -.34086 | .02623 |
| Q4 | .56856 | -.24571 | .22359 |
| Q5 | .31723 | -.12664 | .06508 |
| Q6 | .55572 | -.17718 | -.12217 |
| Q7 | .62677 | -.20951 | -.16655 |
| Q8 | .42341 | -.08785 | .23792 |
| Q9 | .65520 | -.35082 | .06746 |
| Q10 | .72289 | -.09307 | .14102 |
| Q11 | -.33274 | .15496 | .13167 |
| Q12 | .68133 | -.20371 | -.06755 |
| Q13 | .72283 | -.10338 | .01522 |
| Q14 | .34299 | -.04983 | .28487 |
| Q15 | .67924 | -.14831 | .05270 |
| Q16 | .60139 | -.23414 | .25816 |
| Q17 | .52185 | -.43927 | .12517 |
| Q18 | -.18912 | .17136 | .13374 |
| Q19 | .71484 | -.17480 | .09965 |
| Q20 | -.00754 | -.16207 | .11265 |
| Q21 | .66050 | .08785 | -.29140 |
| Q22 | .05824 | .28136 | .03052 |
| Q23 | .04900 | .40272 | -.03853 |
| Q24 | .27026 | .49906 | -.10348 |
| Q25 | .10447 | .59068 | .14313 |
| Q26 | .10597 | .40329 | .48378 |
| Q27 | .40092 | .18371 | .55384 |
| Q28 | .39705 | .48731 | .47746 |
| Q29 | .46184 | .31688 | -.17443 |
| Q30 | .55592 | .05897 | .14853 |
| Q31 | .20389 | .29304 | -.46769 |
| Q32 | .06247 | .05104 | .01795 |
| Q33 | -.35788 | -.19992 | .04394 |
| Q34 | -.37076 | -.30721 | -.14800 |
| Q35 | -.36093 | .17798 | -.06991 |

(table continues)

| Item | Factor 1 | Factor 2 | Factor 3 |
|---|---|---|---|
| Q36 | -.03370 | .20128 | .38997 |
| Q37 | -.22426 | .15252 | .03282 |
| Q38 | -.18614 | .50563 | .37859 |
| Q39 | .06833 | .26027 | .33850 |
| Q40 | .45322 | .58681 | -.30352 |
| Q41 | .72676 | .24966 | -.23835 |
| Q42 | .42952 | .65457 | -.26816 |
| Q43 | .38144 | .56505 | -.39101 |
| Q44 | .42656 | .54960 | -.23744 |

Highest Factor Loadings and Related Questions:

Factor 1:

| | | |
|---|---|---|
| .72676 | Q41 | It will be easy for me to teach physical sciences (physics, chemistry) in elementary school. |
| .72289 | Q10 | My junior high/high school science teachers were patient and understanding. |
| .72283 | Q13 | I could relate my science education in school to my personal life and apply it. |
| .71484 | Q19 | I was comfortable asking questions of the teacher. |
| .68133 | Q12 | The educational instruction in science classes stimulated my present curiosity. |
| .67924 | Q15 | I had opportunities for making unexpected new discoveries and for exploring new ideas in science class. |
| .66050 | Q21 | I have confidence about my general science knowledge. |
| .65520 | Q9 | My junior high/high school teachers could explain science on my level. |
| .62677 | Q7 | I found somebody who would answer my questions about science (teacher, parent, sibling, or another person). |
| .60139 | Q16 | I was encouraged to discover my own mistakes and misconceptions in science. |
| .56856 | Q4 | My science classes in junior high/high school were taught in an interesting fashion. |
| .56334 | Q1 | I remember science being taught in an exciting hands-on approach in elementary school. |
| .55592 | Q30 | I have confidence about my mathematical ability for non-CTL science classes. |
| .55572 | Q6 | My parents were supportive in establishing an interest in science in their children (examples: purchased dissecting kits or telescopes, pointed out aspects of nature, went on trips to museums or on nature walks, initiated discussion). |
| .52185 | Q17 | In junior high/high school understanding concepts was stressed. |
| .46184 | Q29 | I am confident I would be successful taking non-CTL science classes. |

(table continues)

Factor 2:

| | | |
|---|---|---|
| .65457 | Q42 | It will be easy for me to teach earth sciences (geology) in the elementary school. |
| .59068 | Q25 | I seek answers to my questions about science (examples: from teachers, library, news magazines, science journals). |
| .58681 | Q40 | It will be easy for me to teach life science (biology) in the elementary school. |
| .56505 | Q43 | It will be easy for me to teach space sciences (astronomy) in the elementary school. |
| .54960 | Q44 | It will be easy for me to teach ecology in the elementary school. |
| .50563 | Q38 | It will be easy for me to teach social studies in the elementary school. |
| .49906 | Q24 | I read articles about science and deliberately try to stay informed about advances in science. |
| .48731 | Q28 | I have cultivated a desire to search for patterns and meanings. |
| .43927 | Q17 | In my junior high/high school understanding concepts was stressed. |
| .40329 | Q26 | I have acquired the habit of questioning information. |
| .40272 | Q23 | I want to learn more science. |

Factor 3:

| | | |
|---|---|---|
| .55384 | Q27 | I logically and methodically approach the solution of problems. |
| .48378 | Q26 | I have acquired the habit of questioning information. |
| .47746 | Q28 | I have cultivated a desire to search for patterns and meanings. |
| .46769 | Q31 | Anybody can be a scientist. |

Table 13

Shrigley Science Attitude Scale: Item Analysis Using Cronbach's Alpha to Measure Attitude toward Science (Education)

| Item Retained | Scale Mean If Item Deleted | Corrected Item-Total Correlation | Squared Multiple Correlation | Alpha If Item Deleted |
|---|---|---|---|---|
| S1 | 63.7544 | .501 | .4603 | .9037 |
| S2 | 64.7018 | .645 | .6467 | .8998 |
| S3 | 63.3509 | .725 | .6929 | .8979 |
| S4 | 63.9298 | .462 | .5110 | .9049 |
| S5 | 63.4035 | .440 | .7169 | .9049 |
| S6 | 64.7193 | .506 | .6730 | .9036 |
| S7 | 63.1228 | .479 | .7649 | .9043 |
| S8 | 64.5088 | .781 | .7502 | .8957 |
| S9 | 64.5263 | .785 | .7943 | .8955 |
| S10 | 63.9825 | .528 | .5862 | .9033 |
| S11 | 63.3509 | .413 | .4662 | .9055 |
| S12 | 63.9825 | .589 | .6038 | .9013 |
| S13 | 63.9649 | .567 | .5140 | .9020 |
| S14 | 64.2281 | -.145 | .2894 | .9205 |
| S15 | 63.4211 | .478 | .5150 | .9042 |
| S16 | 64.1228 | .715 | .7952 | .8980 |
| S17 | 64.0351 | .590 | .5944 | .9013 |
| S18 | 63.3333 | .716 | .7157 | .8999 |
| S19 | 64.0175 | .559 | .5700 | .9022 |
| S20 | 63.5439 | .733 | .8018 | .8979 |

Note. Alpha = .9069

Questions Shown in Table 4:

S1: I daydream during science class.
S2: I would like to have chosen science as a minor in my elementary education program.
S3: I dread science classes.
S4: Science lab equipment confuses me.
S5: I enjoy manipulating science equipment.
S6: I am afraid young students will ask me science questions I cannot answer.
S7: In science classes, I enjoy lab periods.
S8: Science is my favorite subject.
S9: If given the choice in student teaching, I would prefer teaching science over another subject in the elementary school.

(table continues)

S10: My science classes have been boring.
S11: I would enjoy helping children construct science equipment.
S12: When I become a teacher, I fear that science demonstrations will not work in class.
S13: I enjoy college science courses.
S14: I prefer that the instructor of a science class demonstrate equipment instead of expecting me to manipulate it.
S15. I would be interested working in an experimental elementary science curriculum project.
S16: I enjoy discussing science topics with my friends.
S17: Science is very difficult for me to understand.
S18: I expect to be able to excite students about science.
S19: I frequently use science ideas or facts in my personal life.
S20: I believe that I have the same scientific curiosity as a young child.

Table 14

Shrigley Science Attitude Scale: Item Analysis Using Cronbach's Alpha to Measure Attitude toward Science (Education)

Category I: Attitudes toward Science Content

| Item | Scale Mean If Item Deleted | Corrected Item-Total Correlation | Squared Multiple Correlation | Alpha If Item Deleted |
|---|---|---|---|---|
| S2 | 15.9825 | .637 | .4736 | .8231 |
| S3 | 14.6316 | .652 | .4451 | .8215 |
| S8 | 15.7895 | .787 | .6720 | .7929 |
| S9 | 15.8070 | .743 | .6224 | .8016 |
| S10 | 15.2632 | .470 | .2397 | .8571 |
| S13 | 15.2456 | .537 | .3384 | .8421 |

Note. Alpha = .8489

Questions Asked in Category I:

S2: I would like to have chosen science as a minor in elementary education program.
S3: I dread science classes.
S8: Science is my favorite subject.
S9: If given the choice in student teaching, I would prefer teaching science over another subject in the elementary school.
S10: My science classes have been boring.
S13: I enjoy college science courses.

Table 15

Shrigley Science Attitude Scale: Item Analysis Using Cronbach's Alpha to Measure Attitude toward Science (Education)

Category II: Attitudes toward Handling Science Equipment

| Item | Scale Mean If Item Deleted | Corrected Item-Total Correlation | Squared Multiple Correlation | Alpha If Item Deleted |
|---|---|---|---|---|
| S4 | 18.7895 | .350 | .2770 | .4444 |
| S5 | 18.2632 | .523 | .4813 | .3555 |
| S7 | 17.9825 | .646 | .5375 | .3433 |
| S11 | 18.2105 | .327 | .3320 | .4639 |
| S14 | 19.0877 | -.145 | .1082 | .7023 |
| S15 | 18.2807 | .242 | .1576 | .5009 |

Note. Alpha = .5302

Questions Asked in Category II:

S4: Science lab equipment confuses me.
S5: I enjoy manipulating science equipment.
S7: In science classes, I enjoy lab periods.
S11: I would enjoy helping children construct science equipment.
S14: I prefer that the instructor of a science class demonstrate equipment instead of expecting me to manipulate it.
S15: I would be interested working in an experimental elementary science curriculum project.

Table 16

Shrigley Science Attitude Scale: Item Analysis Using Cronbach's Alpha to Measure Attitude toward Science (Education)

Category III: Attitudes toward Science Teaching

| Item | Scale Mean If Item Deleted | Corrected Item-Total Correlation | Squared Multiple Correlation | Alpha If Item Deleted |
|---|---|---|---|---|
| S1 | 14.0351 | .335 | .1670 | .8710 |
| S16 | 14.4035 | .750 | .6338 | .7409 |
| S18 | 13.6140 | .798 | .6504 | .7504 |
| S19 | 14.2982 | .643 | .4988 | .7763 |
| S20 | 13.8246 | .652 | .5696 | .7738 |

*Note*. Alpha = .8206

Questions Asked in Category III:

S1: I daydream during science class.
S16: I enjoy discussing science topics with my friends.
S18: I expect to be able to excite students about science.
S19: I frequently use science ideas or facts in my personal life.
S20: I believe that I have the same scientific curiosity as a young child.

Table 17

Shrigley Science Attitude Scale: Item Analysis Using Cronbach's Alpha to Measure Attitude toward Science (Education)

Category IV: Antipathy toward Science Teaching

| Item | Scale Mean If Item Deleted | Corrected Item-Total Correlation | Squared Multiple Correlation | Alpha If Item Deleted |
|---|---|---|---|---|
| S6 | 6.5088 | .606 | .3745 | .5886 |
| S12 | 5.7719 | .562 | .3324 | .6455 |
| S17 | 5.8246 | .510 | .2626 | .7071 |

Note. Alpha = .7344

Questions Asked in Category IV:

S6: I am afraid young students will ask me science questions I cannot answer.

S12: When I become a teacher, I fear that science demonstrations will not work in class.

S17: Science is very difficult for me to understand.

Table 18

Sampson Survey: Frequencies and Percentages

DS - disagree strongly
DM - disagree mildly
U - undecided
AM - agree mildly
AS - agrees strongly
M - mean
SD - standard deviation

Q1: I remember science being taught in an exciting hands-on approach in elementary school.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 21 | 19 | 3 | 11 | 3 | 2.228 | 1.282 |
| % | 36.8 | 33.3 | 5.3 | 19.3 | 5.3 | | |

Q2: I remember almost nothing about science in elementary school.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 4 | 14 | 3 | 22 | 14 | 3.491 | 1.297 |
| % | 7.0 | 24.6 | 5.3 | 38.6 | 24.6 | | |

Q3: I remember a few hands-on experiences.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 9 | 11 | 3 | 26 | 8 | 3.228 | 1.350 |
| % | 15.8 | 19.3 | 5.3 | 45.6 | 14.0 | | |

Q4: My science classes in junior high/high school were taught in an interesting fashion.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 7 | 14 | 5 | 25 | 6 | 3.158 | 1.265 |
| % | 12.3 | 24.6 | 8.8 | 43.9 | 10.5 | | |

Q5: My physical science classes, such as chemistry and physics, were more interesting than my life science classes, such as biology.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 17 | 18 | 13 | 5 | 4 | 2.316 | 1.198 |
| % | 29.8 | 31.6 | 22.8 | 8.8 | 7.0 | | |

Q6: My parents were supportive in establishing an interest in science in their children (examples: purchased dissecting kits or telescopes, pointed out aspects of nature, went on trips to museums or on nature walks, initiated discussions).

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 9 | 14 | 8 | 16 | 10 | 3.070 | 1.374 |
| % | 15.8 | 24.6 | 14.0 | 28.1 | 17.5 | | |

Q7: I found somebody who would answer my questions about science (teacher, parent, sibling, or another person).

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 6 | 14 | 8 | 20 | 9 | 3.211 | 1.278 |
| % | 10.5 | 24.6 | 14.0 | 35.1 | 15.8 | | |

(table continues)

Q8: I was taught how to find answers by myself to my questions about science.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (DS) 8 | (DM) 14 | (U) 15 | (AM) 15 | (AS) 5 | (M) 2.912 | (SD) 1.199 |
| % | 14.0 | 24.6 | 26.3 | 26.3 | 8.8 | | |

Q9: My junior high/high school teachers could explain science on my level.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (DS) 6 | (DM) 15 | (U) 6 | (AM) 23 | (AS) 7 | (M) 3.175 | (SD) 1.255 |
| % | 10.5 | 26.3 | 10.5 | 40.4 | 12.3 | | |

Q10: My junior high/high school science teachers were patient and understanding.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (DS) 2 | (DM) 21 | (U) 7 | (AM) 16 | (AS) 11 | (M) 3.228 | (SD) 1.239 |
| % | 3.5 | 36.8 | 12.3 | 28.1 | 19.3 | | |

Q11: My non-school experiences stimulated my present curiosity more than my science classes (examples: camping, playing with a sibling, gardening, raising animals and plants, nature walks, collecting items, classifying collections, finding constellations).

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (DS) 1 | (DM) 2 | (U) 2 | (AM) 21 | (AS) 30 | (M) 4.375 | (SD) .865 |
| % | 1.8 | 3.6 | 3.6 | 37.5 | 53.6 | | |

Q12: The educational instruction in science classes stimulated by present curiosity.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (DS) 4 | (DM) 24 | (U) 5 | (AM) 19 | (AS) 4 | (M) 2.911 | (SD) 1.164 |
| % | 7.1 | 42.9 | 8.9 | 33.9 | 7.1 | | |

Q13: I could relate my science education in school to my personal life and apply it.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (DS) 9 | (DM) 18 | (U) 8 | (AM) 17 | (AS) 4 | (M) 2.804 | (SD) 1.242 |
| % | 16.1 | 32.1 | 14.3 | 30.4 | 7.1 | | |

Q14: I could relate my physical science classes (chemistry, physics) more to my personal life than my life science classes (biology).

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (DS) 20 | (DM) 15 | (U) 18 | (AM) 3 | (AS) 0 | (M) 2.071 | (SD) .951 |
| % | 35.7 | 26.8 | 32.1 | 5.4 | 0 | | |

Q15: I had opportunities for making unexpected new discoveries and for exploring new ideas in science class.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (DS) 13 | (DM) 15 | (U) 9 | (AM) 16 | (AS) 3 | (M) 2.661 | (SD) 1.269 |
| % | 23.2 | 26.8 | 16.1 | 28.6 | 5.4 | | |

Q16: I was encouraged to discover my own mistakes and misconceptions in science.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (DS) 11 | (DM) 19 | (U) 12 | (AM) 12 | (AS) 2 | (M) 2.554 | (SD) 1.143 |
| % | 19.6 | 33.9 | 21.4 | 21.4 | 3.6 | | |

Q17: In my junior high/high school understanding concepts was stressed.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (DS) 7 | (DM) 16 | (U) 8 | (AM) 18 | (AS) 7 | (M) 3.036 | (SD) 1.279 |
| % | 12.5 | 28.6 | 14.3 | 32.1 | 12.5 | | |

(table continues)

Q18: In my junior high/high school memorizing the science terminology was stressed.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 1 | (DM) | 3 | (U) | 2 | (AM) | 13 | (AS) | 37 | (M) | 4.464 | (SD) | .934 |
| % | 1.8 | | 5.4 | | 3.6 | | 23.2 | | 66.1 | | | | |

Q19: I was comfortable asking questions of the teacher.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 7 | (DM) | 12 | (U) | 8 | (AM) | 22 | (AS) | 7 | (M) | 3.179 | (SD) | 1.266 |
| % | 12.5 | | 21.4 | | 14.3 | | 39.3 | | 12.5 | | | | |

Q20: I learned as much about teaching science from my bad science teachers as from my good science teachers.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 17 | (DM) | 8 | (U) | 15 | (AM) | 12 | (AS) | 4 | (M) | 2.607 | (SD) | 1.317 |
| % | 30.4 | | 14.3 | | 26.8 | | 21.4 | | 7.1 | | | | |

Q21: I have confidence about my general science knowledge.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 6 | (DM) | 14 | (U) | 13 | (AM) | 20 | (AS) | 3 | (M) | 3.000 | (SD) | 1.128 |
| % | 10.7 | | 25.0 | | 23.2 | | 35.7 | | 5.4 | | | | |

Q22: I feel that taking more science classes outside of CTL would make me a better teacher of science.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 0 | (DM) | 6 | (U) | 8 | (AM) | 24 | (AS) | 18 | (M) | 3.964 | (SD) | .953 |
| % | 0 | | 10.7 | | 14.3 | | 42.9 | | 32.1 | | | | |

Q23: I feel I want to learn more science.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 0 | (DM) | 0 | (U) | 1 | (AM) | 27 | (AS) | 28 | (M) | 4.482 | (SD) | .539 |
| % | 0 | | 0 | | 1.8 | | 48.2 | | 50.0 | | | | |

Q24: I read articles about science and deliberately try to stay informed about advances in science.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 4 | (DM) | 20 | (U) | 9 | (AM) | 22 | (AS) | 2 | (M) | 2.965 | (SD) | 1.085 |
| % | 7.0 | | 35.1 | | 15.8 | | 38.6 | | 3.5 | | | | |

Q25: I seek answers to my questions about science (examples: from teachers, library, news magazines, science journals).

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 1 | (DM) | 20 | (U) | 13 | (AM) | 21 | (AS) | 2 | (M) | 3.053 | (SD) | .971 |
| % | 1.8 | | 35.1 | | 22.8 | | 36.8 | | 3.5 | | | | |

Q26: I have acquired the habit of questioning information.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 1 | (DM) | 9 | (U) | 9 | (AM) | 26 | (AS) | 12 | (M) | 3.684 | (SD) | 1.038 |
| % | 1.8 | | 15.8 | | 15.8 | | 45.6 | | 21.1 | | | | |

Q27: I logically and methodically approach the solution of problems.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 2 | (DM) | 11 | (U) | 13 | (AM) | 25 | (AS) | 6 | (M) | 3.386 | (SD) | 1.031 |
| % | 3.5 | | 19.3 | | 22.8 | | 43.9 | | 10.5 | | | | |

Q28: I have cultivated a desire to search for patterns and meanings.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 1 | (DM) | 14 | (U) | 12 | (AM) | 23 | (AS) | 7 | (M) | 3.368 | (SD) | 1.046 |
| % | 1.8 | | 24.6 | | 21.1 | | 40.4 | | 12.3 | | | | |

(table continues)

Q29: I am confident I would be successful taking non-CTL science classes.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 5 | 13 | 12 | 15 | 12 | 3.281 | 1.278 |
| % | 8.8 | 22.8 | 21.1 | 26.3 | 21.1 | | |

Q30: I have confidence about my mathematical ability for non-CTL science classes.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 8 | 17 | 7 | 18 | 7 | 2.982 | 1.302 |
| % | 14.0 | 29.8 | 12.3 | 31.6 | 12.3 | | |

Q31: Anybody can be a scientist.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 10 | 11 | 11 | 17 | 8 | 3.035 | 1.336 |
| % | 17.5 | 19.3 | 19.3 | 29.8 | 14.0 | | |

Q32: A scientist acts and thinks differently than other people.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 10 | 21 | 6 | 16 | 4 | 2.702 | 1.253 |
| % | 17.5 | 36.8 | 10.5 | 28.1 | 7.0 | | |

Q33: I fear that I will make incorrect statements about science when I teach.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 6 | 12 | 13 | 21 | 5 | 3.123 | 1.166 |
| % | 10.5 | 21.1 | 22.8 | 36.8 | 8.8 | | |

Q34: I feel I may need some support from other professionals when I teach science.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 4 | 7 | 4 | 28 | 14 | 3.719 | 1.176 |
| % | 7.0 | 12.3 | 7.0 | 49.1 | 24.6 | | |

Q35: It will be easy for me to teach reading in the elementary school.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 2 | 1 | 7 | 33 | 14 | 3.982 | .876 |
| % | 3.5 | 1.8 | 12.3 | 57.9 | 24.6 | | |

Q36: It will be easy for me to teach art in the elementary school.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 0 | 5 | 4 | 30 | 18 | 4.070 | .863 |
| % | 0 | 8.8 | 7.0 | 52.6 | 31.6 | | |

Q37: It will be easy for me to teach music in the elementary school.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 6 | 14 | 4 | 25 | 8 | 3.263 | 1.275 |
| % | 10.5 | 24.6 | 7.0 | 43.9 | 14.0 | | |

Q38: It will be easy for me to teach social studies in the elementary school.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 2 | 8 | 7 | 28 | 12 | 3.702 | 1.068 |
| % | 3.5 | 14.0 | 12.3 | 49.1 | 21.1 | | |

Q39: It will be easy for me to teach math in the elementary school.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
|---|---|---|---|---|---|---|---|
| | 1 | 7 | 7 | 31 | 11 | 3.772 | .964 |
| % | 1.8 | 12.3 | 12.3 | 54.4 | 19.3 | | |

(table continues)

Q40: It will be easy for me to teach life science (biology) in the elementary school.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 1 | (DM) | 8 | (U) | 8 | (AM) | 31 | (AS) | 9 | (M) | 3.684 | (SD) | .967 |
| % | 1.8 | | 14.0 | | 14.0 | | 54.4 | | 15.8 | | | | |

Q41: It will be easy for me to teach physical sciences (physics, chemistry) in the elementary school.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 7 | (DM) | 24 | (U) | 10 | (AM) | 14 | (AS) | 2 | (M) | 2.649 | (SD) | 1.094 |
| % | 12.3 | | 42.1 | | 17.5 | | 24.6 | | 3.5 | | | | |

Q42: It will be easy for me to teach earth sciences (geology) in the elementary school.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 0 | (DM) | 19 | (U) | 8 | (AM) | 23 | (AS) | 7 | (M) | 3.316 | (SD) | 1.072 |
| % | 0 | | 33.3 | | 14.0 | | 40.4 | | 12.3 | | | | |

Q43: It will be easy for me to teach space sciences (astronomy) in the elementary school.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 6 | (DM) | 15 | (U) | 10 | (AM) | 23 | (AS) | 3 | (M) | 3.035 | (SD) | 1.149 |
| % | 10.5 | | 26.3 | | 17.5 | | 40.4 | | 5.3 | | | | |

Q44: It will be easy for me to teach ecology in the elementary school.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 2 | (DM) | 12 | (U) | 10 | (AM) | 22 | (AS) | 11 | (M) | 3.491 | (SD) | 1.136 |
| % | 3.5 | | 21.1 | | 17.5 | | 38.6 | | 19.3 | | | | |

Table 19

Shrigley Science Attitude Scale: Frequencies and Percentages

AS - agree strongly
AM - agree mildly
U - undecided
DM - disagree mildly
DS - disagree strongly
M - mean
SD - standard deviation

S1: I daydream during science class.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | 12 | 25 | 3 | 14 | 3 | 2.491 | 1.227 |
| % | 21.1 | 43.9 | 5.3 | 24.6 | 5.3 | | |

S2: I would like to have chosen science as a minor in my elementary education program.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | 11 | 22 | 10 | 9 | 5 | 2.561 | 1.225 |
| % | 19.3 | 38.6 | 17.5 | 15.8 | 8.8 | | |

S3: I dread science class.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | 21 | 21 | 6 | 7 | 2 | 2.088 | 1.138 |
| % | 36.8 | 36.8 | 10.5 | 12.3 | 3.5 | | |

S4: Science lab equipment confuses me.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | 11 | 21 | 6 | 14 | 5 | 2.667 | 1.286 |
| % | 19.3 | 36.8 | 10.5 | 24.6 | 8.8 | | |

S5: I enjoy manipulating science equipment.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | 2 | 6 | 6 | 27 | 16 | 3.860 | 1.060 |
| % | 3.5 | 10.5 | 10.5 | 47.4 | 28.1 | | |

S6: I am afraid young students will ask me science questions I cannot answer.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | 5 | 10 | 8 | 22 | 12 | 3.456 | 1.255 |
| % | 8.8 | 17.5 | 14.0 | 38.6 | 21.1 | | |

S7: In science classes, I enjoy lab periods.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | 1 | 2 | 3 | 33 | 18 | 4.140 | .811 |
| % | 1.8 | 3.5 | 5.3 | 57.9 | 31.6 | | |

S8: Science is my favorite subject.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | 10 | 20 | 7 | 14 | 6 | 2.754 | 1.299 |
| % | 17.5 | 35.1 | 12.3 | 24.6 | 10.5 | | |

S9: If given the choice in student teaching, I would prefer teaching science over another subject in the elementary school.

| | (DS) | (DM) | (U) | (AM) | (AS) | (M) | (SD) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | 11 | 18 | 10 | 11 | 7 | 2.737 | 1.316 |
| % | 19.3 | 31.6 | 17.5 | 19.3 | 12.3 | | |

(table continues)

S10: My science classes have been boring.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 12 | (DM) | 20 | (U) | 6 | (AM) | 10 | (AS) | 9 | (M) | 2.719 | (SD) | 1.398 |
| % | 21.1 | | 35.1 | | 10.5 | | 17.5 | | 15.8 | | | | |

S11: I would enjoy helping children construct science equipment.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 0 | (DM) | 7 | (U) | 7 | (AM) | 27 | (AS) | 16 | (M) | 3.912 | (SD) | .950 |
| % | 0 | | 12.3 | | 12.3 | | 47.7 | | 28.1 | | | | |

S12: When I become a teacher, I fear that science demonstrations will not work in class.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 9 | (DM) | 20 | (U) | 8 | (AM) | 18 | (AS) | 2 | (M) | 2.719 | (SD) | 1.176 |
| % | 15.8 | | 35.1 | | 14.0 | | 31.6 | | 3.5 | | | | |

S13: I enjoy college science courses.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 5 | (DM) | 15 | (U) | 7 | (AM) | 18 | (AS) | 12 | (M) | 3.298 | (SD) | 1.267 |
| % | 8.8 | | 26.3 | | 12.3 | | 31.6 | | 21.1 | | | | |

S14: I prefer that the instructor of a science class demonstrate equipment instead of expecting me to manipulate it.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 9 | (DM) | 14 | (U) | 9 | (AM) | 20 | (AS) | 5 | (M) | 2.965 | (SD) | 1.267 |
| % | 15.8 | | 24.6 | | 15.0 | | 35.1 | | 8.8 | | | | |

S15: I would be interested working in an experimental elementary science curriculum project.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 1 | (DM) | 3 | (U) | 13 | (AM) | 27 | (AS) | 13 | (M) | 3.842 | (SD) | .902 |
| % | 1.8 | | 5.3 | | 22.8 | | 47.4 | | 22.8 | | | | |

S16: I enjoy discussing science topics with my friends.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 4 | (DM) | 16 | (U) | 14 | (AM) | 14 | (AS) | 9 | (M) | 3.140 | (SD) | 1.202 |
| % | 7.0 | | 28.1 | | 24.6 | | 24.6 | | 15.8 | | | | |

S17: Science is very difficult for me to understand.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 9 | (DM) | 20 | (U) | 10 | (AM) | 11 | (AS) | 7 | (M) | 2.772 | (SD) | 1.282 |
| % | 15.8 | | 35.1 | | 17.5 | | 19.3 | | 12.3 | | | | |

S18: I expect to be able to excite students about science.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 0 | (DM) | 3 | (U) | 13 | (AM) | 26 | (AS) | 15 | (M) | 3.930 | (SD) | .842 |
| % | 0 | | 5.3 | | 22.8 | | 45.6 | | 26.3 | | | | |

S19: I frequently use science ideas or facts in my personal life.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 2 | (DM) | 16 | (U) | 13 | (AM) | 18 | (AS) | 8 | (M) | 3.246 | (SD) | 1.123 |
| % | 3.5 | | 28.1 | | 22.8 | | 31.6 | | 14.0 | | | | |

S20: I believe that I have the same scientific curiosity as a young child.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DS) | 1 | (DM) | 11 | (U) | 5 | (AM) | 26 | (AS) | 14 | (M) | 3.719 | (SD) | 1.098 |
| % | 1.8 | | 19.3 | | 8.8 | | 45.6 | | 24.6 | | | | |

Table 20

Sampson Survey: Pearson Correlation and Approximate Significance for Every Question by Question 21 ("I have confidence in my general science knowledge.")

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q1 | .339 | .005 |
| Q2 | -.361 | .003 |
| Q3 | .261 | .026 |
| Q4 | .342 | .005 |
| Q5 | .067 | .311 |
| Q6 | .479 | .001 |
| Q7 | .489 | .001 |
| Q8 | .253 | .030 |
| Q9 | .307 | .011 |
| Q10 | .276 | .020 |
| Q11 | -.130 | .169 |
| Q12 | .484 | .001 |
| Q13 | .532 | .001 |
| Q14 | .102 | .228 |
| Q15 | .356 | .004 |
| Q16 | .240 | .038 |
| Q17 | .277 | .019 |
| Q18 | -.173 | .102 |
| Q19 | .471 | .001 |
| Q20 | -.024 | .429 |
| Q22 | .051 | .355 |
| Q23 | -.060 | .331 |
| Q24 | .208 | .062 |
| Q25 | .033 | .404 |
| Q26 | -.015 | .455 |
| Q27 | .140 | .152 |
| Q28 | .171 | .104 |
| Q29 | .368 | .003 |
| Q30 | .338 | .005 |
| Q31 | .305 | .011 |
| Q32 | .141 | .151 |
| Q33 | -.304 | .011 |
| Q34 | -.243 | .036 |
| Q35 | -.109 | .211 |
| Q36 | -.112 | .205 |

(table continues)

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q37 | -.051 | .356 |
| Q38 | -.239 | .038 |
| Q39 | .090 | .255 |
| Q40 | .538 | .001 |
| Q41 | .513 | .001 |
| Q42 | .427 | .001 |
| Q43 | .350 | .004 |
| Q44 | .429 | .001 |

Table 21

Sampson Survey: Pearson Correlation and Approximate Significance for Every Question by Question 23, "I feel I want to learn more science."

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q1 | -.077 | .287 |
| Q2 | .027 | .423 |
| Q3 | -.119 | .191 |
| Q4 | -.049 | .359 |
| Q5 | -.089 | .257 |
| Q6 | -.109 | .213 |
| Q7 | .097 | .238 |
| Q8 | -.044 | .373 |
| Q9 | -.089 | .256 |
| Q10 | .157 | .125 |
| Q11 | -.122 | .185 |
| Q12 | -.017 | .450 |
| Q13 | -.046 | .368 |
| Q14 | -.068 | .308 |
| Q15 | -.049 | .360 |
| Q16 | -.028 | .419 |
| Q17 | -.157 | .123 |
| Q18 | .234 | .042 |
| Q19 | -.128 | .173 |
| Q20 | -.036 | .397 |
| Q21 | -.060 | .331 |
| Q22 | .211 | .059 |
| Q24 | .076 | .289 |
| Q25 | .316 | .009 |
| Q26 | .151 | .134 |
| Q27 | .045 | .370 |
| Q28 | .272 | .021 |
| Q29 | .193 | .077 |
| Q30 | .092 | .249 |
| Q31 | .179 | .094 |
| Q32 | .260 | .027 |
| Q33 | -.169 | .106 |
| Q34 | .008 | .477 |
| Q35 | .133 | .165 |
| Q36 | .100 | .232 |

(table continues)

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q37 | .034 | .402 |
| Q38 | .006 | .482 |
| Q39 | .069 | .308 |
| Q40 | .287 | .016 |
| Q41 | .097 | .239 |
| Q42 | .233 | .042 |
| Q43 | .162 | .117 |
| Q44 | .223 | .049 |

Table 22

Sampson Survey: Pearson Correlation and Approximate Significance for Every Question by Question 40, "It will be easy for me to teach the life sciences in the elementary school."

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q1 | .088 | .258 |
| Q2 | -.045 | .370 |
| Q3 | .043 | .377 |
| Q4 | .115 | .198 |
| Q5 | .011 | .469 |
| Q6 | .340 | .005 |
| Q7 | .301 | .012 |
| Q8 | .191 | .077 |
| Q9 | .046 | .366 |
| Q10 | .210 | .058 |
| Q11 | .025 | .428 |
| Q12 | .233 | .042 |
| Q13 | .218 | .053 |
| Q14 | -.033 | .405 |
| Q15 | .262 | .025 |
| Q16 | .075 | .291 |
| Q17 | -.064 | .319 |
| Q18 | -.065 | .318 |
| Q19 | .335 | .006 |
| Q20 | -.151 | .134 |
| Q21 | .538 | .001 |
| Q22 | .205 | .064 |
| Q23 | .287 | .016 |
| Q24 | .398 | .001 |
| Q25 | .417 | .001 |
| Q26 | .006 | .483 |
| Q27 | .107 | .215 |
| Q28 | .276 | .019 |
| Q29 | .362 | .003 |
| Q30 | .095 | .241 |
| Q31 | .520 | .001 |
| Q32 | .216 | .054 |
| Q33 | -.266 | .023 |
| Q34 | -.268 | .022 |
| Q35 | .014 | .458 |

(table continues)

| | Pearson Correlation | Approximate Significance |
| --- | --- | --- |
| Q36 | .027 | .421 |
| Q37 | .011 | .469 |
| Q38 | .184 | .086 |
| Q39 | .075 | .291 |
| Q41 | .485 | .001 |
| Q42 | .650 | <.001 |
| Q43 | .476 | .001 |
| Q44 | .648 | <.001 |

Table 23

<u>Sampson Survey: Pearson Correlation and Approximate Significance for Every Question by Question 41, It will be easy for me to teach the physical sciences in the elementary school."</u>

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q1 | .249 | .031 |
| Q2 | -.317 | .008 |
| Q3 | .116 | .196 |
| Q4 | .260 | .025 |
| Q5 | .236 | .039 |
| Q6 | .373 | .002 |
| Q7 | .424 | .001 |
| Q8 | .289 | .015 |
| Q9 | .449 | .001 |
| Q10 | .455 | .001 |
| Q11 | -.227 | .046 |
| Q12 | .402 | .001 |
| Q13 | .536 | .001 |
| Q14 | .267 | .023 |
| Q15 | .411 | .001 |
| Q16 | .253 | .030 |
| Q17 | .138 | .155 |
| Q18 | -.074 | .294 |
| Q19 | .501 | .001 |
| Q20 | .069 | .305 |
| Q21 | .513 | .001 |
| Q22 | .023 | .433 |
| Q23 | .097 | .239 |
| Q24 | .366 | .003 |
| Q25 | .203 | .065 |
| Q26 | .042 | .378 |
| Q27 | .249 | .031 |
| Q28 | .302 | .011 |
| Q29 | .519 | .001 |
| Q30 | .397 | .001 |
| Q31 | .363 | .003 |
| Q32 | .027 | .422 |
| Q33 | -.232 | .041 |
| Q34 | -.258 | .026 |
| Q35 | -.323 | .007 |

(<u>table continues</u>)

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q36 | -.144 | .143 |
| Q37 | -.125 | .178 |
| Q38 | -.045 | .369 |
| Q39 | .024 | .429 |
| Q40 | .485 | .001 |
| Q42 | .523 | .001 |
| Q43 | .536 | .001 |
| Q44 | .429 | .001 |

Table 24

Sampson Survey: Pearson Correlation and Approximate Significance for Every Question by Question 42, "It will be easy for me to teach the earth sciences in the elementary school."

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q1 | .259 | .026 |
| Q2 | -.075 | .290 |
| Q3 | -.001 | .496 |
| Q4 | .015 | .455 |
| Q5 | .018 | .446 |
| Q6 | .070 | .304 |
| Q7 | .159 | .118 |
| Q8 | -.075 | .289 |
| Q9 | .117 | .192 |
| Q10 | .281 | .017 |
| Q11 | -.040 | .385 |
| Q12 | .213 | .057 |
| Q13 | .293 | .014 |
| Q14 | .016 | .455 |
| Q15 | .236 | .040 |
| Q16 | .032 | .407 |
| Q17 | -.142 | .148 |
| Q18 | -.063 | .322 |
| Q19 | .124 | .181 |
| Q20 | -.062 | .326 |
| Q21 | .427 | .001 |
| Q22 | .245 | .034 |
| Q23 | .233 | .042 |
| Q24 | .486 | .001 |
| Q25 | .275 | .019 |
| Q26 | .220 | .050 |
| Q27 | .049 | .358 |
| Q28 | .309 | .010 |
| Q29 | .443 | .001 |
| Q30 | .170 | .103 |
| Q31 | .379 | .002 |
| Q32 | .058 | .334 |
| Q33 | -.360 | .003 |
| Q34 | -.467 | .001 |
| Q35 | -.013 | .462 |

(table continues)

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q36 | .130 | .167 |
| Q37 | -.075 | .290 |
| Q38 | .177 | .094 |
| Q39 | .002 | .495 |
| Q40 | .650 | <.001 |
| Q41 | .523 | .001 |
| Q43 | .701 | <.001 |
| Q44 | .560 | <.001 |

Table 25

Sampson Survey: Pearson Correlation and Approximate Significance for Every Question by Question 43, "It will be easy for me to teach the space sciences in the elementary school."

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q1 | .346 | .004 |
| Q2 | .012 | .464 |
| Q3 | -.005 | .485 |
| Q4 | -.028 | .417 |
| Q5 | .018 | .448 |
| Q6 | .055 | .342 |
| Q7 | .129 | .170 |
| Q8 | -.101 | .226 |
| Q9 | .033 | .404 |
| Q10 | .132 | .163 |
| Q11 | -.135 | .161 |
| Q12 | .191 | .079 |
| Q13 | .219 | .053 |
| Q14 | -.018 | .448 |
| Q15 | .178 | .094 |
| Q16 | .020 | .442 |
| Q17 | -.025 | .427 |
| Q18 | -.075 | .290 |
| Q19 | -.015 | .457 |
| Q20 | -.067 | .311 |
| Q21 | .350 | .004 |
| Q22 | .150 | .135 |
| Q23 | .162 | .117 |
| Q24 | .517 | .001 |
| Q25 | .254 | .028 |
| Q26 | .174 | .098 |
| Q27 | .094 | .244 |
| Q28 | .182 | .087 |
| Q29 | .492 | .001 |
| Q30 | .191 | .077 |
| Q31 | .395 | .001 |
| Q32 | -.017 | .449 |
| Q33 | -.230 | .043 |
| Q34 | -.336 | .005 |
| Q35 | -.124 | .180 |

(table continues)

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q36 | -.111 | .206 |
| Q37 | -.055 | .342 |
| Q38 | .052 | .350 |
| Q39 | -.057 | .336 |
| Q40 | .476 | .001 |
| Q41 | .536 | .001 |
| Q42 | .701 | <.001 |
| Q44 | .630 | <.001 |

Table 26

Sampson Survey: Pearson Correlation and Approximate Significance for Every Question by Question 44, "It will be easy for me to teach ecology in the elementary school."

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q1 | .277 | .018 |
| Q2 | -.033 | .403 |
| Q3 | .112 | .203 |
| Q4 | .020 | .442 |
| Q5 | -.011 | .467 |
| Q6 | .161 | .116 |
| Q7 | .161 | .115 |
| Q8 | -.007 | .479 |
| Q9 | .001 | .497 |
| Q10 | .312 | .009 |
| Q11 | .042 | .379 |
| Q12 | .198 | .071 |
| Q13 | .274 | .020 |
| Q14 | .053 | .348 |
| Q15 | .303 | .012 |
| Q16 | .093 | .247 |
| Q17 | .026 | .424 |
| Q18 | -.070 | .303 |
| Q19 | .196 | .074 |
| Q20 | -.144 | .144 |
| Q21 | .429 | .001 |
| Q22 | .219 | .053 |
| Q23 | .223 | .049 |
| Q24 | .362 | .003 |
| Q25 | .316 | .008 |
| Q26 | .104 | .221 |
| Q27 | .155 | .124 |
| Q28 | .311 | .009 |
| Q29 | .346 | .004 |
| Q30 | .115 | .198 |
| Q31 | .377 | .002 |
| Q32 | .080 | .278 |
| Q33 | -.276 | .019 |
| Q34 | -.336 | .005 |
| Q35 | -.045 | .370 |

(table continues)

| | Pearson Correlation | Approximate Significance |
|---|---|---|
| Q36 | .165 | .111 |
| Q37 | -.066 | .312 |
| Q38 | .138 | .154 |
| Q39 | -.075 | .289 |
| Q40 | .648 | <.001 |
| Q41 | .429 | .001 |
| Q42 | .560 | <.001 |
| Q43 | .630 | <.001 |

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