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Development of Interest in Science and Interest in Teaching Elementary Science: Influence of Informal, School, and Inquiry Methods Course Experiences

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ACCEPTANCE

This dissertation, DEVELOPMENT OF INTEREST IN SCIENCE AND INTEREST INTEACHING ELEMENTARY SCIENCE: INFLUENCE OF INFORMAL, SCHOOL, AND INQUIRY METHODS COURSE EXPERIENCES by MIZRAP BULUNUZ was prepared under the direction of the candidate's Dissertation Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Doctor of Philosophy in the College of Education, Georgia State University.

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ABSTRACT

DEVELOPMENT OF INTEREST IN SCIENCE AND INTEREST IN TEACHING ELEMENTARY SCIENCE: INFLUENCE OF INFORMAL, SCHOOL, AND INQUIRY METHODS COURSE EXPERIENCES

by

Mizrap Bulunuz

Inquiry-based science instruction is a major goal of science education reform. However, there is little research examining how preservice elementary teachers might be motivated to teach through inquiry. This quantitative study was designed to examine the role of background experiences and an inquiry science methods course on interest in science and interest in teaching science. The course included many activities and assignments at varying levels of inquiry, designed to teach content and inquiry methods and to model effective teaching. The study involved analyses of surveys completed by students in the course on their experiences with science before, during, and at the end of the course.

The following questions guided the design of this study and analysis of the data:

1. What science background experiences (school, home, and informal education) do participants have and how do those experiences affect initial interest in science?
2. Among the hands-on activities in the methods course, is there a relationship between level of inquiry of the activity and the motivational quality (interesting, fun, and learning) of the activity?
3. Does the course affect participants' interest and attitude toward science?

4. What aspects of the course contribute to participants' interest in teaching science and choice to teach science?

Descriptive and inferential analysis of a background survey revealed that participants with high and low initial interest in science differed significantly on remembering about elementary school science and involvement in science related activities in childhood/youth. Analysis of daily ratings of each hands-on activity on motivational qualities (*fun*, *interest*, and *learning*) indicated that there were significant differences in motivational quality of the activities by level of inquiry with higher levels of inquiry rated more positively. Pre/post surveys indicated that participants increased in interest in science and a number of variables reflecting more positive feelings about science and science teaching. Regression analysis found that the best predictors for *interest in teaching science* were experiencing *fun* activities in the science methods course followed by the interest participants brought to the course. This study highlights the motivational aspects of the methods course in developing interest in science and interest in teaching science.

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CHAPTER 1

INTRODUCTION

Although the *National Science Education Standards [NSES]* (National Research Council, 1996) advocate teaching science through inquiry in schools as well as in the preparation of teachers, many elementary school teachers teach very little science and seldom engage their students through inquiry (Weiss, 1997; Fulp, 2002). There are many possible reasons for this including the following: commitment to school system adopted textbooks, difficulties in assessing results of inquiry learning, concerns about how to manage inquiry classrooms in which teacher and student play new roles (facilitator and active inquirer, respectively), lack of lab materials, and dominant commitment to "coverage" to prepare students for standardized testing and the next grade level (Anderson, 2002). However, there is little research on whether teachers are interested in science and in teaching science. Teachers who have negative attitudes toward science and are unenthusiastic about teaching and learning science may be less likely to involve their students in inquiry science experiences.

The reason teachers have negative feelings and attitudes about science may relate to their own science related experiences in elementary and high schools (deLaat & Watters, 1995; Jarrett, 1999; Watters & Ginns, 2000). According to Hawkins (1990), an unproductive cycle in education is that people uninterested in science may pass that disinterest on to the children. This has serious implications not only for the preparation of scientifically literate citizens but also for the preparation of the next generation of

teachers. To break this cycle, teacher preparation programs must confront preservice teachers' negative attitudes toward science and lack of personal interest in teaching science (Weiss 1997). Teachers' interest in science and enjoyment of science may be important factors for achieving science education reform. The *NSES* stressed that only the teachers who "exhibit enthusiasm and interest and who speak to the power and beauty of scientific understanding can instill inquiry skills as well as curiosity, openness to new ideas, and skepticism that characterizes science" (NRC, 1996, p.37). According to Dewey (1933/1986), there is a connection between interest and effort, i.e., the more a person becomes interested in a subject the more effort he will put in it. Researchers suggest that: (a) interest is a motivational construct that emerges from an individual's interaction with his/her environment (Krapp, 2004) (b) interest is dispositional and enduring (or habitual) (Krapp, 2004), and (c) interest motivates behavior (Deci, 1992). From these connections, it can be concluded that once an interest in science is developed, teachers may make the effort to seek out additional scientific information and science related experiences, thus further deepening science interest. Based on these connections, psychologists hypothesize that interest in a subject, such as science, can be developed over a period of time through interaction with objects valuable to the individual (Krapp, 2004; Hidi & Harackiewicz, 2000).

Research on playfulness, science, and creativity suggests that there is a connection between having positive background experiences with science and interest in science. Childhood playful engagement with science played an important role in the careers of such eminent scientists as Albert Einstein, Robert Burns Woodward, and Richard Feynman (Jarrett, 1998). Research with geology undergraduates and faculty

indicated that playful experiences in youth such as kitchen chemistry, outdoor explorations, making collections, museum visits, and building with LEGO bricks and other construction toys influenced them to select science as a career (Jarrett, & Burnley, 2003, 2007). Also biographies of scientists show a connection between playfulness, interest, and the processes of science. Interest is an important motivator throughout scientific investigations and playfulness plays a role in the generation of research ideas (Ganschow & Ganschow, 1998). According to Kean (1998), many professional chemists continue to have fun by playing with interesting reactions having powerful visual effects, such as color changes. James Watson began his interest in DNA with questions about what occurs in the development of a fertilized egg and spent years "playing" with the structure of DNA (exploring models and playing with ideas) before he and Francis Crick won the Nobel Prize for discovery of the DNA molecule structure (Ganschow & Ganschow, 1998).

In the literature, there is body of research on how to teach through inquiry. These research studies include preservice and inservice teachers' views of scientific inquiry and the nature of science (Abd-El-Khalick & Lederman, 2000; Colburn & Bianchini, 2000; Gess-Newsome, 2002; Schwartz, Lederman, & Crawford, 2004), how to implement teaching standards (Van Zee, 1998), theoretical understanding of inquiry (Odom & Settlage, 1996; Settlage, 2000; Marek, Laubach, & Pedersen, 2003), and understanding of teaching science (Zembal-Saul, Haefner, Avraamidou, Severs, & Dana, 2002). The studies also address the ability to connect scientific principles to real life (Davis & Petish, 2005); improvement of self-efficacy as a result of inquiry-based science instruction (Reiff, 2002; Enochs, Scharman, & Riggs, 1995), and implementing inquiry in field

placement (Hayes, 2002). However, these studies do not explore whether teachers are interested in science, whether they enjoy studying and teaching science, and what aspects of teacher development courses motivate teachers to want to implement inquiry science.

A review of the literature identified a few studies on interest and enjoyment in science methods courses that suggest a connection between course teaching methods and these motivational qualities. Jarrett (1999) found that background experiences of preservice teachers predicted initial interest in science and that an inquiry-based methods course increased both interest in science and confidence in teaching science. Palmer (2004) determined that interesting and enjoyable science activities in an elementary science methods class changed preservice elementary teachers' attitudes positively. In research on the *fun, interest*, and *learning* qualities of hands-on activities in a methods class, Jarrett (1998) found high correlations among these qualities. Similar results were found in Bulunuz, Jarrett, and Bulunuz (2001) and Bulunuz and Jarrett (2004). Since these are correlational studies, the findings are open to many interpretations, i.e. fun activities could promote interest, interest could promote learning, etc.

Without longitudinal research, conclusions on classroom application are limited. Jarrett (1998) found that preservice teachers intended to use activities in their own classroom that they rated highly on *fun*, *interest*, and *learning*. In another study, Bulunuz and Jarrett (2005) explored the connection between preservice teachers' ratings on *fun, interest* and *learning,* what they intended to implement in their own classes and what they actually implemented in their field placement. Their own activity ratings correlated with what they would like to implement in their own classes. However, what they actually

implemented was limited by accessibility of materials and most importantly, what they were allowed to implement in their mentor teacher's classroom.

This study explores connections that have not been examined in other studies. Teaching through inquiry has been strongly recommended in the *NSES* (NRC, 1996) and a guide to implementing the standards (NRC, 2000) identifies levels of inquiry corresponding to how much choice the student is given in asking research questions and designing the research methods. Previous studies have not examined whether teachers find these levels of inquiry to differ in fun, interest, and learning, characteristics that may motivate them to teach in the same way. Also, relationships between background science experiences and attitude toward science and science teaching were examined by Jarrett (1999), but she drew her conclusions from just a few open-ended questions. In this study a new survey is used that will give more detail on background variables with experiences rated on many dimensions, such as fun, interesting, hands-on, promoting understanding, and allowing for student input.

Definition of Terms

The subjects in this study are undergraduate preservice elementary teachers in two sections of a science methods course. They will generally be referred to as preservice teachers though, for variety, the terms *student* and *participant* will also be used to refer to preservice elementary teachers in both sections.

Interest is a motivational construct involving concern or curiosity that promotes attention and concentration toward the object of interest. According to Dewey (1916), interest involves the close identification of the person with the object, activity, or idea of interest. Psychologists define two main types of interest: (a) situational interest, generated

in certain conditions by external stimulus such as activity or concrete objects and (b) individual interest that develops over a long period of time and is stable, enduring and dispositional. A person interested in an object or activity demonstrates highly focused attention and displays enjoyment (Krapp, Hidi & Renninger, 1992). In measuring interest as an outcome variable, it is hard to separate how much of it comes from situational interest (from activity) or individual interest (personal). Therefore, in this study, *interest* refers to both situational interest and individual interest. The intent of the weekly activity ratings on *interest* is to measure situational interest; whereas the intent of the variables *overall interest in science* and *interest in teaching* is to measure individual interest.

Inquiry concerns asking questions and conducting investigations. *Inquiry and the National Science Education Standards* (NRC, 2000), in order to expose children to processes used by scientists, recommends teaching through inquiry by including opportunities for children to conduct investigations. This guide book for implementing the *Standards* (NRC, 2000) identifies a range of *levels of inquiry* depending on who (teacher or student) asks the question, who designs the investigation, who implements the investigation, and who collects data. *Level of inquiry*, a variable in this study, categorizes activities by how much choice students have in posing and answering questions. *Inquiry* is in the name of the course (*Science and Inquiry in Early Childhood Education*), since the course is designed to prepare students to teach through inquiry.

Play is not a separate variable in this study but is being defined here because it is discussed in the literature review and is connected with fun and its role in background experience activities. Play is hard to define. According to Klugman and Fasoli (1995, p.101) play includes some but not necessarily all of the following aspects: intrinsic, self-

selected, enjoyable, active, mind involving, and empowering. It is intriguing and captivating, frequently involves choice on the part of the player, and can be self-perpetuating. Play takes a variety of forms. Some of these are exploratory, functional, constructive, symbolic, and games with rules. According to Dewey (1933/1986), *playfulness* is an attitude of mind and play is expression of that attitude. *Playing* in the context of doing research refers to exploring, “messing around,” “tinkering,” and toying with various ideas or data.

Fun is defined as a subset of play but all play is not fun and not everything that is fun would be considered play (Arieti, 1976). In this study in general fun refers to having enjoyment while working or doing a class activity or assignment (e.g. science fair project).

Significance of the Study

Educational philosopher Dewey (1913/1979), psychologists Krapp, Hidi, and Renninger (1992), and the *NSES* (NRC, 1996) describe effective teachers as interested in their subject and demonstrating enthusiasm for teaching the course content. However, there is little empirical research on where, how, and when teachers’ interests develop, especially their interest in science. Are there experiences that motivate them to be more interested in science? The purpose of the first part of this study is to ascertain the connection between the quality and type of background science experiences and preservice teachers’ interest in science. In other words, what sorts of experiences affect the development of interest in science? A finding that childhood experiences are important factors would have implications for choice of toys, exposure to informal experiences, and early childhood schooling. Importance of science in upper grades and

college and ratings of preferred high school and university courses would have implications on content for preparation of teachers.

The second part of the study explores the relationship between motivational variables, *fun, interest,* and *learning,* and the inquiry levels of course activities. No research was found that explores whether student-centered inquiry (more input into asking the research questions and designing the investigations, however simple) is considered more fun, interesting, and results in more learning. A positive relationship between the inquiry level of the activities and these motivational variables would suggest the need to include activities with higher levels of inquiry in teacher preparation programs, both to capture the interest of the teachers and to model how they can make science more engaging for the children.

The third part of the study evaluates the effectiveness of the science methods course in the development of interest in science, interest in teaching science, and choice to teach science. The course includes various hands-on activities in which preservice teachers are encouraged to investigate different aspects of the activities through an inquiry-based approach. A finding that students are more interested and motivated at the end of the course and that course variables positively contribute to interest in teaching science, would suggest that active engagement with fun, interesting inquiries should be incorporated into science methods courses.

Rationale

According to Pearce (1999), science is the only subject in which children come to class interested and ready to learn because they do not differentiate science from their play in a classroom where inquiry and other hands-on activities take place. Play is the

way children explore and experiment with the world they live in. However, this mode of learning is often not taken into account in school. Science is often taught from test-driven curricula through lecture by emphasizing memorization. In order to teach science in fun and interesting ways, preservice teachers should have rich formal and informal experiences that make them interested in science so that they will implement experiences similar to these in their future classrooms.

My interest in this study stems from my childhood informal science experiences, formal science education, professional teaching practices, and graduate study. When I took my science methods course, our professor told us that learning by doing is the best way to teach science. What he was saying contradicted all of my previous formal science experiences. However, I believed him because what he said was compatible with my childhood informal experiences with science. When I started teaching middle school, I took my students to the science lab. My students enjoyed their experiments and conducted some interesting explorations, but they were over-active and loud. I struggled to “control” and manage their interest and curiosity in the lab. As a result, I easily conformed to the teacher-oriented school culture and started to teach science the way I was taught, in spite of my belief that “learning by doing is the best way to teach science”.

In graduate school, while I was searching for ideas for my thesis, I found an article written by Olga Jarrett (1998). Like my methods course professor, Jarrett emphasized hands-on science activities as being playful, interesting and motivating for preservice elementary teachers. I found Jarrett’s ideas interesting. Her ideas reminded me of my childhood’s enjoyable and engaging informal science experiences. Here is a little

story from my childhood in which I was able to make connections from my experience with nature:

> When I was a child in Turkey, there was a river by our farm. My friends and I used to spend the bulk of our summer holiday in the river, swimming and playing games. When I was eight years old, the river flooded. We went to the river bank to watch the flood. Then I stepped in the dark muddy river bank, and I realized that fish were hitting my knees. I was very excited about that and called my friends "Come here guys! Fish cannot see in muddy water. Let's catch fish!" We caught a lot of fish just by using our hands and feet.

I now know that this was discovery learning and that I was learning through my curiosity and the consequences of my actions.

I connected to Jarrett's ideas in science teaching. As a result, I decided to replicate her study with Turkish preservice elementary teachers for my masters thesis (Bulunuz, 2001), and I found results similar to Jarrett's. This study changed my teaching philosophy from teacher-oriented to student-oriented. I taught science methods and science laboratory courses to Turkish students with a lot of hands-on science activities and field trips. Most of the students enjoyed the class and were interested in the activities we were doing in the class. For instance, one of my masters students who had a bachelors in chemistry wrote in his journal, "I was so interested and curious about the explanation of the activity we did in class, as soon as I got home I opened my chemistry book which had been closed for four years." Both in Turkey and in my doctoral program, I have conducted research studies related to motivational quality of hands-on activities and

discrepant event demonstrations. (Bulunuz & Jarrett, 2004; 2005) which have given me further insight on this topic.

All these formal and informal science experiences had an impact on my research interest and research questions. I have several questions: How much influence do early childhood or youth science experiences have on personal interest in science? What was missing in my early teaching practice in the lab? What was wrong or missing in the science methods course I took? Is learning by doing sufficient to teach science? Can science class be fun, interesting, and educational and promote inquiry at the same time? These are a few of the questions that I have considered over my years of teaching and conducting research in my graduate studies. These questions comprise the context on which this study was built.

Theoretical Framework

Key aspects of the study (i.e., research questions, course pedagogy, and data collection) are informed by the following theoretical constructs: constructivism, modeling, and motivation (fun and interest).

Constructivism

The course is the intervention in this study and the conduct of the course is influenced by the following constructivist theorists: Piaget and Vygotsky. The common premise for the two theorists is that learning is an active process that requires physical and intellectual engagement with the learning task. According to Piaget (1970), individuals have prior experiences that shape their understanding and knowledge. This knowledge is continuously assimilated into newly acquired understanding through the process of active engagement leading to *assimilation, disequilibrium, accommodation,*

and *equilibrium*. Piaget does not reject the social aspect of learning; but, for him individuals cannot understand knowledge transmitted via language if they do not have a structure to receive information. Piaget (1973, p. 36) states, "Understanding always means inventing or reinventing, and every time the teacher gives a lesson instead of making the child act, he prevents the child from reinventing the answer." People sometimes lack the necessary experiences or cognitive schemas to accommodate new knowledge. Discourse often does little to adequately fill in their experiential gaps; consequently, this is why exploration is a vital component of learning. The course includes a variety of hands-on activities and discrepant events using simple materials with which students can connect. Physical engagement is ensured by active participation of the students in the activities. Intellectual engagement is ensured by posing questions, designing experiments, and collecting and analyzing data to construct understanding.

Vygotsky's (1978) social constructivist theorist has also influenced the course. According to Vygosky, learning occurs in contexts in which students internalize experiences through a series of social interactions. This process occurs first between the students and then with the teacher or between students and other peers. In assisting the student's construction of knowledge, the teacher or peer creates a zone of proximal development in which scaffolding occurs. The zone of proximal development is the distance between what individuals can accomplish alone and what they are able to accomplish when assisted by a more capable person.

In the course, students are encouraged to do activities in groups where they can challenge one another's thinking. They are also assigned a cooperative project.

Modeling

According to Bandura's (1974) modeling theory, people are social beings and do not function in isolation. They observe others and benefit from direct observation of the behavior of others. According to Bandura, learning occurs naturally in two ways: by experience and observation. The *NSES* suggest that teacher preparation programs must include experiences that engage preservice teachers in active learning that builds their knowledge, understanding, and ability and that inquiry teaching is not likely to be implemented unless teachers themselves have similar experiences in their science methods course (NRC, 1996). This course is conducted in a way that models how to teach science through inquiry as recommended in the *NSES* (1996). By conducting the class this way, hopefully students will see the value in hands-on, inquiry teaching and will engage in similar teaching in their classrooms.

Motivation

Motivation is a multi-dimensional construct described as "an internal state that activates, guides, and maintains behavior" (Green, 2002, p. 989). Several theories that support the motivational value of *interest, fun,* and *learning* have influenced this research. These theories are Dewey's (1913/1979) ideas of interest and effort, Glasser's (1998) *choice theory*, Csikszentmihalyi's (1990) ideas on *flow,* and Piaget's ideas on disequilibrium. Added to these is a body of theory and research on the role of interest in learning and behavior by psychologists, Krapp, Hidi, and Renninger (1992) and Deci, (1992, 1995). According to Dewey (1913/1979), curiosity in children is innate. Becoming interested in a particular subject is a process that often begins in childhood with play. Unfortunately, as children pass through schooling, their natural desire to

inquire is gradually diminished, largely because of the prevalence of traditional, didactic, teacher-centered instruction. However, according to his theory of interest, as people grow older, childhood interests can often carry on to adulthood interests.

Fun and choice. According to Glasser's (1998) choice theory of motivation, humans have five basic needs: love and belonging, power, freedom, fun, and survival. The premise of this theory is that individuals choose behaviors to meet one or more of these basic needs, which constitute the general motivation for everything they do. According to Glasser, fun, freedom, and power are the most salient motivators for learning. This freedom in the learning environment not only motivates students to learn but also develops their creativity and reduces their dependence on external control (i.e., adults, textbooks, curriculum, etc.). Research findings indicate that when people are interested in something, they become more attentive and alert (Krapp, Hidi, & Renninger, 1992). This leads to a level of absorption called *flow* (Csikszentmihalyi, 1990). Flow is the "state of mind when consciousness is harmoniously ordered, where people want to pursue whatever they are doing for its own sake" (p.6). Flow activities are not static. Neither boredom nor anxieties are positive experiences. Flow activities involve greater challenges, and demand greater skills. Flow activities have a dynamic feature which leads to growth and discovery. Scientists and inventors have identified *flow* as part of the process of scientific discovery (Csikszentmihalyi, 1996).

Interest. Working within the conceptual framework of Dewey (1913/1979), Krapp (2004) espoused creation of learning environments in which students actively interact with materials to reach an actualized state called *situational interest*, which would eventually develop into an enduring and more diffuse state, called *individual interest*.

Krapp (2004) hypothesizes that transition from situational to individual interest can occur only if both feeling-related experiences and cognitively represented factors are experienced together in a positive way.

Learning. According to Piaget (1964/2003), children are naturally curious and learn through actively exploring their environment. Across the life span, according to Piaget, exposure to new experiences that throw existing ideas into disequilibrium drive people to make sense out of new information. Piaget's ideas on equilibration suggest a state of disequilibrium is disconcerting and that the learning that occurs when accommodating one's thinking to make sense out of new experiences is satisfying.

Application of theory to the research. Glasser (1998), describes freedom to choose as a human need. Degree of student choice in this research is related to level of inquiry, in that more student-centered inquiry results in students choosing their own questions and designing and implementing their own investigations. *Interest*, *fun,* and *learning* are important outcome variables in the parts of this study that examine background experiences, ratings of course activities, and effects of the course. These variables may be related to one another in various ways, e.g., enjoyment of an activity can increase interest in the topic and promote learning, interest in a topic can make it fun to engage with that topic, or learning something new can create interest. A purpose of the research is to determine whether the course, with its various activities and assignments, promotes interest in teaching science. In this study, high ratings on interest in course activities may be measures of situational interest that might develop into a more enduring individual interest, especially interest in science teaching, by the end of the course.

Research questions

The following questions guided the design of this study and the data analysis:

1. What science background experiences (school, home, and informal education) do participants have, and how do those experiences affect initial interest in science?
2. Among the hands-on activities in the methods course, is there a relationship between level of inquiry of the activity and the motivational quality (*interesting*, *fun*, and *learning*) of the activity?
3. Does the course affect preservice teachers' interest and attitudes toward science?
4. What aspects of the course contribute to preservice teachers' interest in teaching science and choice to teach science?

Overview of Methodology

The purpose of this research was to explore connections among students' background experiences, methods course experiences, science attitudes and interest, and interest in teaching science. The sample was made up of students in two sections of a preservice elementary science methods course (n=53). Quantitative methodology allowed the analysis of a variety of data from a series of surveys. The study has three parts. The first part of the study identifies various science background experiences that predict students' initial interest in science (Question 1). The second part connects level of inquiry and personal ratings of motivational quality of the activities in the course (Question 2). The third part ascertains the effectiveness of the course in the development of positive interest/enjoyment with regard to science and science teaching (Questions 3 and 4).

Question 1: Examination of preservice teachers' background experiences in science

Near the end of the course, students were administered a self-report Science Background Experiences Survey (Appendix A) to describe their background experiences. Means and frequencies were used to describe background experiences of students with high versus low overall interest in science (Science Teaching Survey I: Question 7). See Appendix B. Multiple regression analysis determined which background experiences predict interest in science.

Question 2- Relationship between level of inquiry of science methods course activities and preservice teachers' ratings

This part explores the relationship between level of inquiry of the activities in the methods course and student ratings of the motivational qualities of those activities: *fun*, *interest,* and *learning*. The Activity Rating Scale, using the activities for one day as an example, is found in Appendix C. Each activity was classified by the researcher according to level of inquiry using the Activity Classification Rubric found in Appendix D. The description of each course activity with level of inquiry is in Appendix E. ANOVA's with level of inquiry as the independent variable were computed for each dependent variable: *fun*, *interest*, and *learning*.

Question 3: The effectiveness of the science methods course on participants' interests and attitudes toward science.

The third question concerns the role of the science methods course in the development of positive interest and attitude toward science and overall interest in teaching science. At the end of the semester, two surveys were administered to the students, Science Teaching Survey II (Appendix F) and Course Rating Survey (Appendix

G). The effects of the course were analyzed in two ways. First, pretest and posttest scores on the common items in Science Teaching Surveys I and II were compared by using paired sample t-tests. Second, to determine whether the methods course contributes to motivation to teach science, end-of-course ratings (Course Rating Survey) and initial interest/background variables were used to predict overall *interest in teaching science* (Question 9) and *choice to teach science* (Question 10) from Science Teaching Survey II.

Question 4: Science Methods Course Contribution to Participants' Interest in Teaching Science

To determine whether the methods course contributes to motivation to teach science, end-of-course ratings (Course Rating Survey) and initial interest/background variables were used to predict overall *interest in teaching science*, (question 9) and *choice to teach science* (Question 10) from science Teaching Survey II. Stepwise regression analyses were computed to determine best predictor for interest in teaching science.

Assumptions

There are several assumptions in this study:

1. That both sections of the methods course were taught in a similar manner. Although the sections have very similar syllabi, differences in teaching experience and in personality between the two instructors could cause course differences.
2. That students remembered their background experiences well enough to answer accurately.
3. That students filled out the surveys honestly, knowing and trusting that their answers would not affect their grades.

4. That the convenience sample and sample size are sufficient to support generalizations based on quantitative data.
5. That interest affects behavior; i.e., that teachers who have more interest in science will more likely teach more inquiry science than will less interested teachers.

Summary

Inquiry science teaching constitutes the core of the *NSES* (NRC, 1996), which recommends teaching science through inquiry in all grade levels of science education. Whether teachers employ inquiry teaching may be affected by their interest in science, which could be influenced by their background experiences with science, as well as how they were prepared to teach through inquiry. The purposes of this study were to identify students' background experiences that affect their interest in science, to explore the motivational qualities of hands-on course activities varying in inquiry level, and to determine the effectiveness of a science methods course in sparking interest and motivation to teach science.

CHAPTER 2

REVIEW OF LITERATURE

This literature review covers two main bodies of theory and research: (a) on inquiry learning and teaching and (b) on motivation and motivators. The first part of the chapter defines inquiry and reviews the literature on the following: theoretical base of inquiry, inquiry and the National Science Education Standards, inquiry and the Nature of Science, types of inquiry, and preparing elementary teachers to teach science as inquiry. The second part of the chapter defines motivation and reviews theories and research on motivation, especially the roles of fun, interest, learning, and background experiences as motivators for interest in science and science teaching.

Inquiry Science Education

In the second half of the twentieth century, science as inquiry has been the focus of modern science education reform. Although inquiry in science education is relatively new, its pedagogical origin goes back to classical philosophers Aristotle and Plato. Inquiry pedagogy stems from the philosophical analysis of what knowledge is and how it is learned. In the *National Science Education Standards* (NRC, 1996), science as inquiry is the central strategy for teaching science in schools and at college.

The *NSES* (NRC 1996) provide a broad explanation of inquiry, factors to be considered in inquiry pedagogy, and a framework for research on inquiry practices. In this framework, teacher preparation programs, including both science content and science method courses, and professional development programs are created to develop teachers'

understanding of science content and scientific inquiry. In much of the research on science in schools, as well as in teacher preparation, inquiry serves as a benchmark for good science teaching and learning. The *NSES* expound on how inquiry-based education helps students to learn science content, develop inquiry skills, and understand the nature of scientific inquiry.

The Definition of Inquiry

The definition of inquiry varies in the literature. The *NSE*S (NRC, 1996) give three definitions of inquir*y. Scientific inquiry* “refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work” (p. 23). *Inquiry learning* “refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world” (p. 23). *Inquiry teaching* is defined as “providing a classroom where learners can engage in scientific oriented questions to formulate explanations based on evidence” (p. 29). The *NSES* called *inquiry* a “multifaceted activity” that involves:

> making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in the light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating results. Inquiry requires identification of assumptions, use of critical and logical thinking and considerations of alternative explanations (NRC 1996, p.23).

Lincoln and Guba (2000) define inquiry as a teaching method within the frame of the constructivist paradigm in which reality is a socially and experientially constructed entity. Inquiry is seen as synonymous with being inquisitive; having curiosity to ask “why” and “how” (Bruce, 2000). Inquiry is a method of learning and teaching in which

students are active in terms of asking questions and making discoveries in collaboration with their teacher and friends rather than listening passively. Teaching science as a process of inquiry requires a learning environment in which students engage in hands-on activities and investigations so that they can explore the world and discover its patterns (Bruce, 2000).

Inquiry is a broadly used construct in science education. Several images of inquiry, associated with a wide range of activities, often describe "the scientific method," science process skills, hands-on science, or Socratic dialogue (Windschitl, 2003; Wheeler, 2000). Most of the science textbooks start with "the scientific method." This method represents in linear steps, questioning, observing, guessing, hypothesizing, testing hypothesis, and drawing conclusions (Biggs, Daniel, Feather, Ortleb, Snyder, & Zike, 2005). This representation misleads students by claiming that the scientific method has certain steps in a linear direction to be followed with a beginning and an end (Victor & Kellough, 1997). Yet, scientific inquiry is cyclical and does not have a discrete beginning and ending point. In contrast to textbook representations of the scientific method, in the NSES, scientific inquiry is defined as diverse ways to study the natural world (NRC 1996).

The other image of inquiry that confuses many novice teachers is to equate inquiry with hands-on activity. This confusion emerges from having a shallow understanding about scientific inquiry and how to teach science. *Benchmarks for Science Literacy*, (American Association for the Advancement of Science [AAAS], 1993) states that hands-on activities alone do not guarantee meaningful learning. Children may do fun hands-on work but may have little evidence of understanding in their minds. Inquiry is

more than just a hands-on approach. In inquiry, students are required to interact with materials and be actively engaged mentally (Wheeler, 2000). In order to assess inquiry learning, it is crucial to examine *what* is being done and *how* it is being done. Students learn in their own way by experimentation with the materials. A teachers' role is to encourage students to pose questions and design investigations to answer their own questions.

Student and teacher dialogue is central in inquiry science education. Sometimes this dialogue is called Socratic dialogue or questioning. According to Boyles (1996), Socratic questioning does not represent a particular answer or end point, but rather it represents continuous dialogue between teacher and students. Authentic dialogue requires students to be active questioners. In Socratic dialogue, teachers do not engage in an authoritarian role of transmission of scientific information. Rather, knowledge is mediated through transactions between teacher and student. Pearce (1993, 1999) has written about ways he has nurtured inquiries among his students by encouraging students to ask the following questions: "what will happen if …," "is it possible to…," "when comparing…with…, which will…," "how can we…," "what if…," and "what changes when more…." (p.15). Giving students opportunities to seek answers moves the inquiry to the next level in which they try to answer their questions by making observations, collecting data, and analyzing data to come up with explanations and communicating results. For Wheeler (2000), a necessary quality of teachers is ability to recognize the ways in which materials and curiosity relate and to help students as they tentatively try to connect their own questions to the ways of "finding out." Also, teachers work with

children to make sense of what they find and construct arguments that seem convincing to others in their "scientific community."

The *NSES* (1996) state that science process skills and understanding about scientific inquiry cannot be separated. The scientific way of knowing the natural world cannot be taught by lecturing on science process skills. These process skills and understanding about scientific methods, or inquiry, are inextricably woven together. According to Bybee (2000) science as inquiry has three elements important for inquiry science teaching. These are: ability to do scientific inquiry, understanding of scientific inquiry, and understanding science content. Abilities necessary to do scientific inquiry include asking questions, designing and conducting investigations, collecting and analyzing, coming up with evidence-based explanations, and communicating results. Understanding about scientific inquiry includes the understanding of what science is and how scientists conduct actual science inquiries. Content standards highlight important features of major ideas, link to meaningful experiences, and organize fundamental science concepts in a developmentally appropriate sequence for the learner. Science content is organized in such a way that formal teaching begins with informal ideas and experiences students bring to classroom and progresses gradually to formal science concepts in the upper grades.

Theoretical Base of Inquiry

The roots of inquiry science education are undergirded by the synthesis of Plato and Aristotle's ideas. In the Platonic view, the method of learning should be rational inquiry through the intellectual process of questioning and critical thinking. In Plato's *Meno*, according to Jaeger (1943, p.170), "true learning is not passive reception, but a

hard-working search, which is possible only if the learner spontaneously takes part in it." In his view, children are born with the ability to inquire, infer, and reason.

Opposed to Plato's rationalist view, in Aristotle's empiric view, science is a systematically organized body of knowledge, and the student's mind is like a blank slate. With Aristotle, students are passive and experiences inscribe knowledge. This theory of education is called *traditional lecture text* (Hein, 1995). In this view, teachers transfer scientific information to the empty mind of the student. Dewey called this information transfer the "pour in" approach in education. Dewey's theory of education synthesized the tenets of these two philosophers.

For Dewey (1916) and Piaget (1970), education is neither just a "pour in" process nor is it solely "in the mind." Dewey called this separation "dualism" and Piaget also criticized this dichotomy, which separates mind and object. For them, knowledge is gained through concrete experiences and abstract reasoning. According to Piaget, learning is neither simply a copy of an external object nor a mere unfolding of structures performed in the mind; rather it is an active process constructed by continuous interaction between individuals and their environment. In this interaction, learning begins when individuals experience disequilibrium (disagreement between previous knowledge and what they observe in their environment). In order to equilibrate or adapt to new experiences, individuals must change their cognitive structure. The National Research Council (2000), Odom and Settlage (1996), and Settlage (2000) stated that Piaget's ideas on constructivism provided a logical basis for inquiry-based instruction, referred to as a "learning cycle." This instructional model has three phases in accordance to Piaget's theory of learning. These phases are exploration, invention, and discovery. Exploration

refers to experiencing new information and the disequilibrium it produces. Invention refers to the effort to bring new information to their understanding, and discovery refers to change in cognitive structure or being able to apply the new concept to novel situations.

Since the nineteenth-century, many eminent educational philosophers, scientists and educators have agreed that the combination of memorizing and being able to repeat the facts of science is not a true representation of science learning. Furthermore, teachers who concentrate on leading students to memorize the facts, laws, and principles of science are not teaching science. Dewey (1916), in his *Democracy and Education*, disdained this process:

> Why is it, in spite of the fact that teaching by pouring in, learning by passive absorption, are universally condemned, that they are still so intrenched in practice? That education is not an affair of "telling" and being told, but an active and constructive process, is a principle almost as generally violated in practice as conceded in theory (p.38).

According to the *NRC* (2000), Dewey (1910) contended that science teaching puts too much emphasis on memorization of facts and information and not enough on processes of thinking. According to Boyles (2005), in the Deweyan classroom, students are active inquirers of their own questions and constructers of their own knowledge. Boyles also pointed out that through active inquiry processes, students investigate relationships among abstract concepts by identifying problems and solving them.

Levels of Inquiry

In the 1960s, Joseph Schwab first generated three levels of inquiry based on who poses the questions and develops methods to solve problems. For Schwab, in the first level of inquiry laboratory manuals or textbooks dominate inquiry in terms of posing questions and methods; but students discover the relationships that they do not know. At

the second level, guided inquiry, teachers or textbooks usually pose the questions; but, methods and answers are left to students although teachers help students to develop investigations. The third level of inquiry is the most sophisticated level in Schwab's taxonomy in which posing questions, methods and answers are left to the students. Zembal-Saul, Haefner, Avraamidou, Severs, and Dana, (2002), in research on prospective elementary teachers' understanding of teaching science, added level 0 to Schwab's taxonomy for activities that did not represent any form of inquiry.

The taxonomy of inquiry today is mainly concerned with a similar approach. The NSES (NCR, 1996) did not go into detail on different types of inquiry but "authentic" or "full inquiry" was emphasized as a central strategy which starts with questions of interest to students. However, in *Inquiry and the National Science Education Standards* (NRC, 2000) five essential features of inquiry (asking questions, evidence-based response to questions, explanations based on evidence, connecting explanations with scientific knowledge, communication and justification of evidence) were described in four varying levels. These levels are based on the amount of initiative taken by teacher or student in the activity. In the highest level of inquiry, students take initiative for all of the five essential features of the inquiry. In the lowest level of inquiry, teachers take initiative and structure the activity. In the other words, the higher the level of inquiry the more student-directed the activity; the lower the level, the more teacher-directed the activity. Based on the variations on the five essential features of inquiry, the levels of inquiry are called: "confirmation," "structured," "guided," "open" (Bell, Smethana, & Binns, 2005); "inquiry level 1" through "inquiry level 4" (Eick, Meadows, & Blakcom, 2005); or

“structured inquiry,” “coupled inquiry,” “guided inquiry,” and “full inquiry” (Martin-Hansen, 2002).

The National Research Council (2000) and science educators emphasized that being knowledgeable on various levels of inquiry is useful for teaching science. According to the *NRC* (2000) students should experience all types of inquiries in science courses. Depending on objectives, teachers should decide which level to use in their instruction. For instance, low level of inquiry activities can be useful to teach a particular science concept, while high level of inquiry activities can be useful in developing understanding about scientific inquiry. Various science educators have agreed with the NRC (2000) that knowledge about levels of inquiry could be helpful in transitioning from traditional methods to inquiry science teaching (Eick et al., 2005; Bell et al., 2005) and useful in meeting the needs of all students (Martin-Hansen, 2002).

First level of inquiry. In the first level, teachers or textbooks dominate inquiry in terms of posing questions, and methods. Also, the solution of the question is known in advance. At this level, inquiry in the form of “structured” or “cookbook lessons” is characterized by students following teachers’ directions or predefined procedures in their textbooks, e.g., experiments presented at the end of each chapter in science textbooks (Bell, et al., 2005). There is a place in science courses for the first level of inquiry to teach certain skills; but this level tends to involve low level thinking and engagement of students (Martin-Hansen, 2002).

Second level of inquiry. At the second level, teachers or textbooks usually pose questions and methods; but answers are left to students. According to Martin-Hansen, the second level of inquiry can naturally lead into full-inquiry and can be used by teachers to

teach certain skills for authentic investigations. The use of demonstrations in science class is an example of second level of inquiry (Eick, Meadows, & Balkcom, 2005). In this level, the teacher chooses a demonstration and asks students to make a prediction, to make observations, and finally to explain the phenomena.

Third level of inquiry. At the third level, teachers or textbooks only pose the question, and the procedure and solution are left to the students. According to Bell et al. (2005), cookbook activities in science textbooks can be easily turned into third level inquiry by simply removing the procedure for the activities. For example, students can design an investigation to determine the effect of water temperature on the rate at which effervescent anti-acid tablets will react. Martin-Hansen (2002) called the third level “coupled inquiry” in which inquiry begins with teachers’ questions and then can continue with student-generated questions to the fourth level of inquiry. Eick et al. (2005) stated that any kind of science demonstration can be extended into the third level of inquiry by allowing students to investigate phenomena through in-depth investigations. For instance, a teacher can provide materials for pendulums (washers and string) and ask students to find out the effects of length of string and mass of washers on the period of the pendulum.

Fourth level of inquiry. Referred to as open inquiry (Bell et al. 2005), or full inquiry (Martin-Hansen, 2002), this is the most sophisticated level in the taxonomy of inquiry and important in the development of scientific reasoning. In this level, students participate fully in the development of questions, methods, and solutions. In addition to full participation in all aspects of inquiry, students’ interest, curiosity and questions arise from their experiences (NCR, 1996). Open inquiry requires a higher level of thinking

than the other levels and is closely related to how scientists study phenomena. According to Eick et al. (2005) and Bell et al. (2005), science fair projects are a typical example of fourth level inquiry in which teachers guide students in the development of researchable or testable questions and the design of appropriate methods to answer questions.

Research in a hands-on science museum suggests that interest in exhibits and length of time spent at exhibits may be related to level of inquiry. Children's museums and science museums have successful traditions of hands-on activities that help children learn playful exploration and inquiry (Resnick, 2004). In one science center, Gutwill (2006) compared *planned discovery exhibits* in which visitors follow instructions and explanations (lower level of inquiry) with *active prolonged engagement exhibits* in which visitors ask and answer their own questions (higher level of inquiry). He found that visitors spent a short time at the *planned discovery exhibits* but three times longer at the *active prolonged engagement exhibits*. He also found that visitors asked more "why" and "what if?" questions at the *active prolonged engagement exhibits*.

In the classroom, at all levels of inquiry, the teachers' role is crucial. According to German, Haskins, and Auls (1996), at any level of inquiry, teacher help in establishing background knowledge, experiences, and techniques is likely to result in successful completion of the inquiry. How much help should students be given in the inquiry science classroom? According to Boyles (1994), the Deweyan perspective answers this question in a very simple and clear way.

> …school should be places where meaning-making occurs through experimentation. Experimentation is based on the interest of children -- naturally occurring -- but with guidance from teachers. Accordingly, one role of teachers was to reveal the natural curiosity already within their charges. Once this curiosity was revealed, the teacher (as a guide) had to spend almost as much energy staying

> out of the students' way as looking over their shoulders and offering help, information, and encouragement when needed (p. 88).

The *NSES* advocate that teachers should be able to select, adapt, and design curricula based on students' experiences, questions, and interests (NRC 1996). According to Greene (1988), for this adaptation, teachers should have freedom from textbooks and prescribed curriculum, in addition to being permitted to design their own curriculum by focusing on children's experiences, interests and questions.

Inquiry and the Nature of Science

The first chapter of *Benchmarks for Science Literacy* (AAAS, 1993) defined nature of science (NOS) as understanding how science itself works. It is also emphasized that acquiring scientific knowledge does not necessarily lead to understanding NOS. Driver, Leach, Miller, and Scott (1996) defined NOS as follows: "knowledge about scientific knowledge, an understanding of the processes of the scientific enquiry, and understanding scientific approach" (p. 12). According to Driver et al., the nature and status of scientific knowledge constitute the core of NOS. Understandings of NOS involve abilities to define scientific study, its limits as well as its power, and the difference between science and non-science or pseudo-science, such as astrology.

Research on students' conceptions of NOS has indicated in general that students typically have not acquired valid understandings of NOS for two reasons, because NOS is not covered in the curriculum and because teachers are not clear on NOS (Tamir & Zohar 1991; Lederman & O'Mally 1990). Research on teachers' conceptions of NOS has been consistent in indicating that teachers possess inadequate conceptions of NOS (Abd-El-Khalick & Lederman, 2000; Lederman, 1992). Lederman (1992) found that most teachers believed that scientific knowledge did not change. Other teachers still held a dogmatic,

perfectionist view of science. These results seem to indicate that learning science content in undergraduate courses or participating in professional science activities does not contribute to science teachers' understanding of NOS.

Interventions have been designed to enhance teacher understanding of nature of science. There are two types of approaches: implicit and explicit. The implicit approach suggests that an understanding of NOS can be facilitated through inquiry-based instruction. The researcher who adopts this implicit approach uses science process skills instruction or scientific inquiry activities (Abd-El-Khalick & Lederman 2000). The explicit approach attempts to enhance teachers' understanding of NOS by utilizing elements from history and philosophy of science. In the explicit instruction model, integration and discussion of NOS and scientific inquiry is necessary (Gess-Newsome, 2002). This model discusses and distinguishes between the skills of scientific inquiry and understanding of scientific inquiry.

Research on teaching NOS in inquiry-oriented elementary science methods courses indicated a progression in preservice teachers' understanding of NOS. Gess-Newsome (2002) used explicit instruction to teach NOS and inquiry in an elementary science method course in which NOS and scientific inquiry were blended and explicitly taught. The analysis of preservice teachers' journals indicated that at the beginning of the course, science was viewed primarily as a body of knowledge. This view changed at the end of the course into science as body of knowledge generated through the active application of scientific inquiry. Similar attempts were also undertaken in a science research internship course by Schwartz, Lederman, and Crawford (2004). They used an explicit approach in an authentic context to develop preservice secondary science

teachers' views of NOS. The analysis of pre/post tests and interviews indicated that most of the interns showed substantial development in NOS knowledge. Schwartz et al. identified three important factors for developing preservice teachers' concepts of NOS during internship: (a) reflective journal writing and seminars, (b) the science research component being a context for reflection, and (c) the interns' role perspective, i.e., interns who assumed a reflective stance were more successful in deepening their NOS conceptions.

Colburn and Bianchini (2000) conducted research on explicit and implicit instruction in which they videotaped students in groups and also as a whole classroom. They analyzed student-student talk as implicit instruction and teacher-student talk as including explicit discussion on NOS. They found out that only providing opportunity in inquiry investigations did not lead to enough and rich discussion of NOS. Preservice teachers need explicit instruction to help learn the conceptual purpose of activities teaching NOS by engaging in discussion to connect ideas in activities to NOS. They also highlighted the critical role of teachers in initiating discussion on what science is and how scientists work.

Inquiry in the Classroom

The *NSES* (NRC, 1996) supports the use of inquiry-based science curricula, in which students' active participation in their own learning is critical. The inquiry approach has shifted the students' role in the classroom and requires students to be active constructors of scientific knowledge. Studies comparing traditional science teaching with inquiry-based science instruction reported that students demonstrated positive effects on

laboratory skills, science process skills, and understanding about scientific knowledge (Ertepinar & Geban, 1996; Geban, Askar, & Ozkan, 1992; Mattheis & Nakayama, 1988).

In a longitudinal study, Gibson and Chase (2002) examined the effect of an inquiry-based science program on middle school students' attitudes toward science. Pre/posttest data indicated that students in the program maintained a more positive attitude toward science and a higher interest in science careers than students in a comparison group. Crawford (2000) conducted a case study that focused on interactions of a high school biology teacher and 20 students in her ecology class. This study employed a complex model of inquiry-based teaching called "collaborative inquiry," in which teachers and students collaborate to develop conceptual understandings through shared learning experiences. Six characteristics of "collaborative inquiry" were identified from classroom observations: (1) study of authentic problems, (2) focus on grappling with data, (3) collaboration between teacher and students, (4) connection with society, (5) role of teacher in modeling behaviors of a scientist, and (6) development of student ownership. Crawford posited that common descriptors such as "teacher as facilitator" and "teacher as a guide" oversimplify teachers' roles in constructivist and inquiry-oriented approaches. He promoted the notion of collaborative inquiry because it requires the teacher to take on more active and demanding roles than the traditionally depicted roles. In addition to the teachers' roles as motivator, diagnostician, guide, innovator, experimenter, and researcher suggested by Osbourne and Freyberg (cited in Crawford, 2000), Crawford identified teachers as modelers, mentors, collaborators, and learners.

Teachers must create a classroom environment where students explore ideas and ask relevant and testable questions (Hofstein, Oshrit, Kipnis, & Mamlok-Naaman, 2005).

Hofstein et al. compared the ability of high school chemistry students in an inquiry laboratory group with students in a traditional laboratory group to ask meaningful and scientifically sound questions. They asserted that students in the inquiry group outperformed the control group in their ability to ask more thoughtful and high-level questions. Inquiry oriented teachers do not usually provide students' questions with explanations; rather, they answer students' questions with more questions. By doing this, teachers guide students to construct their own evidence-based explanations (Volkmann & Zgagacz, 2004). Van Zee, Iwasyk, Kurouse, Simpson, and Wild (2001) investigated ways that encourage students to formulate meaningful questions and express their ideas during reflective discussions. Van Zee et al. elicited student thinking by asking questions that helped students clarify their meanings, explore various points of view in a neutral and respectful manner, and monitor the discussion and their own thinking.

Preparing Elementary Teachers to Teach Science through Inquiry

In the *NSES* (NRC, 1996), inquiry-based science instruction is the ultimate goal of teaching and learning science from elementary to college level. The *NSES* state that inquiry instruction with students should include identifying testable questions, making investigations, developing evidence-based explanations, and communicating results. The implementation of such instruction in the classroom requires teachers to engage in instructional approaches that model inquiry-based science teaching. The *NSES* recommend that prospective and practicing teachers take courses in which they learn science through inquiry, "having the same opportunities as their students will have to develop understanding" (NRC, 1996, p.61). The *Standards* criticize science method courses as being too technical by emphasizing lesson planning and discussion of science

teaching strategies and recommend that preservice teachers engage in active learning in which they develop their knowledge, understanding and teaching abilities.

Within the *NSES* (NRC, 1996) framework, model programs, innovative science content courses, science method courses, and professional development programs were created to develop prospective teachers' understanding of science content and scientific inquiry. These programs include a prototypical elementary education program including content and methods (Boone & Gabel, 1998); an elementary science specialist program (Schwartz, Abd-El-Khalick, & Lederman, 2000); an inquiry based content and methods course (Luera & Otto, 2005); and inquiry-based laboratory courses (Suits, 2004; Liang & Gabel, 2005). In these programs, content and pedagogy were taught through inquiry-based approaches. Students studied fewer topics in depth through hands-on inquiry laboratory activities. Researchers compared inquiry-based model programs with traditional lecture-based science courses and found that the inquiry programs improved preservice teachers' acquisition of science process skills (Boone & Gabel, 1998); content knowledge, laboratory skills, and self-efficacy (Suits, 2004; Luera & Otto, 2005); and attitude toward science and conceptual understanding (Liang & Gabel, 2005).

Inquiry in Science Methods Courses

In teacher preparation programs, inquiry science methods courses are taught through different teaching strategies. In some of these methods courses, preservice elementary teachers engaged in hands-on activities and applied their learning in field placements (Jarrett, 1998, 1999; Watters & Ginns, 2000; Bell, 2001; Reiff, 2002; Palmer, 2004; Bulunuz & Jarrett, 2005). Another approach is to expose preservice teachers to real research-based projects in their science methods course. In these courses, preservice

elementary teachers are engaged in real research situations in which they develop a project and turn the project into a science unit that they implement in an elementary classroom (Van Zee, 1998; Zembal-Saul et al., 2002; Hayes, 2002; Newman, Abel, Hubard, McDonald, Otaala, & Martini, 2004; Hubbard & Abell, 2005). Two examples are “the Great Salt Lake Project” and “Advanced Bug Camp” in which participants generated their own questions and experiments. In “the Great Salt Lake Project,” students used real science tools to collect data on varying conditions (salt content, temperature, light, etc) for hatching brine shrimp, growing salt grass, and growing salt tolerant bacteria (Baxter, Jenkins, Southerland, & Wilson, 2005). In Advanced Bug Camp (Zembal-Saul et al., 2002), prospective teachers engaged in scientific investigations with children under the guidance of entomology faculty and graduate students.

Some methods courses focused on learning cycles (Odom & Settlage, 1996; Settlage, 2000; Marek, Laubach, & Pedersen, 2003). In these courses, the instructors modeled the use of learning cycles and preservice teachers participated in activities, watched video demonstrations of effective use of learning cycles, and designed and taught a learning cycle lesson to their peers (Settlage, 2000) or to elementary school children (Marek et al., 2003).

In a reflection-oriented methods course (Zembal-Saul, Blumenfeld, & Krajcik, 2000), preservice teachers were provided with opportunities to do short inquiry activities and projects. They implemented inquiry teaching in their field practicums and examined their own teaching and learning through reflective journaling (Newman et al., 2004). Preservice teachers also conducted projects and reflected on their projects and their

teaching experiences with the projects in their field practicums (Hayes, 2002; Hubbard & Abell, 2005).

As a measure of outcomes, researchers surveyed preservice teachers' interest and confidence (Jarrett, 1998:1999), attitudes toward science (Palmer, 2004), motivation to teach science (Watters & Ginns, 2000), self-efficacy (Enochs et al., 1995; Bell, 2001), understanding of the nature of science and science inquiry (Gess-Newsome, 2002; Colburn & Bianchini, 2000; Schwartz et al., 2004), and theoretical understanding of learning cycle (Odom & Settlage, 1996; Settlage, 2000; Marek et al., 2003). Other research examined beliefs regarding the teaching and learning of science by analyzing students' journals, as well as using a beliefs questionnaire (Reiff, 2002; Hubbard & Abell, 2005). In real research-based methods courses, students' journals, interviews, unit plans, and portfolios were used as data sources to determine students' understanding and ability to apply inquiry teaching (van Zee, 1998; Zembal-Saul et al., 2002; Hayes, 2002; Baxter et al., 2005). In a reflection-oriented study, students' reflections on short inquiry activities and projects (e.g. a month-long moon investigation) were the main data sources (van Zee, 1998; Zembal-Saul et al., 2000). Hayes (2002) and Newman et al., (2004) conducted research on dilemmas and struggles to understand and implement inquiry by analyzing students' reflective journals on their course experiences, projects, and teaching experiences in field placements.

Research findings have indicated that engaging in hands-on activities improved preservice elementary teachers' attitudes toward science and science teaching, interest and self-efficacy, and motivation to teach science, (Jarrett, 1988, 1999; Watters & Ginns, 2000; Bell, 2001). Watters and Ginns (2000) and Bell (2001) also found an increased

level of self-efficacy to teach science. They reported that preservice elementary teachers with greater science self-efficacy perceive inquiry-based hands-on instruction to be the most appropriate choice of instructional approaches. A Two-Tier Test on the learning cycle (Odom & Settlage, 1996), assessing both respondents' understanding of the philosophy and phases of the learning cycle and the educational reasons underlying their answers indicated that preservice elementary teachers had naïve conceptions about the philosophy and phases of the learning cycle even after receiving instruction about the method. These naïve conceptions were that the teacher should explain or define certain concepts before students explore, the teachers' role is to interpret data for students, emphasis should be on acquisition of vocabulary, and teachers should introduce new concepts at the final stage of the learning cycle. Intervention studies on the learning cycle indicated that preservice teachers' understanding of inquiry and belief improved by modeling methods course activities in the learning cycle and discussions on ways to make lessons more inquiry-based (Kelly, 2000; Reiff, 2002). After activities based on the learning cycle, Settlage (2000) found not only increased understanding of the learning cycle, but also a relationship between students' perception of their ability to positively affect students' learning and their performance on the learning cycle test. However, in another study, Marek et al. (2003) found that students had high scores on concept exploration but low scores on concept application on the Two-tier Test because of a mismatch between the test and the concepts learned in the course. In real research-based methods courses, "Advanced Bug Camp" (Zembal-Saul et al., 2002) and "the Great Salt Lake Project" (Baxter et al., 2005), analysis of students' portfolios with portfolio interviews, unit plans, and qualitative surveys revealed a developing understanding of

how to teach science to children. There was also a shift from students' understanding of science as content to seeing science as process.

In reflective-oriented research studies, qualitative analysis of students' reflective journals (Hayes, 2002; Newman et al., 2004) indicated that preservice teachers had struggles in defining and implementing inquiry in their field teaching. For instance, Hayes (2002) found that preservice teachers struggled to let go of the teachers' authority to control and direct student engagement with the curriculum, to provide their students more opportunity to define the content and direction, and to ask the right questions.

Inquiry in Content Courses

Research studies have also been conducted in science content courses in which content and inquiry teaching pedagogy are integrated as emphasized in the *NSES* (1996). The researchers called these courses "innovative elementary science content courses" in which content and pedagogy are combined, designed and taught by an interdepartmental instructional team. The findings indicated an improvement in prospective teachers' content and pedagogical knowledge (McLoughlin & Dana, 1999). Also, the prospective teachers gained confidence in their ability to teach science, motivate children, and use activities more effectively. Haefner and Zembal-Saul (2004) examined prospective elementary teachers' learning about scientific inquiry in an innovative life science course and found that engaging in scientific inquiry in the class supported the development of more appropriate understandings of science and scientific inquiry. Hubbard and Abell (2005) compared preservice elementary teachers' beliefs about teaching and learning science according to whether they had taken an inquiry-based physics content course or a traditional physics course. They found that students who had taken the inquiry-based

content course had better understanding and were able to apply an inquiry approach to their lesson planning. Similarly, Weld and Funk (2005) analyzed the effect of an inquiry biology content course on preservice teachers' self-perceived effectiveness to teach biology. Qualitative and quantitative analysis of data indicated significant improvement in command of subject matter, curriculum development, competence, and pedagogical skills.

Motivation

> Teachers who exhibit enthusiasm and interest and who speak to the power and beauty of scientific understanding instill in their students some of those same attitudes toward science. [*National Science Education Standards* (NRC, 1996, p. 37].

Teacher motivation is an important factor in achieving the vision of science education reform. Teachers often complain about unmotivated students in their classrooms. However, according to Jesus and Lens (2005), the majority of students' motivational problems arise from lack of teacher motivation. The research findings on teachers' motivation show that teachers often have low levels of motivation and satisfaction, and high levels of stress (Jesus & Lens, 2005; Pithers & Fortgary, 1995; Prick, 1989). Teaching through inquiry requires effort by the teacher. In *Motivating the Academically Unmotivated: A critical Issue from the 21st Century*, Hidi (2000) explains that motivating students at all levels requires not only ability but also effort and effort is strongly affected by motivation.

This section of the chapter discusses the nature of motivation and the theory and research that relate motivation to the variables examined in this dissertation. In this study, important variables are whether background and course experiences are *fun* and *interesting* and whether the participants believe that they have *learned a lot*. These

background and course aspects are examined as motivators. Interest as a variable is also used in another way in this research, in that *interest in science* and *interest in teaching science* are also considered as outcomes.

Definition of Motivation

There are many attempts to define motivation. Defining motivation is difficult since there are many dimensions in explaining human behavior. Huitt (2001) collected the following definitions from a variety of psychology textbooks:

> Internal state or condition that activates behavior and gives it direction; desire or want that energizes and directs goal-oriented behavior; influence of needs and desires on the intensity and direction of behavior; and the arousal, direction, and persistence of behavior (p.1).

According to Ryan and Deci (2000), "To be motivated means to be moved to do something. A person who feels no impetus or inspiration to act is thus characterized as unmotivated, whereas someone who is energized or activated toward an end is considered motivated" (p.54). According to Bickard (2003), motivation is about why a person does one thing rather than another.

Theories on Motivation

Several theories of motivation have guided this study in general, including Self-Determination theory (Deci, Vallerand, Pelletier, & Ryan, 1991; Ryan & Deci, 2000) and Choice Theory (Glasser, 1998). The works of Dewey (1913/1979), Piaget (1970), Csikszentmihalyi (1990), and Festinger (1957) influenced the use of the variables interest, fun, and learning in the study of motivation to teach science.

Self-Determination Theory. "Motivated actions are self-determined to the extent that they are engaged in wholly volitionally and endorsed by one's sense of self" (Deci et al., 1991, p. 326). The regulatory process of motivated actions is choice and the locus of

causality is internal to the self. On the other hand, the locus of causality of unmotivated actions is external to the self and the regulatory process is compliance. Self-Determination theory defines three psychological needs that direct and energize the individual's behavior: competence, relatedness, and autonomy. Competence refers to the ability to satisfy internal and external needs. Relatedness includes the development of secure and fulfilling social relationships. Autonomy refers to the ability to self-initiate and self-regulate of one's own actions (Deci et al., 1991). Accordingly, competence, relatedness, and autonomy are needs that motivate behavior.

In Self-Determination Theory, two types of motivation are defined, based on the reasons or goals that lead to action (Ryan & Deci, 2000). These are *intrinsic* and *extrinsic* motivation. Intrinsic motivation is doing an activity for its own sake such as engaging in activities that are fun, interesting and done without external prods, pressures, or rewards. On the other hand, extrinsic motivation is doing an activity in order to attain some separable outcome or doing something for its instrumental value. Intrinsic motivation involves qualities natural to human beings (e.g. active, inquisitive, curious, playful, ready to learn and explore, and interested in novelty). It can be facilitated or undermined depending on the learning environment, and it emerges from interactions between the person and his/her environment. Intrinsic motivation is seen as an important educational phenomenon because it has potential to result in high-level learning and creativity.

While intrinsic motivation can drive learning, Ryan and Deci (2000) note that many school tasks are neither interesting nor enjoyable for students. Thus, extrinsic motivation becomes an essential part of successful teaching in school. Self-Determination Theory accepts extrinsic motivation as a valid approach in education as long as students

perform school tasks with active personal commitment rather than passive compliance to teachers or parents. The behavioral approach uses reinforcement, rewards, incentives, praise, privileges, or attention, to motivate students (Skinner, 1974). According to the Self-Determination perspective, this way of motivation is a low level of external motivation (Deci et al., 1991). In Self-Determination Theory, internalization and integration processes are important for students' adoption of values and modifications of their behaviors from passive compliance to active personal commitment. In this theory, extrinsically motivated behaviors can be changed into self-determined behaviors through the processes of internalization (associated sense of personal commitment) and integration (transformation of regulation into individuals' sense of self) that may result in greater persistence, more positive self-perceptions, and better quality of engagement. A meta-analysis by Deci, Koestner, and Ryan (2001) showed that without internalization and integration, extrinsic motivation with expected and tangible rewards can take away from intrinsic motivation. Students conditioned with extrinsic motivation may have problems later on in motivating themselves in academic endeavors. Instead of using external rewards, the researchers recommended focusing on how to facilitate intrinsic motivation by providing more choice and developing more interesting activities with optimal challenge.

Choice Theory of Motivation. According to Glasser (1997, 1998), rewards and punishment (behavioral theory) rule the school, and are destructive of relationships in the classroom. Instead of places where rewards and punishment dominate, Glasser (1997) says that classrooms should be places where teachers and students care about each other, listen to one another, and play together (fun). In this environment, students are

encouraged to cooperate rather than compete. Choice Theory proposes five basic needs--embedded in human genes-- survive, belong and love, gain power, be free, and have fun. *Survive* includes basic biological needs such as food, shelter, and safety. The need to *belong and love* refers to having satisfying social relationships in the classroom. *Fun* is associated with play: enjoying activities or playing with others. *Freedom* involves having choices to decide what you want to do and also being independent from sources of physical and psychological discomfort. *Power* refers to developing knowledge and skills that are important factors to achieve a high quality of life. Choice Theory suggests that it is important to create a risk-free learning environment in which students are allowed to choose work partners, the timing of work to be done and the tasks assigned. Also, students' control over their learning situation meets their freedom needs and increases students' motivation to learn. Allowing group work cooperatively in the classroom also seems to be essential to satisfy many aspects of the students' needs. For instance, while working in groups on an activity, students' ideas influence others, meeting the need for power and love and belonging. According to Alderman (2003), choice is an important factor because it is related to intrinsic value or interest and influences attention, persistence, and acquisition of knowledge.

Interest and Motivation

Dewey (1913/1979, p.160) described an interested person as "being engaged, engrossed, or entirely taken up with some activity because of its recognized worth." The American Heritage Dictionary (Berube et al., 2002) defines *interest* as "a state of curiosity or concern about, or attention to something; involvement with or participation in something." *Interesting* refers to "arousing or holding the attention; absorbing" (p.723).

For Dewey, “interest is a tool through which the distance between the person and the materials is annihilated, facilitating an ’organic union’ between the two” (p.160). According to Dewey (1933/1986), in many learning tasks in school, the process and outcome are separated which results in “divided interest,” and students cannot connect the process of executing a task and with its outcome. For Dewey, this dilemma is the biggest “enemy of effective thinking” (p.137). Dewey believed that children give external attention to school learning tasks (e.g., to teachers and to textbooks and lessons) while their deepest thoughts are concerned with objects and materials.

> When a person is absorbed, the subject carries him on. Questions occur to him spontaneously; a flood of suggestions pour in on him; further inquiries and readings are indicated and followed; instead of having to use his energy to hold his mind to the subject (thereby lessening that which is available for the subject, itself, and creating a divided state of mind), the material holds and buoys his mind up and gives an onward impetus to thinking. A genuine enthusiasm is an attitude that operates as an intellectual force. A teacher who arouses such an enthusiasm in his pupils has done something that no amount of formalized method, no matter how correct, can accomplish (Dewey, 1933/1986, p.137)

Dewey conceptualized the interest acquisition process into three distinct and cohesive components: active, based on objects, and having personal meaning or emotional value. Dewey (1913/1979) identifies direct and indirect interest. A direct interest originates from the individual or immediate experience, but indirect interest is mediated by a teacher or parent. For Dewey, the development of interest begins in childhood with play. As children grow older, they engage in higher levels of activities that require materials, tools, rules, and procedures. Eventually, childish activities mature into adult intellectual interests. According to Dewey, development of interest cannot be separated from the child’s lives, needs or desires.

Krapp, Hidi, and Renninger (1992), Hidi and Harackiewicz (2000), and Krapp (2004) use the terms “individual interest” and” situational interest” when expanding on Dewey’s ideas on direct and indirect interest. Individual interest is defined as a long-lasting person-object relationship which develops over a period of time, and it is conceptualized as being both a disposition and an actualized state. A disposition refers to an interest enduring or remaining over a long period of time. An actualized state refers to behaviors such as highly focused attention, display of pleasure, and high degree of persistence in a task (Hidi, 2000). However, situational interest refers to a state of interest generated externally or formed as a result of ongoing interactions between a person and the environment. According to Hidi and Harackiewicz (2000), individual and situational interest are distinct; but they seem to interact and influence each other’s development. For instance, individual interest in a particular topic maintains a student’s attention even though the presentation or text is boring. Or interesting texts or presentations may maintain a student’s attention or performance even though he/she does not a have personal interest in that topic.

The hypothesized relationship between situational interest and individual interest is that situational interest can be turned into long lasting individual interest if the individual is exposed to situational interest over a certain period of time (Krapp et al., 1992; Hidi, 2000; Krapp, 2004). For the development of individual interest, the individual should experience both feeling-related experiences--enjoyments, involvements in doing an activity-- and cognitively represented factors--goals and values in doing an activity-- together in a positive way. The researchers argued that situational interest may have a critical role in learning, especially when students do not have pre-existing

individual interest in particular subject matter (Hidi, 2000; Ainley, Hidi, & Berndorf, 2002).

In order to promote situational interest, researchers have focused on task and environmental factors. According to Ames (1992), tasks that involve variety and diversity are more likely to facilitate an interest in learning. According to Resnick, Martin, Berg, Borovoy, Colella, Kramer, and Silverman (1998), if people work on projects that are familiar, relevant and interesting, they work longer and harder and make deeper connections. In a statistic class, Mitchell (1997) found that utility and perceived meaningfulness, engaging in an activity that is personally relevant, enhance situational interest. Mitchell (1993) refers to an interested person as an empowered learner who has potential to exert pressure for change. In a review of research on interest and learning, Tobias (1994) concluded that “working on interesting, compared to neutral, materials may engage deeper cognitive processing, arouse a wider, more emotional, and more personal associative network, and employ more imagery” (p. 37).

Research studies indicate that there is a relationship between situational and individual interest. Mitchell (1997) found that creating high situational interest in a statistics class was effective in increasing individual interest in statistics especially for students who have low previous interest in statistics. In a similar study, Mitchell and Gilson (1997) investigated the effect of students’ perceived situational interest in mathematics classes (from fifth grade through graduate school) on individual interest as well as on mathematics anxiety. They found an increase in individual interest and a small decrease in mathematics anxiety at the end of the course.

There are few studies on teacher preparation programs. Only two studies were found that deal with interest in science classroom and development of interest over the semester. In a study with preservice teachers, Jarrett (1999) examined development of interest and confidence in a science methods course and found that the course with its many hands-on activities increased both interest and confidence at the end of the course. In another study, Palmer (2004) investigated the effect of situational interest, created in a methods course through hands-on activities and discrepant event demonstrations, on the development of positive attitudes toward science. He found an improvement in preservice elementary school teachers' attitudes towards science. The findings of these two studies suggest that interest in class activities might develop enduring interest.

There also is research on the different aspects of interest and learning in various subjects. A longitudinal study by Rathunde and Csikszentmihalyi (1993) investigated the relationship between adolescents' level of interest and their talent-related growth in math, science, athletics and art by examining official transcripts, teachers ratings' on students' quality of attention, involvement with work, enjoyment of challenge, capacity for concentration, and students' self-assessments. They found that adolescents' interest in doing talent-related activities was positively correlated with their achievements in those fields in school. In another study, the relationship between interest, achievement, motivation and various dimensions of experience in mathematics, biology, English, and history was examined (Schiefele & Csikszentmihalyi, 1994). The researchers found that interest not only predicts students' grades in these subjects, but also predicts quality of experiences (active-passive, strong-weak, alert-drowsy, excited-bored), intrinsic motivation, self-esteem, and skills.

Research on the relationship between interest and reading indicates that there is a connection between interest in a topic and learning from a text. Ainley et al., (2002) found that topic interest was related to students' affective response while reading the text and persistence in learning from the text. In another study, Naceur and Schiefele, (2005) found students' level of topic interest to have an influence on text recall. The finding of the research reviewed above suggests that the quality of learning environment (situational interest in classroom) has a substantial impact on individual interest.

Learning as Motivator

The American Heritage College Dictionary (2002) defines learning as: "(1) the act, process, or experience of gaining knowledge or skills; (2) knowledge or skill gained through schooling or study; (3) *Psychology* Behavioral modification esp. through experiences or conditioning" (p. 789). In a psychology textbook, learning is defined as "the process of acquiring relatively permanent change in understanding, attitude, knowledge, or skill through experiences" (Good & Brophy, 1995). According to McCandless (1967), learning is "a change in performance as a function of practice" (p. 178), and therefore learning is closely related to performance. As illustrated by these definitions, learning is a complex phenomenon and has many dimensions.

There are a number of motivation theories on why people learn and under what circumstances they learn, including *need theory* (Maslow, 1943), *social learning theory* (Bandura, 1974, 1989, 1993), *behavioral theory* (Skinner, 1974), and *expectancy theory* (Vroom, 1964). For Maslow, children learn when their basic needs have been met. If students come to class hungry and tired, they are unlikely to learn well. According to Bandura, individuals tend to model learning behaviors from those people whom they

admire or who seem to be successful, and individuals' efforts in a learning task are related to their past experiences. If they have high self-efficacy, they persist to achieve learning goals; but if they have low efficacy, they easily quit the activity. According to Skinner, people learn what they are reinforced for learning. Expectancy theory (Vroom, 1964) explains motivation in relation to attractiveness of academic success with probability of achieving it.

The above theories explain motivation to learn: i.e., how people might be motivated to learn. But in this study, *learned a lot* is examined as a motivator itself: i.e., a motivator for interest in science and interest in teaching science. How might *learning a lot* be a motivator? Do schools teach children in a way that learning would motivate them to learn more or develop individual interests in science? Two prominent theoretical lenses that theorists use to explain the phenomenon of learning are behaviorism and constructivism. Because of the psychological, philosophical, and sociopolitical differences that undergird these two schools of thought, experts and lay people often disagree vehemently over the value and appropriateness of either theory in the formal context of schooling.

From the behaviorist perspective (Skinner, 1974), students learn what they are reinforced for learning. The behaviorist approach, as practiced in schools, appears to view students as passive, empty vessels which must be filled through use of traditional texts, lecturing, disciplinary rewards and sanctions, and memorization and recitation of facts, concepts, and basic principles. Learning occurs by accumulation of knowledge bit by bit through the associations (response to stimuli) with reinforcements, experiences and practices. From this perspective, learning can easily be confounded with memorization or

temporary learning in order to achieve certain outcomes such as praise, good grades, jobs, diplomas, or even avoidance of punishment (Hein, 1995; Fosnot, 1996).

The main deficit of the behaviorist perspective from a constructivist vantage point is the emphasis of outcome over process. Reinforcement of acquisition of knowledge in its final form (outcome) precludes the active construction of knowledge (process). In contrast, constructivists believe that, in order to learn, students must be active both physically and mentally (Piaget, 1970). Learning is not simply adding new information to prior knowledge associated with reinforcements, but rather it is construction by reorganization of existing and creation of new mental structures. According to the constructivist perspective, the learner should discover knowledge in a similar way to the way it was originally created (Piaget, 1973). According to many theorists (Piaget, 1973; Dewey, 1933), human beings are naturally inquisitive and curious; therefore learning itself can be self-perpetuating and self-rewarding. In other words, learning can be motivational itself as long as the process and outcome are combined and not separated. However, extrinsic systems of rewards undermine the self-rewarding nature of learning in schools.

Traditionally, schools have not been set up to facilitate natural curiosity for learning in children. Recitation has been the predominant method of instruction in schools over the last century, even before, during, and after the introduction of numerous constructivist reforms (Cuban, 1993). In short, learning in school has been more about memorizing than actively thinking. There are many problems with this perennial practice, the most important being the lack of depth required by students to function at this level of "learning." In Bloom's Taxonomy, memorization is the lowest level of learning; it

resides just below comprehension (Iran-Nejad, 1990). This ultimately means that students have long been memorizing facts and definitions without understanding them. Understanding goes beyond knowing and requires a variety of complex cognitive skills (Perkins, 1993): for instance, explaining, gathering evidence, finding examples, generalizing, applying concepts, analogizing, synthesizing, and representing knowledge in new ways.

The theorists that might best explain how learning can be motivating are Piaget (1970) and Festinger (1957). According to Piaget (1970), a state of perplexity and doubt, which he called "disequilibrium", is a necessary first step in learning. According to his theory, learning takes place at all ages as people try to equilibrate (make sense of) dissonant experiences through the processes of assimilation and accommodation. Learning new material can cause more disequilibrium, stimulating a new cycle of equilibration. The Theory of Cognitive Dissonance by Festinger (1957) proposes that dissonance, being psychologically uncomfortable, will motivate the person to try to reduce the dissonance. When the learner faces a situation that is in conflict with what he expects, doubt, perplexity, contradiction, and incongruity play an important role in stimulating the learner's curiosity. Events which don't fit one's existing expectations, "discrepant events," function by causing dissonance between what is observed happening and what one thinks should occur. Since it is impossible to change what has been physically observed, the only alternative is to begin seeking information which logically explains the occurrence. The discrepancy between scheme and object must not be too great, or loss of interest can result. Csikszentmihalyi (1990) described this balance as a

flow channel in which a person's skill level is well balanced to level of task. Seeking answers to discrepant experiences may be highly motivating.

Most of the research studies in the literature on motivation and learning are about how to motivate people to learn, but there are a few studies relating how learning itself can be motivational. There are research studies that illustrate that hands-on activities and demonstrations capture students' attention in the science classrooms (Banet & Nunez, 1997; Nussbaum & Novick, 1982) and also help them to change their incomplete understanding of natural phenomena (Bulunuz & Jarrett 2004, 2005). Palmer (2002, 2004) states that hands-on activities and discrepant events have motivational value in a teacher preparation program. When students are exposed to exciting activities that are fun and new to them over a period of time (Palmer, 2004), this experience can enhance their perception of learning a lot about science. The more students learn, the more the disposition to learn increases also. In a study, Jarrett (1998) found high positive correlations between preservice teachers' ratings of activities on fun, interesting, and learning, and their intention to implement those activities in their classroom. This finding suggests that learning has motivational value, in that the more students feel they learn, the more enjoyment and involvement they have in doing science activities. According to Deci et al., (1991), the depth of learning is highly associated with intrinsic motivation and mental schemata are viewed as transient structures rather than long-term memory building blocks, suggesting that interest, or curiosity, might be as important as prior knowledge. In another study, Tobias (1994) reviewed research articles on interest, learning and prior knowledge, and found a strong relationship among these variables. He claimed that prior knowledge accounts for a considerable amount of variance in

explaining learning along with interest. According to Tobias, more learning on a particular topic or activity may lead into greater engagement. The above theoretical and research connections can be interpreted as showing that learning has substantial motivational value.

Fun and Playfulness as Motivator

The American Heritage College Dictionary (Berube et al., 2002) defines fun as "(1) source of enjoyment, or pleasure. (2) enjoyment; amusement. (3) playful" (p. 561). The same dictionary defines playfulness as "full of fun and high spirits" (p. 1068). According to Klugman and Fasoli (1995) play has five possible characteristics: intrinsically motivated, freely chosen, enjoyable, active, and non-literal. Experiences that have most of those characteristics are generally thought of as play. Arieti (1976) defines fun as a subset of play and states that although fun is one of the characteristic elements of play, not all play is fun and enjoyable and not all fun can be considered play. Play is sometimes thought of as the opposite of work. King (1982, 1986) indicates that kindergartens define school play according to whether they are given a choice. Whatever they are told to do is considered work rather than play.

There are connections among fun, playfulness, creativity, and science. Dewey (1933/1986) defines playfulness as an attitude of mind, essential for imagination and creativity. According to Deci (1995) and Csikszentmihalyi (1996), playfulness and creativity are connected to intrinsic motivation. Kaufman and Baer (2004) defined creativity as an ability to produce original and high quality work and concluded that playfulness is an important ingredient of a creative individual's cognitive style. According to Padilla-Concepcion (2005) creativity involves seeing new patterns and

connections, putting parts together to make a whole and breaking the whole to make new parts. All these abilities or skills seem to emerge in playful engagement with an activity or a task. Creativity is relevant in the context of this study because it appears to be an important quality in doing scientific research (Ganschow & Ganschow, 1998; Jarrett & Burnley, 2007).

Play and science are often though of as dichotomous constructs, with play representing fancifulness and frivolity and science representing serious logical thinking. However, the intricate relationships among play, science, and creativity are well established. Severeide and Pizzini (1984) stated that science and play are complementary aspects of problem solving. The former encourages systematic behavior while the latter encourages creative behavior. Pearce (1999), a 5th grade teacher who teaches through inquiry, emphasizes playful involvement with science in elementary schools and states that "the act of play is in itself an intense scientific study, unassigned and internally motivated" (p. 3). According to Laszlo (2004), one definition of science is play with ideas, a process of innovation and discovery, rather than a textbook exercise of learning definitions. For Anderson (1994), play energizes and focuses our activities; and it also breeds creativity. "Play involves the total being, instead of relegating us to the role of a singular drone-like task. It feeds competency by giving us the excitement of a 'safe' and a 'risk-free' challenge instead of a threat" (p.2).

According to child development theorists, play is a natural way of learning and necessary for cognitive, social, and personal development. Piaget's (1964/2003) theory proposes that children construct their knowledge through play by the process of assimilation and accommodation. In assimilation, children try to fit new experiences into

their pre-existing cognitive structures. In Piaget's theory on knowledge construction, assimilation is associated with play whereas accommodation involves logical or serious thinking. These two are not separable in a child's learning. In Vygotsky's (1978, p.102) social constructivist theory, "in play a child always behaves beyond his average age, above his daily behavior; in play it is as though he were a head taller than himself." According to Erikson's (1963), psychoanalytic theory, a playful learning environment provides a medium in which individuals have the opportunity to try to do things by themselves (autonomy). By doing this, they can learn how to take initiative and develop industrious personality. Therefore, play is necessary for cognitive and personality development.

There are various philosophies and theories of education that are compatible with the child development theories just discussed. In Latin, education (paideia) and play (paidia) have the same root, and they both refer to the activity of a child (Jaeger, 1943). In his book, *Paideia*, Jaeger (1943) introduces Plato's views on child education, that knowledge should be introduced to a child through games and play and that children should not be forced to learn anything through slavish fear of punishment. For Jean-Jacques Rousseau, play is also a main source of education for children. Rousseau, in his classic book *Emile* (1911), valued play by stating that **"**Work and play are all one to him, his games are his work; he knows no difference. He brings to everything the cheerfulness of his interest, the charm of freedom, and he shows the bent of his own mind and the extent of his knowledge" (p.150). Along with Rousseau, Dewey (1933/1986) disdained the sharp separation of work and play in school. He stated that

> "The true distinction is not between an interest in activity for its own sake and interest in external result of that activity, but between an interest in an activity just

> as it flows from moment to moment, and an interest in an activity as tending to a culmination, to an outcome, and therefore possessing a thread of continuity binding together its successive stages" (p.287).

For Dewey, both process and outcome can be "for its own sake" when they are not separated. Resnick (2004) applies constructivism in his Media Lab at (MIT) to create a playful learning environment which integrates play and learning for pupils from 10 to 18 years old. The pupils work on creative projects together such as creating animation in the computer by using digital images, building "marble machines"- a series of ramps and race ways bouncing off bells and bumpers by using craft materials, pegboard, wooden slats, bells, string, marbles and crickets (tiny computers). In this environment children come up with "mini-hypotheses," new designs ideas, which they test out and reproduce based on the results. According to Resnick, integration of play and learning creates self-motivation, responsibility, and great concentration. Children are likely to learn the most and enjoy the most when they are engaged as an active participant, not passive recipient. Resnick's Lab is a representative example of how a playful learning environment can be serious, creative, and imaginative as well as being fun and playful.

According to Trumbull (1990), scientists often solve problems creatively in a spirit of play. In the discovery of the structure DNA by Watson and Crick, (Ganschow & Ganschow, 1998), the sprit of playfulness, competitiveness, and creativity played an important role. According to Kean (1998), professional chemists continue to have fun and satisfaction throughout their career with discoveries about how the physical world works. Laszlo (2004) stated that chemists play games with chemicals in a similar way as a child who mixes various colors in a paint box to see what comes out. In the same way, chemists ask themselves the question "what would happen if I change…?" This playful

attitude can be extremely fruitful and can motivate scientists. Laszlo's fellow Chemist Joseph B. Lambert wrote him that:

> When I grew up, every kid put in some serious sandbox time, and it often involved building (what seemed like) complex sand structures around which fantasies were composed and competitions took place with neighborhood kids. The organic chemistry labs (at Yale during the junior year) were fun in the same way. We constructed molecules and competed with each other in the class on speed and yield. We mixed things up, and chemical transformations took place. We separated, we isolated, we analyzed. The odors were pleasant, and the physical process of working with our hands, as with sand, was satisfying. The biweekly organic labs became the high points of my week. By the end of the year, I knew that I wanted to be an organic chemist, as I realized one could play in the sandbox for a living. (Cited in Laszlo, 2004, p.2)

Joseph B. Lambert's letters to Laszlo demonstrate many key elements of play, from sand box to chemistry lab, which represent freedom to explore, active participation, fun, and the integration of process and outcome. These examples illustrate that in scientific endeavors scientists also learn and discover new things in the spirit of play and playful engagement

There is research with school age students on play, playfulness and creativity. In a longitudinal study, Russ (1998, 1999) found that children who play creatively early show best creativity and problem-solving in adolescence. In another study, Trevlas, Matsouka, and Zachopoulou, (2003) found a positive relationship between playfulness and motor creativity of preschool children. Holden (2004) examined development of basic mathematics skills for primary school children when mathematics was taught in a fun way and in a playful context. He found out that the students scored higher than the national and international averages on mathematics tests and that the playful and experimental approach enhanced students' knowledge of basic skills as well as their attitude toward mathematics.

In a study with senior high school students, Court (1993) examined a playful environment in a cooperative physics class. Court found that much of the students' talk was directly on-task and very intense and that the cooperative structure of the lessons provided a positive and fruitful learning atmosphere rather than a deductive, right-answer, test-oriented approach to physics. Palmer (1999) identified junior high school students' perceptions of their best science teachers and found the following: these teachers allow students to do lots of interesting hands-on activities and make lesson fun, and they are interested in science, enjoy science, and are enthusiastic about teaching it.

In a study with preservice teachers, Jarrett (1998) found that exploratory activities tended to be rated playful, fun and interesting and that preservice teachers intended to implement those activities in their future classrooms. In another study, Palmer (2002) found that preservice teachers who observed children at an interactive science center recognized the importance of hands-on science teaching and the value of making science fun. Also through the visit, the students become aware of the science center as an important teaching resource. Due to a professional development program, Radford (1998) found increases in positive attitudes toward science among middle-grades life science teachers. These increases were explained by the inclusion of fun activities that could be implemented in the classroom. The program resulted in changes in teacher behavior and subsequent improvement in students' attitudes and achievements.

The above research findings, from preschool to professional development programs, indicate that playful learning environments enhance students' engagement, creativity, attention span, and enjoyment. Also, preservice and in-service teachers

developed positive attitudes toward hands-on science and making science fun for children.

Background Experiences as Motivator

Autobiographies of eminent scientists demonstrate that rich and playful early childhood experiences with science had an impact on their career and interest in science. For instance, the father of organic chemistry, Robert Burns Woodward (Woodward, 1989) as a child had a chemistry lab in the basement of his house where he performed experiments. Micheal Faraday, whose work made the electric generator possible, claimed that the origin of his knowledge was based on a “hands-on” approach acquired as a child (Tweney, 1989). Charles Darwin’s voyage experiences in the *Beagle* as a young man helped him to learn how to clarify and solve problems. These early experiences played an important role in his whole career (Kegan, 1989). Albert Einstein, though unsuccessful with the rote learning verbal and arithmetic tasks emphasized in his early schooling was fascinated with the behavior of physical devices such as a magnetic compass and a model steam engine. He also delighted in solving problems and mathematical puzzles posed by his uncle from an early age and spent long hours building very high multitiered houses of cards (Shepard, 1988).

Several studies have examined the backgrounds of Nobel laureates, other eminent scientists, and university scientists. An early study by Ann Roe (1952, cited in Rowsey, 1997) examined eminent physicists’ life experiences related to their science career choices. She found that early extracurricular interest in science appeared to relate to later career interests. These extracurricular interests were: playing with physical gadgets, playing with mechanical construction sets, working with electricity, and enjoying

experiments that included “messing around.” Recently, Rothenberg (2005) investigated the familial transmission of creativity in the natural sciences by collecting data from Nobel laureates in science and nonscientific fields. He found that creative achievement is associated with family background that is likely to instill strong motivation for creative achievement.

There are a few studies on university professors’ development of interest in science and selection of science as a career. Jarrett and Burnley (2007) examined the role of a variety of outdoor and indoor activities on geoscientists’ interest in science and found that these informal experiences played an important role in the development of a scientific mindset and the selection of science as a career. Rowsey (1997) examined the influence of schooling on the vocational choice of university professors from various fields of science and ascertained that elementary and middle school teachers had little influence on vocational choice by university professors. Most of the professors were influenced by parents and other relatives in their career choice and said there was not any particular influential event in junior or senior high school to impact their choice to become scientists.

Playful engagement with science in childhood seems to be very influential on development interest in science. According to Dillon, Franks, and Marolla (1975) children need to be relatively free from testing pressures in schools and have freedom to wonder, explore, and discover in order to develop interest in science. Joyce and Farenga (1999) examined the science perceptions of high ability upper elementary students and ascertained that they had already decided whether they liked or disliked science before the age of nine. These students felt that their early childhood science experiences inside

and outside of school played a key role in development of their interest. DeLaat and Watters (1995) studied the origins and changes in preservice teachers' science teaching self-efficacy and found that teachers with high personal teaching self-efficacy had been interested in science for a long time and had a relatively strong background of formal and informal science experiences.

In a survey of more than 1,400 members of the American Association for the Advancement of Science (Bayer/National Science Foundation Survey, 1998), the respondents were asked about their own educational and career experiences. The result of the survey indicated that over half of the scientists became interested in science during their elementary years, and teachers were as influential as parents in sparking an interest in science. Eighty-two percent of scientists mentioned that they were influenced by formal science classes; 80 percent of the scientists were influenced by science toys and equipment like chemistry sets and telescopes; 78 percent mentioned newspapers, magazines, and other media that covered science; 76 percent mentioned science museums; and 69 percent felt that doing science experiments at home was influential. Few scientists (25 percent) believed that science is given enough emphasis in elementary schools. This survey indicates that both informal science experiences and formal science course experiences were important in the development of their interest and their selection of science as a career.

In a survey conducted by Purdue University, more than 30,000 students in Indiana and the Chicago area were asked who was the most influential in their lives in promoting interest in science. Their first choices were TV programs such as the characters from the "Star Trek: The Next Generation." The other top choices in order were: parents, teachers,

the TV show "Beekman's World," NASA and astronauts, Steven Spielberg and George Lucas movies, and Mr. Wizard, respectively (USA Today, 1994). In a study with geology undergraduates, Jarrett (2005) found that outdoor explorations such as collections, museum visits, playing with LEGOs and other construction toys were important aspects of their childhood experiences. These experiences appeared to be influential for geology undergraduates' interest in science and choice of science as a career. In another study, Falk (2002) surveyed adults over 18 years old on the contribution of non-school sources for learning science and found that science was not exclusively nor even primarily learned in school. The survey results revealed that a significant percentage of science learning occurs from the following, in order of significance: books and magazines (not for school), life experiences, TV and cable, school science courses, museums and zoos, on the job, family and friends, radio and audiotapes.

Most of the research on interest and background science experiences has been focused on scientists, but there are a few studies conducted in teacher preparation programs. A study of preservice elementary teachers (Sampson, 1992) examined their previous school and life experiences and attitude toward science and science teaching. The majority of the preservice teachers in the study claimed that their non-school experiences stimulated their curiosity more than their science classes in school. In another study using regression analysis, Jarrett (1999) found that whether elementary school science was memorable was the best predictor of interest in science, followed by informal science experiences.

The above research suggests that informal science experiences are important in promoting interest in science. Research on the influence of teachers on students' future choices, aspirations, and motivations in science yields mixed results.

Summary

This literature review brings together the theories and research on inquiry science education and intrinsic motivational aspect of learning and teaching science. Inquiry is a method of science teaching based on the constructivist theory of learning. It constitutes the core of science education reform. Research findings suggest when students engage in scientific investigations they develop content and pedagogical understanding of inquiry and inquiry science teaching. Inquiry is defined in many ways and various levels of inquiry are identified in the literature, but research on motivational aspects of different levels of inquiry was not found.

Research studies indicate that teachers have motivation problems in teaching science. Part of this problem has been addressed to teachers' science content knowledge, self-efficacy, pedagogical knowledge about inquiry science education. However, teachers' intrinsic motivation to teach science is overlooked in the literature. This literature review on theory and research focuses on intrinsic motivators such as fun, interest, learning, and background science experiences. Fun is seen as a basic human need. Doing playful activities and learning new things are intrinsically motivational for learning. Theory and research on interest reveals that situational interest can develop into individual interest. The literature reviews on background experiences in science suggest that there is a connection between positive experiences in science and interest in science.

CHAPTER 3

METHODOLOGY

The purpose of this study was to explore the connections among background experiences, participation in methods course activities at various levels of inquiry, and ratings of overall course experience on interest in science and interest in teaching science. This study explored three overall questions:

1 What science background experiences (school, home, and informal education) do participants have, and how do those experiences affect initial interest in science?

2 Among the hands-on activities in the methods course, is there a relationship between level of inquiry of the activity and the motivational quality (*interesting*, *fun*, and *learning*) of the activity?

3 Does the course affect participants' interest and attitudes toward science?

4 What aspects of the course contribute to participants' interest in teaching science and choice to teach science?

This chapter describes: (a) participants and context, (b) data sources, (c) overview of research design, (d) the course and instructional intervention, and (e) data analysis.

Participants and Context

The participants in this study were undergraduate preservice elementary teachers in two sections of a science methods course during the spring semester 2006 in the Early Childhood Education Department of the College of an urban southern university. The

preservice teachers were second semester juniors in the undergraduate program. The program was heavily field-based with school placements for different methods courses each semester in schools having various levels of partnership with the university. Following a developmental sequence, preservice teachers were placed in pre-K and Kindergarten classrooms and eventually were placed in grades four or five classrooms. The preservice teachers involved in this study were placed in first grade classrooms the first half of the semester and second or third grade classrooms the second half of the semester. They were in schools two days a week, placed with an experienced cooperating teacher and observed at regular intervals by a university supervisor. They also took classes on campus two days a week. They had taken at least two semesters of laboratory-based science content courses before being admitted to the early childhood education program. One section of the science methods course with 25 students was taught by the researcher (a doctoral student). The other section with 28 students was taught by another doctoral student. All the preservice teachers, a total of 53 participants, agreed to participate in this research study. Most students were the typical age for undergraduates. Ninety-four percent of the students are female.

Data Sources

Science Background Experiences Survey

The purpose of this survey was to identify background experiences of students that might predict interest in science. The survey was administered near the end of the semester. This instrument was adapted by Jarrett and Bulunuz from questions used in a study by Jarrett (1999), with two questions adapted from Samson (1992). The survey consists primarily of items on a five point Likert scale in which students rated their

background experiences in elementary school, middle/junior high school, high school, and college/university. On rating their elementary school science experiences, students were first asked whether they could remember anything about science in elementary school. If they could not remember anything, they skipped the rest of the question about elementary school. Previous research (Jarrett, 1999) found that most teachers could remember nothing about science in elementary school and suggests that having at least some good experiences at the elementary level can be important. At the other levels, the students were to identify their best experience and say whether that experience was typical. The assumption was that having at least one good course might be influential, even if other experiences are negative or neutral. Students also rated parent support and non-school experiences and identified play and recreational activities important to their childhood or youth. The Science Background Experiences Survey can be found in Appendix A.

Science Teaching Survey I & II

One purpose of these surveys was to describe students' initial attitudes and interest in science and to detect any changes in their attitudes and interest from the beginning to the end of the science methods course. Science Teaching Survey I, given as a pretest at the beginning of the semester, includes six statements adapted from the Science Attitude Survey developed by Radford (1998) and two questions from the Science Teaching Survey developed by Jarrett (1999). The Radford survey has no reliability or validity measures. The two five-point Likert scale questions adapted from the survey by Jarrett (1999) have test-retest agreement as follows: 71% identical answers and 29% answers varying by one point.

One of the questions, concerning interest in science, was the dependent variable for a regression analysis on which background variables predict interest in science. Science Teaching Survey II, given as a posttest, includes the questions in Survey I plus two additional questions; one on interest in teaching science, the other on whether one would choose to teach science. Those two questions were dependent variables in regression analyses on the contribution of background variables and the science methods course as predictors of interest in science teaching and the choice to teach science. These two surveys are found in Appendix B and F. With a small sample, test-retest agreement was calculated on the nine five-point Likert Scale items on Science Teaching survey II. There was 92% general agreement, either exact agreement or the answer varied by one point. For the dichotomously coded item (Question 10), 83% of the students gave identical answers both times.

Activity Rating Survey

At the end of each class period, students rated the hands-on activities they engaged in during that class using a five-point Likert Scale ranging from 1 (low) to 5 (high). Their ratings were on three dimensions: (a) *fun*, how much fun it was, (b) *interest*, how interesting it was, and (c) *learning*, how much they learned from it. The Activity Rating Survey is an adaptation of a survey developed by Jarrett for a study of physics labs (unpublished data). The Activity Rating Survey can be found in Appendix C. To determine whether there is a relationship between inquiry level of the activities and ratings on *fun*, *interest*, and *learning*, all of the activities were classified according to level of inquiry using an Activity Classification Rubric. See Appendix D. The purpose of this rubric was to classify activities based on their level of inquiry (Schwab, 1960).

Schwab identified inquiry on three levels based on who poses the questions and who develops the methods to answer the questions. In the first level of inquiry, the teacher dominates by posing the question and deciding methods and answers. In the second level, the teacher poses the question, but methods and answers are left open to students. In the third level questions, methods, and answers are left open to students. In addition to Schwab's three levels of inquiry, a fourth level "0," used by Zembal-Saul et al., (2002), was added for hands-on activities and demonstrations that do not appear to represent any formal form of inquiry, i.e. students do not pose questions, collect data and answer questions. A coding manual was prepared by the researcher for coding the activities by level (see Appendix E). A fellow doctoral student (the instructor of the second cohort) also coded the activities without the labels of inquiry levels of the activities. To compute reliability, first the researcher rated all the activities. Then the instructor of the second cohort rated all the activities independently. The primary researcher's ratings of the activities were used in the analysis. The correlation between two raters is .84 and absolute agreement on the categories is 76 %.

Course Rating Survey

This survey, given during the final class session, used regression analyses to evaluate the contribution of the course in the development of interest in teaching science and the choice to teach science. The students were asked to rate the following on a five point Likert scale: their learning about inquiry, their overall enjoyment of the course, and their description of the course on dimensions of fun, interest, hands-on, student input, learning, and understanding. These ratings of the course are similar to ratings of previous

science course experiences in the Science Background Experiences Survey**.** The Course Rating Survey can be found in Appendix G.

Overview of Research Design

This was an exploratory study, examining in various ways the connections between motivational background experiences, various aspects of the course, and interest in science and the teaching of science. The study involved descriptive and inferential analyses of surveys completed by students in a science methods course on their experiences with science before, during, and at the end of the course. There are four primary research questions. Following is a description of how the questions are answered.

The first question, on the effect of background experiences on students' initial interest in science, is primarily descriptive in nature, and it has two parts. The first part deals with descriptions of students' background experiences in science and includes best science course experiences, informal science experiences, and parental support. These experiences were described separately for those students with higher and lower interest in science with means, standard deviations and frequencies from the Science Background Experiences Survey. Where appropriate, independent samples t-tests were computed to determine whether the higher and lower interest students differed. The second part examines the relationships between science background experience variables and students' initial interest in science using multiple regression analyses to determine which background factors were best predictors of interest in science.

The second question explores the relationship between the level of inquiry of the activities in the course and student ratings of those activities on *fun*, *interest,* and *learning*. To explore these relationships, each activity was classified according to level of

inquiry using the Activity Classification Rubric (Appendix D). Then for each student, the means on *fun*, *interest*, and *learning* for the activities that fall under each level were calculated so that motivational aspects could be compared by inquiry level. Separate ANOVA's were calculated with level of inquiry as the independent variable and *fun*, *interest*, and *learning* as the dependent variables.

The third and fourth questions concern the influence of the inquiry science methods course on student attitudes toward science, interest in science, and motivation to teach science. The effect of the science methods course was analyzed in two ways. First (Question 3), to determine whether students become more positive toward science from beginning to end of the course, pretest and posttest scores on common items on the Science Teaching Surveys I and II (Appendices B and F) were compared using paired samples t-tests. Second (Question 4), to determine the role of the course in developing motivation to teach science, variables from the Course Rating Survey and Science Background Experience Survey were entered into regression equations as predictor variables with the two questions, interest in science teaching and choice to teach science (Science Teaching Survey II) as dependent variables.

Description of Course and Instructional Interventions

The overall goal of the course as stated in the course syllabus was:

> To teach science content and inquiry methods in such a way that those teaching pre-K-5 will feel confident, skilled, and motivated to integrate inquiry science into the curriculum. Specifically, the course is designed to (a) provide participants with content information on science topics relevant to their teaching

and (b) model developmentally appropriate inquiry teaching methods as recommended by the National Standards.

The methods course had two main purposes: to teach students how to teach through inquiry and to develop interest in teaching science. In these two sections of the class, a variety of instructional interventions was implemented with students. The course was designed in a way that similar content and pedagogy were used in both classes. They were taught by the researcher and his wife, a doctoral candidate in the department. Instruction in both sections was similar. Both instructors served as teaching assistants with the same science education professor and learned the same strategies and activities. The instructors planned the course together. They both modeled how to teach through inquiry by using hands-on centers, discovery tub activities, demonstrations, and dialogue journaling. Students participated in hands-on stations and discovery tubs, wrote in journals, and engaged in classroom discussion. Their assignments included: reflections on readings, doing a science fair project, and implementing activities with children during their field assignments. A difference between the sections was that one of the textbooks was different. The researcher assigned his class to read *Nurturing Inquiry* by Pearce (1999). The other instructor assigned *Science Workshop: Reading, Writing, and thinking like a scientist* by Saul, Reardon, Pearce, Dieckman, and Neutze (2002) with a chapter by Pearce. The emphasis in both textbooks is similar; making science hands-on and inquiry based for elementary school children.

Students wrote reflections and participated in classroom discussion on the books mentioned above (Pearce, 1999; Saul, et al., 2002) as well as on the following books and articles assigned in both sections: *NSTA pathways to the science standards: Elementary*

school edition by Lowery (1997), *Drawing on the Child's World: Science Made Relevant* by Jarrett (1995), and *Breaking into Inquiry* by Eick, Meadows, and Balkcom (2005). Pearce (1999, 2002) describes with rich details and examples how to start scaffolding inquiry cycles and how to sustain inquiry throughout the year by focusing on children's experiences, interest and questions. The *NSTA Pathway to Standards* (Lowery, 1997) provides various developmental learning characteristics of primary, middle, and upper elementary students and gives examples of science lessons from classrooms.

In Drawing on the Child's World: Science Made Relevant, Jarrett (1995) discusses various definitions of science and how science should be taught in an engaging and interesting way to elementary school children. This booklet provides many useful ideas, experiments, resources and strategies for teaching science in elementary classrooms. The article, *Breaking into Inquiry* by Eick, Meadows, and Balkcom (2005), defines inquiry at various levels from a teacher-oriented to a student-oriented approach and explains how teachers and their students should transition from one level to another to achieve the highest level of openness. The article delineates ideas and examples for the incremental use of inquiry methodology in science courses.

Most of the class time was spent on modeling hands-on learning stations and discovery tub activities (Pearce, 1999, 2002). Also, one session modeled the use of discrepant event demonstrations to clarify some concepts and spark student interest. Throughout the semester, over 73 hands-on activities at various levels of inquiry were implemented in the 37.5-hour course. Because of time limitations, most of the science topics were chosen from physical science and earth science with a smaller portion devoted to life sciences. The reason for this choice was that many elementary teachers are

lacking in content preparation, especially in the physical sciences and earth science (Yates & Goodrum, 1990; Weiss, 1997; Fulp, 2002). The physical science topics included static electricity, electricity and magnetism, water, air, sound, density, gravity, inertia, and polymers. The earth space science topics were: reason for seasons, phases of the Moon, rock cycle, soil formation, wind, and earthquakes. The life science activities were insects, dissection (owl pellets and octopi) and germination.

Hands-on learning stations and discovery tubs were the main features of the methods course. Many of the hands-on learning stations were designed to teach specific science content and require structure, instruction, and predetermined questions in each station. The preservice teachers moved from one station to another, following the instructions and answering the questions provided in each station. For example, learning stations on properties of air included eight activities dealing with topics such as air occupies space, air exerts pressure, and Boyle's Law. However, discovery tub activities (Pearce, 1999, 2002) tended to be more open-ended for students compared to hands-on learning stations. Discovery tubs included a variety of materials that could be used in various ways. Instructors introduced activities in a fun and engaging way. Then students experienced the materials or activity. Once students became familiar with the materials, the instructors encouraged them to pose their own questions and design their own experiments to explore different aspect of materials or activities. In the next step, students took the initiative. They were allowed to work in groups to explore activities, formulate questions, and design experiments to answer their questions. For example, one activity called "exploring a science kit" included materials such as electric motors, batteries, bulbs, nails, paper clips, magnets, thermometers, magnifying glasses, long and

short wires, and compasses. Students discovered how the materials in their science kit interacted with each other, worked cooperatively to pose questions that they were curious about, and designed and conducted experiments to test their questions. The instructors visited each table and encouraged dialogue about the experiments. The purpose of this dialogue was to learn what the students were doing and how they are doing it. The instructors facilitated students' investigations by building on initial experiences and curiosities to encourage formation of testable questions.

The hands-on stations and discovery tub activities were planned in such a way that students learned both science content and methods of teaching science through inquiry. In presenting science content, general conceptual understanding was emphasized instead of giving detailed scientific formulas and terminology. The explanations of scientific concepts were made by one-on-one dialogue, group/whole class discussions, or through dialogue journaling. The purpose of giving explanations in these ways was to model how to introduce and describe scientific concepts to children using explanations connected to what the children do in the activity rather than being abstract and detached from experiences.

To apply what they learned, the preservice teachers implemented discovery tubs (materials the children could explore and investigate) and learning stations with children during their field placements, using their course experience as a model. The discovery tubs and learning stations could include materials and suggested questions implemented in class or they could be entirely developed by the students. In the first placement, they implemented discovery tub assignment with small group students (3-4). In the second placement, they implemented four hands-on stations, at least one with high level of

inquiry. In both assignments, the preservice teachers were expected to plan the activities, assemble materials, give instructions, and, as appropriate, allow students to pose questions, plan investigations, and make discoveries.

Activities were chosen to model inquiry teaching, teach some content, and develop conceptual understanding. In addition, priority was given to activities suitable for children but also fun for adults, especially activities designed to generate student interest in science and hopefully in teaching science: (a) discrepant activities to provide excitement (for example, cutting a magnetic field with scissors, making polymers, Bernoulli Principle), and (b) enjoyable activities to engage in playful science (for example, paper helicopters, scientific toys, making games out of such materials as magnets, electric motor, batteries, toy cars). Most of the activities used local, readily found and inexpensive materials. According to Brandwein (1968), familiarity coupled with incongruity can be a powerful combination. The majority of the activities involved active participation and group work of preservice teachers to investigate the different aspects of an activity by posing questions and conducting investigations. In addition to the mini-experiments conducted through class inquiry, students did a science fair project. The goal of the project was to cultivate skills in inquiry (including generation of questions, hypotheses, and plans for investigations), control of variables, data collection, data analysis, and reporting of findings. The projects provided a context and environment in which students worked cooperatively to solve problems and communicate their findings to others. The science fair project is a good example of a higher level of inquiry activity in which questions emerge from students' experiences, interests, and curiosities. The science fair project included most of the essential features of high level inquiry

defined by the *NSES* (NRC, 2000) such as posing questions, designing experiments, making observations, gathering data, making discoveries, and justifying and presenting results. One class session was spent introducing the science fair project and conducting a mini-research project in the building or neighborhood. In the mini-research project, students investigated one question from a list of research questions; e.g., Is the temperature the same throughout the building? Is the wait time for an elevator the same on all floors? What variety of markings can be found in a flock of pigeons? In the following few weeks, students posed their own research question, designed an investigation, and collected and analyzed their data. In the last session of the class, students presented their projects to their peers in poster presentations.

The instructional interventions were intended to generate interest in science teaching by implementing activities that required active involvement of students and were meaningful to them (Mitchell, 1997). Involvement refers to active engagement of students with the course activities and the science fair project. Meaningfulness refers to connectedness to preservice teachers' lives and being relevant to their needs. This was ensured in two ways: (1) understanding, rather than formulas and terminology, was emphasized in the explanations of scientific concepts; (2) the activities were appropriate to use with elementary school children. Most of the activities had been previously tried out with elementary school students and found to be highly motivating, fun, interesting and engaging. The essential features of inquiry (asking questions, designing investigations, communicating with results) and variations in inquiry–based teaching were taught implicitly, by actually doing investigations in the course and explicitly by

discussing the examples given in the reading assignment and by discussing a few representative examples from the course activities.

Data Analysis

This study explored relationships that are not clearly established in the literature using descriptive statistics, group comparisons, and regression analyses. Because it was exploratory, there was some "playing" with the data, i.e. trying various combinations of variables to discover connections. The following provides a general guide for how the data were analyzed.

Question one: Background experiences

Question one concerned the effect of background experiences (e.g., best science course experiences, informal science experiences, and parental support) on students' initial interest in science. Answering this question involved two analyses. In the first, descriptive statistics (means, standard deviations, and frequencies) of items on the Science Background Experiences Survey were computed separately for students with high interest in science (ratings 4 or 5) and students with neutral to low interest in science (ratings 1-3) on the Science Teaching Survey, Question 7: *overall interest in science* (Appendix B). In the second, regression analysis determined which background experiences best predict preservice teachers' initial interest in science. Question 7, using the five point scale, was the dependent variable. Data from the Science Background Experiences Survey, such as best science course experiences in school from elementary to college, informal science experiences, and parental support were considered as predictor variables. This analysis was exploratory in nature. To determine what variables to include in the regression equation, a correlation matrix was computed among the

variables, *overall interest in science* and answers on the Science Background Experiences Survey. From the correlation matrix, the variables that correlate highly with the dependent variable but have low inter-correlations were selected for inclusion in the regression analysis. It was predicted that the following null hypothesis would be rejected and the alternative hypothesis would be accepted:

H_0 = Among preservice teachers, background experiences do not predict interest in science.

H_a = Among preservice teachers, certain background experiences predict interest in science.

Question two: Levels of inquiry and activity ratings

Question two concerned the relationships between level of inquiry of the activities in the methods course and students' ratings of those activities on *fun, interest*, and *learning*. To investigate these relationships, the Activity Classification Rubric was used to classify each activity as *0, 1, 2, or 3*. Level of inquiry was the independent variable for three separate ANOVA's, one for each dependent variable, *fun*, *interest*, and *learning*. The dependent variables were calculated by listing the activities by level of inquiry and calculating, for each subject, the mean of *fun*, *interest*, and *learning* for the activities in each level. For example, if five activities were categorized as level 2, the means on the *fun*, *interest*, and *learning* ratings of those five activities were calculated and compared with the means of *fun*, *interest*, and *learning* ratings of the other levels. For each dependent variable, it was predicted that the following null hypothesis would be rejected:

H_0 = There is no relationship between the level of inquiry of the activities and the ratings of the activities on *fun*, *interest*, and *learning*.

H_a = There is a relationship between the level of inquiry of the activities and the ratings of the activities on *fun*, *interest*, and *learning*.

Specifically, it was predicted that higher level of inquiry activities will be considered more fun and more interesting but that *learning* would be less affected by inquiry level.

Question three: Impact of the course on participants' interest and attitude toward science

Question three investigates the effect of the inquiry science methods course on student attitudes toward science and interest in science. The influence of the course was analyzed by computing paired samples t-tests to examine whether there was a change in students' attitudes toward science, and interest in science from beginning to end of the course. Pretest scores on Science Teaching Survey I and posttest scores on the same items on Science Teaching Survey II were compared. It was predicted that the following null hypothesis would be rejected and that the course would be shown to have a positive influence.

H_0 = Students' attitudes toward science and interest in science do not change from beginning to end of the semester.

H_a = Students' attitudes toward science and interest in science increase from beginning to end of the semester.

Question four: Science Methods Course Contribution to Participants' Interest in Teaching Science

To determine the influence of science methods course on the development of motivation to teach science, two regression analyses were originally proposed, one predicting student *interest in teaching science* (Question 9), the other predicting *choice to*

teach science (Question 10), from the Science Teaching Survey II (See Appendix F). However, when presented with the choice of teaching in a classroom the frequency for *choice to teach science* indicated that only four participants out of 53 did not choose to teach science. This disparity in numbers violates the assumptions for multiple linear regression analysis. Therefore, these four participants are described on the variables that are highly correlated with interest in teaching science.

For interest in teaching science, a correlation matrix was first computed to explore interconnections among variables to choose the best predictors. The independent variables included: (a) initial interest in science and (b) course variables (various ratings of the science methods course taken from the Course Rating Survey). It was predicted that the following null hypothesis would be rejected and that the course would add positively to initial *interest in science* in predicting *interest in teaching science*.

H_0= Ratings of the science methods course do not predict students' interest in teaching science.

H_a = Ratings of the science methods course predict students' interest in teaching science. All participants signed informed consent letters allowing their data to be used in this research. See Appendix H for the informed consent letters.

Here is a summary of the instruments and the schedule for administration.

The name of survey	Survey administration
Science Background Experiences Survey	End of the semester
Science Teaching Survey I	Pretest (beginning of the course)
Activity Rating Survey	Weekly throughout to semester
Science Teaching Survey II	Posttest (end of the course)
Course Rating Survey	Final session of the course

CHAPTER 4

RESULTS

The purpose of this chapter is to present the results of the research surveys used to examine: the role of science related background experiences on interest in science, connections between the level of inquiry and motivational quality of science methods course activities, and effects of the course on preservice teachers' attitudes toward science and teaching science. This chapter is organized to answer the following research questions:

1. What science background experiences (school, home, and informal education) do participantshave, and how do those experiences affect initial interest in science?
2. Among the hands-on activities in the methods course, is there a relationship between level of inquiry of the activity and the motivational quality (*interesting*, *fun*, and *learning*) of the activity?
3. Does the course affect preservice teachers' interest and attitude toward science?
4. What aspects of the course contribute to preservice teachers' interest in teaching science and choice to teach science?

What Science Background Experiences Do Students Have, and How Do Those Experiences Affect Initial Interest in Science?

The first question has two parts. The first part deals with descriptions of students' background experiences in science and includes: best science course experiences,

informal science experiences, and parental support. The second part analyzes science background variables that predict initial interest in science.

Analysis of Participants' Background Science Experiences

The first part, description and comparisons of background experiences of preservice elementary teachers' background science experiences were analyzed *in* two main categories: school and non-school science experiences. The school science experiences included elementary science course experiences and best science course experiences, identified as typical or non-typical, from junior high school to college/university. The non-school science experiences included: parental support, school field trips, informal science activities and play experiences related to science. Students' background science experiences are described and compared based on their initial interest in science, i.e. high interest and low interest students are described separately. High interest students are those who gave a response of 4 or 5, and low interest students are those who gave a negative or neutral response (1-3) on the following question on the initial survey:

What is your overall interest in science?

(Low) 1 2 3 4 5 (High)

A frequency count revealed that 22 students (42 %) had low interest in science and 31 (58 %) students had high interest in science. Organized by low versus high interest in science, Tables 1-10 present school science course experiences and Table 11 presents non-school science activities.

Elementary School Science Experiences.

To examine elementary school science experiences, participants were asked two main questions:

How would you describe your general elementary school science experience?

I enjoyed science in elementary school.

Strongly disagree 1 2 3 4 5 strongly agree

If you honestly can't remember anything, check here and skip the rest of this question:

___ cannot remember anything about elementary school science.

If the participants could remember anything about elementary school science they were asked to describe their best year in elementary school science on the following dimensions: fun, interesting, hands-on, level of students input, how much they learned, and emphasis on understanding (See Appendix A). The rationale for asking students to describe their best year or best science course experiences was to determine whether they had at least one good experience.

A frequency count of students who could and could not remember elementary school science, organized by low and high interest in science, is shown in Table 1.

Table 1

Frequencies of Low and High Interest Students Who Do and Do Not Remember Elementary School Science

	Low Interest in Science (N = 22)	High Interest in Science (N = 31)
Can remember elementary school science	8 (36.4%)	23 (74.2%)
Cannot remember elementary school science	14 (63.6%)	8 (25.8%)

Remembering about elementary school science, coded dichotomously (0 = cannot remember anything; 1 = can remember about elementary school science), was analyzed to compare low and high interest students using an *independent samples t-test*. There was significant difference between the high interest group (M = .74; SD =.44) and low interest group (M = .36; SD = .49), t (51) = 2.9, $p < .005$).

The means for *overall enjoyment* and description of best year in elementary school science are based on a 5-point scale, with 5 being the most positive response. The following table shows ratings of the elementary school experiences of those 74% of the high interest group and 36% of the low interest group who could remember science in elementary school.

Table 2

Means and Standard Deviations of Best Year Experiences in Elementary School Science

	Low interest			High interest		
	N	Mean	SD	N	Mean	SD
Enjoyment of elementary school science	8	3.75	.71	23	3.78	.95
Best year in elementary school science						
Fun	8	3.78	.99	23	3.95	1.04
Interesting	8	3.87	.99	23	3.95	1.14
Hands-on	7	3.28	1.11	23	3.39	1.33
Student input	8	3.00	1.06	23	2.91	1.27
Learning	8	4.00	.53	23	3.69	.97
Emphasis on understanding	8	2.75	1.16	23	2.86	1.14

The means indicated that for those who could remember elementary school science, both high interest and low interest groups had slightly above average enjoyment of science in elementary school (Mean = 3.78). The description of best year in elementary school science revealed that the means for f*un*, *interesting*, *hands-on*, and *learning* were above neutral. However, the means for *student input* and *understanding emphasis* were neutral or lower than neutral. The means indicate that even though there were some good experiences, science was teacher-dominated, with memorization rather than understanding emphasized. Because few low interest students remembered science and

therefore answered the questions, as shown in Table 2, the high interest and low interest sample sizes were quite different, precluding statistical comparisons.

The Best Science Course Experiences in Middle/Junior High School

Preservice elementary teachers' best middle/junior high school science experiences were also analyzed. The rationale for asking students to describe their best science course experience was to determine the qualities of their best experience, assuming that having at least one good experience might affect interest. Table 3 reports the ratings of the participants on the following dimensions: *enjoyment*, *fun, interest, hands-on*, *student input, learning,* and *understanding emphasis*. All the ratings were on a 5-point scale, with 5 being the most positive experiences.

Table 3

Means and Standard Deviations of Preservice Teachers' Best Science Course in the Middle/Junior High School

	Low interest			High interest		
	N	Mean	SD	N	Mean	SD
Enjoyment of course	17	3.88	.69	30	3.66	.99
Best science course descriptors						
Fun	19	3.78	.91	30	3.70	1.14
Interesting	19	3.73	1.04	30	3.70	1.26
Hands-on	19	3.10	1.24	30	3.43	1.25
Student input	19	2.63	.95	30	3.30	1.17
Learning	19	3.84	.95	30	3.43	1.19
Understanding Emphasis	19	3.10	1.19	30	3.06	1.17

An analysis of independent samples t-test indicates that only *student input* in the science course is significantly different between low interest (mean = 2.63) and high interest group (mean = 3.30), t (47) = 2.07, p <.04). With the exception of the rating of student input by the low interest group, the ratings were a bit above neutral.

After rating their best science course on the six descriptors, participants were asked to: Describe how typical this was of their middle school science experiences and give any further comments. In order to analyze their responses, a 4-point scale was created ranging from negative and typical to positive and typical. On the Likert Scale ratings of the six course descriptors, there were 5 possible points each, totaling a most positive score of 30 points. If each descriptor had been assigned the lowest rating (1) the lowest possible rating was 6. The ratings on these dimensions were summed and combined with whether the participant said the course was typical as follows:

1. Typical Negative: 6 - 13 points on the best course descriptors with the response that this experience was typical;

2. Typical Neutral: 14 – 21 points on the best course descriptors with the response that this experience was typical;

3. Not Typical Positive: 22 - 30 points on the best course descriptors with the response that this experience was not typical (presumably meaning that the other courses were not as positive);

4. Typical positive: 22 - 30 points on the best course descriptors with the response that this experience was typical.

These categories show in order the quality of experiences the students had in middle school from mainly negative to typically positive. The following table shows the frequencies of the low and high interest students in their middle school science experience on the above ratings. In this table, as in the following tables that report quality of science experience, the number of subjects does not add up to the total number of participants since some participants did not answer whether their experiences were typical.

Table 4

Frequencies of Quality of Science Experience of Low and High Interest Students in Middle/Junior High School

Type of experience	Low Interest (N = 13)	High Interest (N = 29)
Typical Negative	3 (23%)	2 (7%)
Typical Neutral	3 (23%)	17 (59%)
Not Typical Positive	3 (23%)	4 (14%)
Typical Positive	4 (31%)	6 (20%)

For the low interest group there was not one dominant type of experience in middle school. For the high interest group, the dominant type of experiences was neutral (59%) with that experience being typical.

Best Science Course in the High School

Questions asked about high school experiences concerned: favorite science subject, description of best science class, and number of AP classes taken. These findings are presented in Table 5.

Table 5

Frequency of Science Courses Taken in High School by Subject and Number of Advanced Placement Courses Taken

The Most Popular Science Course		Low interest		High interest	
		N	%	N	%
	Biology	8	36	13	42
	Chemistry	6	27	4	13
	Physics	3	13	3	9
	Anatomy	2	9	7	22
	Others	2	9	2	6
Advanced Placement Courses taken					
	None	20	91	27	87
	One to five	2	9	4	13

In answer to *best science course in high school* for both low and high interest groups, biology, chemistry, and physics appear to be the most popular science courses. Only about 10% of the participants took advanced placement courses in high school. As with earlier questions, participants were asked to describe their best science course on the same dimensions. Table 6 presents means and standard deviations by interest level.

Table 6

Means and Standard Deviations of Preservice Teachers' Best Science Course in the High School

	Low interest			High interest		
	N	Mean	SD	N	Mean	SD
Enjoyment of the course	22	4.04	.95	31	4.38	.84
Best science course descriptors						
Fun	22	3.77	1.19	31	4.35	.87
Interesting	22	3.81	1.22	31	4.03	1.19
Hands-on	20	4.00	.917	31	3.87	1.38
Student input	22	3.09	1.30	31	3.45	1.36
Learning	21	4.14	1.15	31	4.06	.99
Understanding Emphasis	22	3.27	1.35	31	3.54	1.23

Independent samples t-test found no significant difference on enjoyment or on any of the six of the descriptors. The means for enjoyment and the course descriptors indicated that for both groups the course was enjoyable and above neutral on all descriptors.

In order to find out whether the best science course was typical of their high school science experience, students were asked to: Describe how typical this was of their high school science experiences and give any further comments. Their response was analyzed in the same scale as described in middle school science experiences, i.e. a range

from mainly negative to typical positive (see page 42-43). The following table shows the frequencies of the low and high interest students on their high school science experiences.

Table 7

Frequencies of Quality of Science Experience of Low and High Interest Students in High School

Type of experience	Low Interest (N = 18)	High Interest (N = 31)
Typical Negative	4 (22%)	4 (13%)
Typical Neutral	3 (17%)	5 (16%)
Not Typical Positive	6 (33%)	11 (35.5%)
Typical Positive	5 (28%)	11 (35.5%)

The frequency count indicated that in high school, low and high interest students had rather similar experiences.

To describe preservice teachers' science fair participation in school, they were asked the following question:

> What experiences have you had as a student participating in science fairs?
>
> ____none ____one year ____ more than one year
>
> Comment about your experiences and whether they were at the elementary, middle, or high school level. Also comment on whether you had experience at the regional or state level.

The following table presents the frequency of science fair participation by interest level.

Table 8

Frequencies and Percentages of Science Fair Project Participation in Schools

Frequency of Science Fair Project Participation		Low interest		High interest	
		N	%	N	%
Overall participation	None	5	24	13	42
	One year	10	47	8	26
	More than one year	6	28	10	32
Elementary	None	13	62	21	72
	Participated	8	38	8	28
Middle /Secondary	None	11	52	18	62
	Participated	10	48	11	38
Regional /state level	None	19	90	26	90
	Participated	2	10	3	10

The overall frequency of science fair participation indicates that for both low and high interest students, about 30% of students participated in science fair project more than one year. Science fair participation in elementary and middle or secondary school revealed that low interest students had slightly more science participation than high interest students. Regional or state level science fair participations are equal for both groups, at 10%.

Means and Standard Deviations of the Best Science Course in College/university

To describe college/university science course experiences of preservice elementary teachers were told to do following: Put a check mark by each college/

university science course taken and rank the two courses you liked best in order, with number one being the course you liked best. A frequency count on the best science course is presented in Table 9.

Table 9

Frequencies and Percentages of the Science Subject Mentioned as "Best Science Course" Taken In College/University for Low and High Interest Students

The Course Subjects Rated as Best	Low interest		High interest	
	N	%	N	%
Biology	6	28	14	46
Geology	7	33	4	13
Astronomy	2	9	7	23
Physics	2	9	0	0
Chemistry	0	0	2	6
Anatomy	1	4	0	0
Others	2	9	2	6
None of the courses	0	0	1	4

Biology was the most popular course among high interest students and geology was the most popular course among the low interest students. The top three best science courses were almost the same for both low and interest groups. The top three best science courses for the low interest groups were biology, geology, and a tie between astronomy and physics. The top three best science courses for high interest group were biology,

astronomy, and geology. One of the students in the high interest group did not like any of the courses he/she took in college/university.

To determine the qualities of the best science experience of the low and high interest students in college/university, means and standard deviations were computed and independent samples t-tests compared low and high interest students. Table 10 reports the ratings of the participants on the following dimensions: *enjoyment of the best science course, fun, interest, hands-on, student input, learning, understanding emphasis*.

Table 10

Means and Standard Deviations of Preservice Teachers' Best Science Course in the College/University

	Low Interest			High Interest		
	N	Mean	SD	N	Mean	SD
Enjoyment of the course	21	3.33	1.27	30	3.50	1.30
Best science course descriptors						
Fun	22	3.00	1.27	30	3.20	1.34
Interesting	22	3.00	1.41	30	3.23	1.54
Hands-on	22	3.31	1.24	30	2.73	1.50
Student input	22	2.59	1.09	30	2.80	1.51
Learning	22	3.45	1.05	30	3.23	1.35
Understanding emphasis	22	2.95	1.29	30	2.76	1.38

There were no significant difference between high interest and low interest participants on any of the variables. In general, the means fall around neutral (3) for both groups of students.

After rating their best science course, participants were asked to describe how typical this was of their college/university courses. Their responses were analyzed in the same scale as was previously described (see page 42-43). The following table shows the frequencies of the low and high interest students on their college/university science experiences.

Table 11

Frequencies and Percentages of Quality of Science Experiences of Low and High Interest Students in College/University

Types of experiences	Low Interest (N = 16)	High Interest (N = 28)
Typical Negative	4 (25%)	10 (36%)
Typical Neutral	7 (44%)	9 (32%)
Not Typical Positive	3 (19%)	6 (21%)
Typical Positive	2 (12%)	3 (11%)

The frequency count revealed that science experiences are similar for low and high interest students and that most of them had neutral to negative science experiences in college/university. For both groups, about 30% had at least one positive experience in college/university science courses, though for approximately 20% this positive experience was not typical.

Non-school Science Activities and Experiences

To further investigate the difference between low and high interest students, several additional questions were asked on the survey. The results of the following three questions are found in Table 12. Again, low and high interest participants are compared.

I felt my parents were supportive in establishing an interest in science in me (examples: purchased dissecting kits or telescope, pointed out aspects of nature, went on trips to museum or nature walks, initiated discussion).

Strongly disagree 1 2 3 4 5 Strongly agree

School field trips were an important part of my science experience.

Strongly disagree 1 2 3 4 5 Strongly agree

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

Strongly disagree 1 2 3 4 5 Strongly agree

Table 12

Means and Standard Deviations of Rating of Outside of Classroom Science Influences

	Low Interest			High Interest		
	N	Mean	SD	N	Mean	SD
Parents were supportive	22	3.22	1.37	31	3.61	1.35
School field trips were important	22	3.18	1.25	31	3.41	1.25
Non-school experiences more important than science classes	22	3.45	1.43	31	4.03	1.19

Independent samples t-tests did not show differences on the ratings of outside of classroom influences.

In addition to the above questions, participants were asked the following question about their play and informal learning experiences:

> Following is a list of activities and experiences. Put a √ before the ones that were part of your childhood/youth and a second √ before the ones that were an important part of your childhood/youth. Add any other childhood/youth activities to the bottom. Put a star after any of these activities that you enjoy now.

The list of activities is found in Appendix A. The list was made up of (a) activities mentioned by scientists and science majors in previous studies (The Bayer Corporation/ National Science Foundation, 1988; Jarrett & Burnley, in press; Jarrett & Burnley, 2003), (b) activities with obvious connections to science or engineering, and (c) non-science items as fillers. For purposes of this study, the following activities were considered science related: LEGO bricks or robotics, computer programming, building with wooden blocks, taking things apart, TV nature or science programs, chemistry kit, microscope or telescope, planting in a garden, care of animals, care of house plants, mixing up "kitchen chemicals", exploring the outdoors, playing in sand, visiting a science museum, visiting zoos/nature centers/aquaria, playing with doctor/nurse kits, risky play (making explosive, etc.), making science collections, making models, camping, star gazing, snorkeling or SCUBA diving, beach combing, and science club.

The frequencies and percentages of participants who checked the above science-related experiences at least once are given in Table 13. They are listed in order from most frequently checked to least frequently checked.

Table 13

Frequencies and Percentages of Non-School Important Childhood/Youth Science Activities

Non-school science Activities	N	%
Visit to zoos, nature centers, aquaria	48	92.3
Playing in sand	46	88.5
LEGO bricks or LEGO robotics	43	82.7
Exploring the outdoors	40	76.9
Care of animals	39	75
Building with wooden blocks	37	71.2
Visit to science museum	36	69.2
Play with doctor / nurse kits	36	69.2
TV nature or science programs	34	65.4
Planting in the garden	33	63.5
Taking things apart	32	61.5
Making science collections	30	57.7
Camping	27	51.9
Star gazing	27	51.9
Beach combing	27	51.9
Microscope or telescope	25	48.1
Care of house plants	25	48
Mixing up “kitchen chemicals”	22	42.3
Risky play (making explosive, etc.)	14	26.9
Making models (e.g airplanes, boats)	13	25
Snorkeling or SCUBA diving	11	21.2
Chemistry kit	9	17.3
Computer programming	6	11.5
Science club	6	11.5

The above science related activities that had at least one check were tallied and formed the variable, *all science activities*. The science related activities with two checks were tallied and formed the variable, i*mportant childhood/youth science activities*. A third variable included all the science activities checked, with those checked twice weighted double. This variable, called *weighted all activities,* was calculated by tallying all the checkmarks for science related activities. Table 14 shows descriptive statistics for these three variables.

Table 14

Means and Standard Deviations of Non-Classroom Influences on Interest in Science

	Low Interest			High Interest		
	N	Mean	SD	N	Mean	SD
Important childhood/youth science activities	22	2.91	2.11	31	6.87	4.38
All science activities	22	10.95	6.01	31	13.94	4.35
Weighted all science activities	22	13.86	7.31	31	20.81	7.82

Independent samples t-tests found that there were significant differences between low and high interest groups on *important childhood/youth science activities, t* (51) = 3.92, *p* <.001, *all science activities*, t (51) = 2.09, p <. 05, and *weighted all science activities*, *t* (51) = 3.27, *p* <.002. Parametric tests, such as t-tests assume that both variables should be measured on an interval or a ratio scale, but it is considered robust for ordinal measures. Also, both variables should be normally distributed. The variables*, important childhood/youth science activities, all science related activities,* and *weighted*

all science activities, are counts for the number of activities, and a statistics advisor suggested that the count data violates both assumptions. Therefore, informal science experiences and activities were recoded into four categories with the highest and lowest number of activities mentioned divided into equal intervals. *Important childhood/youth science activities* were recoded (1 = fewer than four activities; 2 = five to nine activities; 3 = ten to 14 activities; 4 = 15 to 19 activities). The *all science activities* were recoded (1 = fewer than six; 2 = 7 to 13; 3 = 14 to 20, 4 = 21 to 27). The *weighted all science activities* variable was recoded (1= 0 to 9; 2 = 10 to 19; 3 = 20 to 29; 4 = 30 to 39). Using the recoded variables only, high and low interest participants were significantly different on two of the above variables, *recoded important childhood/youth science activities,* t (51) = 3.59, p <.001 and *recoded weighted all science activities*, t (51) = 2.83, p <.01.

Science Background Experiences as Predictors of Initial Interest in Science

To determine the influence of informal experiences and schooling in predicting interest in science, a regression analysis was computed with *interest in science* as the dependent variable. First, a Pearson Correlation matrix was calculated among *initial interest in science* and *background science* variables. Since Pearson Correlation involves parametric analysis, recoded activity variables are included. For information, the original activity variables based on counts and the recoded activity variables are all included in the correlation matrix below. See Table 15. Only the recoded variables are used in further analyses. The other independent variables in the correlation matrix are on a 5-point scale.

Table 15

Intercorrelations between Background Variables and Initial Interest in Science

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Interest In Science (5-Point Scale)	-												
2. High Versus Low Interest In Science	.87**	-											
3. Remember Anything About Elementary School Science	.37*	.38**	-										
4. Enjoyment of Best Middle School Science Course	-.10	-.12	-.03	-									
5. Enjoyment of Best High School Science Course	.25	.19	.10	.05	-								
6. Enjoyment of Best College/Univ. Science Course	.19	.06	-.06	.09	.23	-							
7. Parental Support	.15	.14	.31*	.34*	.19	.01	-						
8. Important Science Activities	.36**	.48**	.43**	.16	.11	-.01	.23	-					
9. All Science Activities	.27	.28*	.33*	.38**	.24	.12	.43**	.56**	-				
10. Weighted All Science Activities	.35*	.42**	.42**	.32*	.21	.07	.39**	.85**	.91**	-			
11. Recoded Important Childhood/youth Science Activities	.32*	.45**	.35**	.23	.15	-.04	.18	.95**	.57**	.83**	-		
12. Recoded All Science Activities	.22	.23	.33*	.37*	.14	.12	.42**	.59**	.93**	.88**	.60**	-	
13. Recoded Weighted All Science Activities	.29*	.37**	.41**	.34*	.13	.05	.41**	.82**	.86**	.95**	.80**	.87**	-

$p^* < 0.05$; $p^{**} < 0.01$ level

Pearson correlation analyses revealed a significant linear relationship between preservice teachers' ratings on *interest in science, remembering elementary school science*, *recoded important childhood/youth science activities, and recoded weighted all science activities.* There is also a significant correlation between *high versus low interest in science* and the same variables. Although there is not a significant correlation between *initial interest in science* and *parental support*, *parental support* is significantly correlated with *recoded all science activities*, *recoded weighted all science activities*, and *remembering elementary school science*, suggesting indirect links among parent influence, informal experiences, and quality of elementary school experience.

To experiment with predictors of preservice elementary teachers' interest in science, a series of step-wise multiple regression analyses was computed using both *interest in science (five point scale)* and *high versus low interest in science* as dependent variables. In the selection of independent variables, the background experience variables that were significantly correlated with the dependent variables were put into the regression analyses. In the first regression analysis, the dependent variable was *initial interest in science* (5-point scale). In the second one, *high versus low initial interest in science* was the dependent variable. When a dichotomous variable is the dependent variable, a regression analysis is essentially the same as a discriminate analysis. However, it can be analyzed and interpreted as regression analysis. Independent variables considered in the equations were *remembering elementary school science*, *important childhood/youth science activities, all science activities*, and *weighted all science activities,* recoded into four categories. The resulting step-wise regression analyses for *initial interest in science* are summarized in Tables 16 -17.

Table 16

Step-wise Regression Analysis Predicting Initial Interest in Science (5-point scale)

Variable	B	SE B	β
Remember anything about elementary school science	.74	.26	.37*

p* < .05

Note: R = .37; R^2 = .14

Table 17

Step-wise Regression Analysis Predicting High or Low Initial Interest in Science

Variable	B	SE B	β
Recoded important childhood/youth Science activities	.26	.07	.45*

p* < .05

Note: R = .45; R^2 = .20

Remembering anything about elementary school science and *important childhood/youth science activities* were significantly associated with preservice teachers' initial interest in science. In the first regression equation, *remembering about elementary school* explained 14% of the variance. In the second analysis, r*ecoded important childhood/youth science activities* explained around 20% of the variance in preservice teachers with high versus low initial interest in science. This result indicates that high interest in science is related to having memorable elementary school science experiences and doing non-school science related activities. The null hypothesis that background science experiences do not predict interest in science is rejected. That both variables did

not enter the same equation is a function of the high correlation between remembering anything about elementary school science and the science activity variables.

Among the Hands-on Activities, Is There a Relationship between
Level Of Inquiry and Motivational Quality of the Activity?

Over the semester, students participated in 73 hands-on activities at various levels of inquiry, as well as a science fair project for which some preparation was done outside of class (See Appendix H). At the end of each class period, students rated the activities on the following dimensions using a five-point scale: fun, interest, and learning. The activities were categorized according to level of inquiry:

Level 0 = hands-on activities or demonstrations that do not appear to represent any formal form of inquiry level, i.e. students do not pose questions, collect data and answer questions;

Level 1= predefined question, method, and answer;

Level 2 = predefined question, but method and answer are left open;

Level 3 = question, method and answer are left open.

There were 22 activities in Level 0, 29 in Level 1, 16 in Level 2, and six in Level 3. To determine the relationship between *level of inquiry* of the activity and the motivational quality (*interesting*, *fun*, and *learning*) of the activity, separate ANOVA's with repeated measures were computed with *level of inquiry* as the repeated variable and the *interest*, *fun*, and *learning* value of the activities as the dependent variables. The means were computed from actual data under each level by using SPSS. In Table 17, means and standard deviations of student ratings on *interest*, *fun*, and *learning* for different *levels of inquiry* are summarized.

Table 18

The Means and Standard Deviations of Student Ratings on Interest, Fun, and Learning for Different Levels of Inquiry

Level	N	Interest		Fun		Learning	
		Mean	SD	Mean	SD	Mean	SD
0	53	3.99	.51	3.97	.50	3.84	.58
1	53	4.19	.51	3.99	.53	4.02	.49
2	53	4.40	.43	4.29	.45	4.25	.43
3	53	4.57	.30	4.52	.34	4.52	.38

Significant differences by *level of inquiry* were found for all three analyses: *interest*, F (3, 156) = 43.00, p<.001; *fun*, F (3, 156) = 43.16, p<.001; and *learning*, F (3, 156) = 34.74, p<.001. Since the ANOVA results were significant, post-hoc analyses were required. However, one of the limitations of SPSS is difficulty in performing post-hoc analysis for within-subjects factors. One solution to this problem is to do a protected dependent t-test. To conduct the protected t-test, level 0, level 1, level 2, level 3 were compared by using paired samples t-tests. Conducting six t-tests inflates the Type 1 error rate so the significance level of .008 (.05/6) instead of .05 (Cronk, 2004) was used. Follow up protected t-tests indicated that on *fun* there was no difference between the means of level 0 and level 1. However, the rest of the pair-wise comparisons for all levels of *interest*, *fun*, and *learning* showed differences, p <.008. The null hypothesis that there is no relationship between the level of inquiry of the activities and the ratings of the activities on *fun*, *interest*, and *learning* is rejected. Activities higher in level of inquiry

were considered more fun, more interesting and higher in learning. A caveat in interpretation is that level of inquiry for the activities (Appendix E) was based on instructor intention and instructions given. Participants may have engaged in the activities at a higher or lower level of inquiry than was actually planned for.

Does the course affect participants' interest and attitudes toward science?

This question was answered by comparing pretest and posttest scores on the Science Teaching Surveys (I and II) that were administered at the beginning and end of the semester. Table 19 shows the means and standard deviations of the questions common to the two surveys.

Table 19

Comparison between Pre/Posttest on Paired Items on the Science Teaching Surveys I &II

		Pretest		Posttest			
	N	Mean	SD	Mean	SD	t	p
Q.1: Science is fun to study	52	4.19	.77	4.38	.60	1.65	.105
Q.2: Personal satisfaction in solving problem	52	3.93	.71	4.44	.61	4.40	.001
Q.3: Ability to think scientifically	51	3.80	.69	4.37	.69	5.04	.001
Q.4: Science fun subject to teach	52	3.75	.74	4.37	.56	5.26	.001
Q.5: Emphasis on science process skills	52	4.73	.49	4.26	.63	-4.42	.001
Q.6: Allow children to conduct their own experiments	52	4.07	.71	4.42	.69	2.64	.011
Q.7: Overall interest in science	52	3.67	1.00	4.19	.65	3.90	.001
Q.8: Feelings about "Science is Fun"	52	4.19	.84	4.40	.60	1.85	.070

To examine the effect of the course on student feelings, attitudes, and interest in science, paired samples t-tests were calculated on the eight paired items in the Science Teaching Surveys I and II. These eight items were not additive, so paired samples t-tests were computed for the separate eight paired items in pre and posttest. Each was scored on a 1-5 scale with 5 being the most positive. Students were significantly more positive at the end of the course on Question 2 (solving own problems, $p<.001$), Question 3 (ability to think scientifically, $p<.001$), Question 4 (fun to teach, $p<.001$), Question 6 (allow students to conduct own experiments, $p<.01$), and Question 7 (interest in science, $p<.001$). On Question 5 concerning emphasis on process skills, the students became significantly less positive, $p < .001$. The null hypotheses that the science methods course does not change students' attitudes and interest from beginning to end of the semester is rejected for the above items. The increase on Questions 1 and 8 concerning science being fun approached significance ($p = .10$).

What Aspects of the Course Contribute to Preservice Teachers' Interest in Teaching Science and Choice to Teach Science?

An implicit goal of science methods courses is to instill in their students a desire to teach science. Two questions on the end of course survey were designed to measure the desire to teach science. The first question was Question 9 on Science Teaching Survey II (See Appendix F):

What is your overall interest in teaching science?

(Low) 1 - 2 - 3 - 4 - 5 (High)

The second question involved a forced choice on whether one would choose to teach science, given the offer of two otherwise similar teaching positions (See Question 10 on the Science Teaching Survey II in Appendix F for the scenario).

Interest in Teaching Science

It was assumed that desire to teach science at the end of the course was a combination of initial interest in science and the effect of the course. Therefore, to answer this research question, initial interest in science, interest in teaching science and various aspects of the science methods course from the Course Rating Survey (Appendix G) were analyzed. Comparison between the two sections of the course, using independent samples t-tests on all items on the Course Rating Survey, indicate that there were no differences between the two sections. Table 20 includes the means and standard deviations of answers on the Course Rating Survey and Table 21 presents the intercorrelations among the above variables.

Table 20

Descriptive Statistics for Relevant Aspects of the Course

Course Aspects	N	Mean	SD
Enjoyed methods course	51	4.43	.57
Fun	52	4.38	.56
Interesting	51	4.39	.66
Hands-on	51	4.82	.38
Much student input	51	4.51	.64
Learned a lot	51	4.24	.65
Understanding emphasis	51	4.43	.67
Experienced inquiry learning	51	4.69	.51
Learned a lot about teaching through inquiry	52	4.52	.61
Feel prepared to teach elementary school science as inquiry	52	4.13	.68
Reading assignments were useful for understanding inquiry teaching	52	3.85	.89
Field placement assignments with children were useful	51	4.29	.85
Liked the way the first placement teacher taught science	52	2.07	1.22
Got to teach a lot of science in the first placement	52	2.15	1.03
Liked the way the second placement teacher taught science	52	2.57	1.30
Got to teach a lot of science in the second placement	52	3.03	1.23

Table 21

Intercorrelations between Interest in Teaching Science, Initial Interest in Science, and Methods Course Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. IST	1																
2. IS	.40**	1															
3. ESMC	.38**	.20	1														
4. FMC	.44**	.08	.69**	1													
5. IMC	.15	.02	.69**	.64**	1												
6. HMC	-.06	.00	.27	.23	.35*	1											
7. SIMC	.32*	.21	.43**	.48**	.50**	.45**	1										
8. LMC	.29*	.06	.57**	.61**	.42**	.24	.42**	1									
9. UEMC	.13	.01	.22	.38**	.33*	.37**	.12	.31*	1								
10.EILMC	.22	-.13	.27	.36**	.31*	.12	.25	.34*	.11	1							
11.LTIMC	.23	-.03	.44**	.43**	.36**	.32*	.26	.38**	.21	.60**	1						
12.FPTTI	.28*	-.12	.50**	.47**	.40**	.39**	.46**	.41**	.17	.35*	.53**	1					
13.URAUIT	.19	.11	.28*	.27*	.20	.14	.17	.23	-.01	.28*	.54**	.51**	1				
14.UFAC	.02	-.12	.37**	.41**	.49**	.40**	.26	.23	.08	.17	.46**	.47**	.21	1			
15.ETFP	.24	.13	-.00	-.01	-.07	-.07	.15	.09	.07	-.27	-.16	-.03	.08	-.18	1		
16.FTFP	.02	-.19	-.16	-.06	-.13	-.08	.16	-.01	-.00	-.18	-.06	.10	.11	-.20	.58**	1	
17.ETSP	-.10	.09	-.13	-.22	-.16	-.08	-.00	-.13	.15	-.48**	-.21	-.22	-.05	-.23	.67**	.39**	1
18.FTSP	.00	.12	.03	-.19	.00	-.02	.22	-.15	-.09	-.13	-.00	.04	.02	-.03	.46**	.40**	.55**

*p<.05; **p<.01

NOTE: 1. ITS = Interest in Science Teaching; 2. IS = Interest in Science; 3. ESMC = Enjoyment of Science Methods Course; 4. FMC = Fun in Methods Course; 5. IMC = Interest in Methods Course; 6. HMC = Hands-on Methods Course; 7. SIMC = Student Input in Methods Course; 8. LMC = Learning in Methods Course; 9. UEMC = Understanding Emphasis in Methods Course; 10. EILMC = Experiencing Inquiry in Learning in the Method Course; 11. LTIMC = Learning to Teach through Inquiry in Methods Course; 12. FPTTI = Feeling Prepared to Teach Through Inquiry; 13. URAUIT = Usefulness of Reading Assignments to Understand Inquiry Teaching; 14. UFAC = Usefulness of Field Assignments with Children; 15. ETFP = Evaluation of Teacher in First Placement; 16. FTFP = Frequency of Teaching Opportunity in First Placement; 17. ETSP= Evaluation of Teacher in Second Placement; 18. FTSP = Frequency of Teaching in Second Placement.

As indicated on Table 21. across the descriptors of the methods course, a high rating of *interest in teaching science* was significantly correlated with the following aspects of the methods course: *enjoyment*, *fun*, *students' input*, *learning, feeling prepared to teach science through inquiry*, and also *initial interest in science*. *Learning to teach through inquiry in the methods course* is significantly intercorrelated with: *enjoyment, fun, interest, hands-on, learning,* and *experiencing inquiry learning in the methods course*.

Feeling prepared to teach through inquiry in the methods course was significantly correlated with the following many aspects of the science methods course: *enjoyment, fun, interest, hands-on, student input, learning, experiencing inquiry,* and *learning to teach through inquiry in the methods course*.

Usefulness of reading assignments in understanding inquiry teaching was significantly related to following aspects of the science methods course: *experiencing inquiry learning*, *learning to teach through inquiry* and *feeling prepared to teach through inquiry*.

Usefulness of field assignments with children (discovery tubs and hands-on learning centers) was significantly correlated to *learning to teach through inquiry* (in the methods course), and *feeling prepared to teach through inquiry* at the end of the course However, preservice teachers' rating of their field placement experiences in terms of *the way teachers taught science* and *the frequency of their teaching experiences* were neither related to feeling prepared to teach inquiry nor interest in teaching science. Also, participants' ratings of the ways teachers taught science in the first and second placements were negatively correlated with preservice teachers' feeling about being prepared to teach science.

To investigate the best predictors of interest in teaching science, step-wise regression analyses were computed. The variables that were significantly correlated with interest in teaching science were included in the regression analyses to determine which variables significantly predicted *interest in teaching science*. The independent variables and the dependent variable, *interest in teaching science*, are all on 5-point scales with 5 as the highest response. The results of the regression analysis predicting the most variance in interest in teaching science are found in the following table.

Table 22

Regression Analysis for Preservice Teachers' Interest in Teaching Science

Variable	*B*	*SE B*	β
Fun in Science Methods Course	.49	.14	.41**
Initial Interest in Science (five point scale)	.26	.08	.38*

p* <.002; p** < .001

Note: R = .58; R^2 = .34

The regression analysis found that *fun in method course* and *initial interest in science* were significantly associated with preservice teachers' interest in teaching science. These variables explained 34% of the variance. The best predictor of interest in teaching science was doing fun activities in the methods course followed by *initial interest in science*. The null hypothesis of no association between students' interest in teaching science and the science methods course is rejected.

Choice to Teach Science

To measure preservice teachers' motivation to teach science in elementary school, they were asked on the Science Teaching Survey II which teaching position they would

choose, when they are ready to start teaching, given these factors: there are two schools which are equal in terms of many aspects; one position includes science teaching; and the other one is departmentalized and does not include science teaching. A step-wise regression analysis was computed for *choice to teach science* (taking a position which includes teaching science). The best predictors for *choice to teach science* were *all science activities*, *fun in the methods course*, and recoded *initial interest in science*. However, a descriptive analysis indicated that only four students out of 53 chose not to teach science, i.e., did not choose the position that included science teaching. Therefore, the regression analysis was not considered valid. Instead, the four preservice teachers who said they would not choose to teach science are described in terms of the above variables. Descriptive statistics for these four of preservice teachers indicated the following: three of them do not remember anything about their elementary school experiences, each double checked only one science-related activity in his/her childhood/youth as "important," all four were in the low science interest group of students, and for *fun* in the methods course, one of them rated the methods course a neutral (score of 3) and the rest rated course as rather fun (a score of 4). The other 18 students with low initial interest in science, including the 10 of these who could not remember elementary school, said they would choose the science position.

Summary

Findings from the surveys revealed that whether participants could remember anything about their best elementary school science course experiences was the main difference between the school experiences of those with low versus high interest in science. Other formal school science course experiences, from middle school to

university, seem to be similar for preservice teachers who have high versus low interest in science. The main difference emerged from experiencing or not experiencing science related activities as an important part of their childhood/youth, which was related to parental support. Regression analysis indicates that having memorable experiences from elementary school years and doing important science related activities in childhood/youth were the best predictors of *initial interest in science*.

Analysis of daily ratings of each hands-on activity on motivational qualities (*fun*, *interest*, and *learning*) indicated that there were significant differences in motivational quality of the activities by level of inquiry. This result means participants found activities of higher inquiry level to be more fun, to be more interesting, and to promote more learning than those of lower levels.

Pre/post surveys indicated that participants increased in interest in science and a number of variables reflecting more positive feelings about science and science teaching. In addition, regression analysis indicated that the best predictors for *interest in teaching science* were experiencing *fun* activities in the science methods course followed by the interest participants brought to the course, *initial interest in science*.

CHAPTER 5

DISCUSSION

This chapter presents interpretations of results of this research, implications of findings, suggestions for further research, and strengths and weaknesses of the study. It is organized by research question.

What Science Background Experiences (School, Home, And Informal Education) Do Participants Have, and How Do those Experiences Affect Initial Interest in Science?

The background science experiences question has two parts. The first part discusses descriptive statistics of items on the Science Background Experiences Survey and compares students with high interest (ratings of 4 or 5) and low interest (moderate to low, ratings of 3, 2 or 1) interest on those items. The second part discusses predictions of how background experiences affect initial interest in science.

Participants' background science experiences

The analysis of background science experiences showed several important findings. An encouraging finding was that more than half of the preservice elementary teachers (58%) came to the science methods course with high interest in science. Only two school-related background variables distinguished between high and low interest groups. Students with high and low initial interest in science were significantly different on remembering about their elementary school science. Most of the low interest students could not remember anything about elementary school science, suggesting that their experiences were simply

not memorable. They may not have remembered because they did not have science, they had very little science, or their science experiences were uninteresting. According to Dewey (1916) and Piaget (1964/2003), children learn science by acting on objects and manipulating materials rather than by a process of being told or just reading from books. People tend to remember experiences that are fun, interesting, exciting, and new to them.

These results are similar to the findings of Jarrett (1999) with preservice teachers, Bayer Corporation (1998) with scientists, and Joyce and Frenga, (1999) with children. All these studies found relationships between the quality of elementary school science experiences and interest in science. Jarrett (1999) found that elementary school experience was the best predictor of preservice elementary teachers' interest in science. Survey research with scientists indicated that over half of the scientists surveyed became interested in science during their elementary school years (Bayer Corporation, 1998), and Joyce and Frenga (1999) found that by the end of elementary school most children developed the perception of whether they liked or disliked science based on their experiences in school and out of school.

Only one other school experience differentiated between students of high and low interest in science. High interest participants said that they had a greater degree of student input during middle school classes than did low interest participants. This finding would suggest that student input is important for developing interest in science. Students' input in their science courses means they are not passive recipients of scientific facts, concepts and principles in science class, but are active, both physically and mentally. This importance of student input is consistent with philosophers/child development theorists (Dewey, 1916; Piaget, 1964/2003) and the NSES (1996), who accepted the premise that

every student comes to the classroom with different background experiences, and discovery should start with students' curiosities, interests, and experiences that are salient motivators for learning. However, since multiple t-tests had been computed on the various qualities of experience variables, and student input is the only variable showing differences in middle/secondary or college, there is the possibility that this difference may have occurred by chance.

The comparisons of science courses taken from middle/secondary school through college/university indicated that there was not much difference among students by interest level. The dominant "best course" for both high interest and low interest students in both high school and university was biology. Both groups took few advanced placement courses and not many participated in science fairs. The ratings of "best courses" appeared to drop between middle/secondary and college/university. In middle/secondary over a third of the students' course ratings showed that they had a good experience that was typical of their coursework. However, at the university level only 11.5% gave similarly high ratings. In their ratings of their "best science course," neutral levels of *enjoyment* of the course corresponded to neutral ratings on course descriptors of *student input*, *hands-on*, and *understanding emphasis* suggesting that enjoyment decreased as students had less control over their learning, a situation typical of introductory lecture courses with cookbook-type labs.

Aside from remembering elementary school, what best differentiated between high and low interest students was involvement in non-school science activities, including the number of science activities experienced in early childhood and youth and the number of activities considered an important part of childhood. The most frequently

mentioned activities were visits to science museums, nature centers, zoos, and aquaria. Also mentioned frequently were home related activities such as care of animals, planting a garden, play with science kits, making science collections, taking things apart, playing with LEGO bricks and wooden blocks, and watching science programs on TV. Such experiences appear to be more important than formal science courses in distinguishing between high and low interest students. Autobiographical studies of eminent scientists (Kegan, 1989; Shepard, 1988; Tweney, 1989; Woodward, 1989) and research on university science professors (Jarrett & Burnley, 2007; Rowsey, 1997) indicate that out-of-school science activities have a strong influence on selecting science as a career. Also, research with children (Joyce & Farenga, 1999), research with preservice teachers (DeLaat & Watters, 1995; Sampson, 1992), and survey results (Falk, 2002; USA Today, 1994) indicate that informal science experiences are influential in learning and developing interest in science. These out-of-school science experiences are likely to be highly dependent on parental support and encouragement. In this study, this relationship is verified by finding correlations between the activity variables and parental support.

Effect of Background Science Experiences on Interest in Science

The regression analyses found that having memorable science in elementary school and doing non-school science activities were strongly associated with interest in science for preservice elementary teachers. These two variables did not emerge as predictors in the same regression equation because there was a high inter-correlation between remembering elementary school science and doing non-school science related activities. Both of these variables are strongly associated with parental support. This result suggests that parents have strong influences both on exposing their children to non-

school science activities and on choosing schools for their children, where science is an important subject and might be taught from the early years.

Implications

One of the implications of this research is that it is important for people to have memorable science experiences in elementary school and involvement in out-of- school science activities in order for them to develop interest in science. These findings have implications for parents, school systems, curriculum developers and teacher preparation programs. Parents should be aware of their own impact in promoting their children's interest in science by doing home-related activities such as experimenting with kitchen chemicals, looking at things under a microscope, taking care of plants or pets, playing with LEGO bricks or LEGO robotics, and making science collections. In order to increase parent awareness, schools can organize family science nights or family science festivals where parents, children and teachers do science activities together and where parents can obtain ideas for science activities they can do with their children using free or inexpensive materials.

Science related community facilities such as science museums, nature centers, zoos, and aquaria are valuable resources for parents and schools. Since such community resources are often expensive, it is important that schools provide field trip opportunities to these sites, increasing budgeted monies or finding corporate sponsors if necessary. These trips are particularly important for children whose parents are unable to afford frequent, expensive out-of-school science experiences for their children. However, not all field trips are expensive. Children can also learn from observing nature on the school yard.

School experiences can also include science clubs, classroom plants and pets, and classroom science museums. Participating in science clubs was the least frequent activity among participants. Schools can support or facilitate these activities by encouraging teachers who are interested in science to organize science clubs. Elementary schools should also be equipped with appropriate science equipment and materials, including LEGO bricks, microscopes, and measuring devices. Some schools have such materials in storage and unavailable to teachers. An answer to the school equipment problem may be to take inventory of specialized items and arrange a check-out system, perhaps from the media center. However, each classroom should have basic science equipment in the classroom (e.g. balances, microscopes, thermometers, magnifying glasses) so they can do ongoing investigations.

According to the preservice teachers' ratings of their "best course experience" and whether this was typical of their science courses, many middle and high school students do not have very positive science experiences. They generally rated their best course between 3 and 4 on a five point scale. For many, this course was better than the other courses, not typical of them. Only 11% took any advanced placement (AP) science classes, and only 10% participated in science fairs beyond their own school level. High school students with aspirations for teaching should be encouraged to take advanced placement classes and engage in their own research leading to science fair recognition. Middle and high school science curricula also should take into account teachers' enjoyment while teaching science. Science curricula should be designed in a way that provides guidelines for teachers without restricting their freedom and creativity.

Teachers' freedom to design their own curricula may lead to focus on students' questions, curiosities, interest and experiences.

The tendency for "high and typical" science course ratings to be lower at the university level (just over 11%) than at the middle and high school levels (over 30%) implies that there is a need to examine and possibly revise science content courses for preservice elementary teachers at the college/university level. Students' ratings for those science content courses indicated that there is much emphasis on memorization, little fun, few interesting hands-on science activities, and low student input. Introductory science content courses for teachers should model inquiry science teaching practice in order to teach science content and deepen preservice teachers' understanding the processes of scientific inquiry.

The finding that having memorable science experiences in elementary school is a predictor of interest in science and that after elementary school, the experiences of high-interest and low-interest students start to look more and more alike is consistent with the results of previous research. Studies with children (Joyce and Farenga, 1999) and scientists (Bayer/National Research Foundation, 1998) found that children decide whether or not they like science in the upper elementary school. The quality of science experience in elementary school appears to be critical in developing either interest in science or disinterest in science. This finding has strong implications for elementary science education and for the preparation of teachers. With a current emphasis on improving test scores in reading and mathematics there is pressure to teach less rather than more science. Teacher preparation programs should teach their students how to integrate inquiry science with reading and mathematics. The science pipeline and the

science education pipeline begin early, and positive science experiences in elementary school can affect the choice of science or science education as professions.

Also, according to *AAAS* (1989), a scientific mindset is necessary for all citizens. Today's children will need to be the scientifically informed citizens of the future, as well as the teachers of the next generation of citizens. Modeling theory (Bandura, 1993/1989) would predict that teachers tend to teach science the way they were taught science. Teacher preparation programs could break the unproductive science education cycle in which teachers who are uninterested in science make science less than memorable for children. A primary concern of science methods courses should be to revise preservice teachers' poor science learning experiences and help them to feel excited and motivated to teach science through hands-on discovery approaches. Teacher preparation programs should also communicate to preservice teachers how important their mission is to educate scientifically literate citizens.

Further research

Previous research on science background experiences has been conducted primarily with scientists and science majors, with little research on how preservice elementary teachers' background experiences influence their interest in science. More research on teachers is needed.

This study relied on participants' memories about their background science experiences. Because many participants had difficulty in remembering their elementary school science experiences, what actually happened in the non-memorable classroom is not known. Further research studies on background experiences could be conducted with current middle school or high school students who might still remember the perhaps

boring aspects of elementary school, as well as the more memorable aspects. Additional research could also include interviews with students, parents, and teachers.

The Science Background Experiences Survey has a potential for use in other studies. For further research use, one change should be made; i.e., the question on remembering about elementary school science should be asked before the question on the enjoyment of science in elementary school. Also, students' comments at the end of their ratings could be used as qualitative data to get more insight about their experiences in each level of schooling. In this study, only the science-related activities on the background survey are presented. In further research, science activities and non-science activities can both be included as predictors of interest in science to see whether a combination of activities has predictive value.

This study showed that from middle school to college/university, the percentage of students with positive science experiences, that they considered typical, declined from over 30% to just over 11%. In further research, there is a need for in-depth interviews or classroom observations on how preservice teachers were taught science in college/university. Why did they perceive their college/university science experiences negatively?

Among the Hands-on Activities in the Methods Course, Is There a Relationship between Level of Inquiry of the Activity and the Motivational Quality of the Activity?

There are many books (NRC, 1996, 2000) and articles about inquiry and levels of inquiry (Bell, et al., 2005; Martin-Hansen, 2002; NRC, 2000). However, in an extensive review of the literature, no research was found that examined the relationship between

inquiry level and motivational quality of the activities. This may be the first study that explores the relationship between the level of inquiry of activities and their motivational qualities.

The finding of significant differences among the ratings of the activities at varying levels of inquiry suggests that there is a positive relationship between the level of inquiry of the activity and motivational quality of the activity. The higher the inquiry level of the activity, the higher the rating is on fun, interest, and learning. The higher inquiry level activities allowed students more independence in exploring the materials and designing their own investigations. Students also were able to spend more time on these activities. This result is consistent with Ames's (1992) recommendations that classroom tasks and structure should allow more opportunities for students to select tasks, materials, and methods of learning.

When students' curiosities, questions, interests, and observations drive science investigations, students may be more engaged with the course activities and learning more. These results suggest that there is a need to include more open-ended activities in content and science methods courses in preservice teacher education. This result supports philosophers and child development theorists' views on education that individual interest and previous knowledge should be allowed to drive the inquiry process with the guidance of teachers. For Dewey (1933/1986), the process of learning should not be separated from the outcome of learning. When process and outcome are in continuity with the individual's active inquiry, the activity becomes intrinsically motivating and playful.

That high level inquiry activities are more fun than lower level activities supports the premise of Glasser's (1998) choice theory of motivation, which states that fun,

freedom, and power are the most salient motivators for learning. In this study, higher level inquiry provided a learning environment in which participants had freedom to explore and pose their own questions, exercising control over learning tasks by designing their own investigations. This research builds on the previous research by Jarrett (1988) and Bulunuz, Jarrett, and Bulunuz (2001) who found that hands-on activities perceived as fun, interesting, and promoting learning are motivational.

The finding that preservice teachers perceive more learning with high level of inquiry activities suggests that these activities might be important for learning content, as well as learning to teach through inquiry. This finding is consistent with research studies (Zembal-Saul, Haefner, Avraamidou, Severs, & Dana, 2002; Hayes, 2002; Baxter, Jenkins, Southerland & Wilson, 2005), that reported that engaging preservice teachers in real research-based situations, representing the highest level of inquiry, developed understanding about science and science teaching. Also, Boddy, Watson, and Aubusson (2003) examined preservice teachers' implementation of unit work based on the Five Es (engagement, exploration, explanation, elaboration, and evaluation) inquiry model in a school practicum and found that the model was interesting, fun and motivational for students' learning.

Finding that students are more interested and engaged in open-ended science activities is similar to findings of Gutwill (2005), who examined planned discovery and open-ended exhibits in a science museum. Gutwill found that at open inquiry exhibits, visitors spent more time, got more involved, asked more "why" and "what if?" questions, and engaged in more social interactions than at planned discovery exhibits.

That the mean ratings of fun, interest, and learning for the high level of inquiry activities were significantly higher than low level inquiry activities can be interpreted that by spending more time and more in-depth exploration, students experienced the processes of science and found these experiences motivational. But, the low level of inquiry activities were also rated considerably higher than neutral. In some of the hands-on learning stations, students were exposed to a lot of content related activities in a short period of time. Though some of these activities were low level inquiry (or not inquiry at all), the participants might have learned interesting science content that they did not know before.

Implications

The finding that high level of inquiry activities are motivational and promote learning suggests the need to include some high level inquiry activities in science methods courses as well as in science content courses at all levels. In addition to the motivational and learning potential of these activities, higher levels of inquiry model for preservice teachers ways in which they can use inquiry in their classrooms. In this study, only six activities were at the highest level, level 3, and most of the content related activities were at low levels of inquiry. In teaching future courses, the researcher plans to adapt some of the lower level content-related activities to be more open-ended inquiry.

However, although the activity ratings differed by level, even the lower level activity ratings were positive. On a five-point scale, the ratings ranged from 3.97 to 4.57. To be engaging, not all the activities in a science methods course have to be at higher levels of inquiry. The major disadvantages of open-ended activities are that they are time-consuming, limiting the number of activities students can be exposed to throughout the

semester. Many of the activities at lower levels of inquiry had clear and positive benefits for the preservice teachers, because they taught science content in a hands-on manner. While open-ended activities are motivational and assist students in learning how to teach through inquiry, exposing them to some of the lower level activities from various fields might help them be successful, enjoy, and become interested in subject areas in which they had little previous interest. Based-on previous research (Fulp, 2002; Yates & Goodrum, 1990; Weiss, 1997), many preservice elementary teachers tend not to like physical science. Physical science activities, even at low levels of inquiry, might increase teacher knowledge, while giving ideas for hands-on ways to physical science efficiently.

Further research

As probably the first study to examine the relationships between level of inquiry and fun, interest, and learning, this research must be considered as an exploratory study. Further research is needed with other activities, other instructors, and in other settings to see whether these relationships are sustained. In addition to the surveys used in this study, other data collection tools, such as interviews with students, videotaping, and artifacts from the course and field practicum could be used.

Another area for future research is to document the actual level of inquiry of the activities. The inquiry level ratings used in this research were based on instructions for the activities that were posted at the learning stations. However, some of the participants might have engaged in those activities at higher levels of inquiry, doing more exploring and posing their own questions. In further research, observations, journals, and videotaping could document the actual level of inquiry in which the students were engaged.

In this study, the level of the inquiry relied on instructors' ratings of the activities. Level of inquiry was discussed in the classroom, but activities were not identified by level. Additional research might look at the effect of teachers' explicit knowledge about level of inquiry on their ratings of the activities and on their choices of various activities to implement in their classrooms.

Does the Course Affect ParticipantsParticipants' Interest and Attitude toward Science?

This section interprets the pretest and posttest results of the questions on the Science Teaching Surveys I & II. These questions were of various types, concerning personal interest in science, attitude toward science, and attitude toward science teaching. They will be discussed according to type of question.

The finding that preservice elementary teachers' overall interest in science increased from the beginning to the end of the semester suggests that the course provided many activities of situational interest (Krapp, Hidi, & Renninger, 1992). The analysis of background science experiences indicated that 42% of the preservice elementary teachers came to the methods course with low interest in science and only 13 % left the course with low interest in science. Pre-post positive changes in interest in science could mean that situational interest has promoted personal interest as discussed by (Hidi, & Harackiewicz, 2000; Krapp, 2003). Many hands-on activities at varying levels of inquiry appeared to contribute to the development of personal interest in science. This study corresponds to previous research findings that preservice teachers' interest in science (Jarrett, 1999) and attitudes toward science (Palmer, 2004), can be improved in a science methods course through active participation in hands-on activities and collaboration with peers.

The study also showed that it is possible to improve preservice teachers' attitude toward science, which was measured by participants' ratings on their ability to think scientifically and personal satisfaction in solving problems they had posed themselves. However, their ratings of "science is fun" and "science is fun to study" changed only slightly from pre to posttest. Participants seem to have come to the science methods course with high positive attitudes that "science is fun" (mean = 4.19) and "science is fun to study" (mean = 4.19). Therefore, there was not much space for improvement.

In addition to improvement in attitude toward science, there were also improvements in preservice teachers' attitude toward science teaching. For example, agreement with the items "science is fun to teach" and "when I teach science I will have students plan and conduct their own experiments" increased significantly from the beginning to the end of the course. However, on one item, concerning emphasis on process skills in teaching science, there was a significant decrease from pretest to posttest. One explanation for this may be that students were confused about the meaning of the construct, *science process skills*. This terminology was not explicitly taught or discussed in the course. Even though the students used most of the science process skills in the course activities, they might not have realized that science process skills were used throughout the course activities and projects. This finding confirms that research surveys need to include terminology with which respondents are familiar.

The findings of this study can be interpreted through the lens of several theories. According to Krapp, Hidi, and Renninger (1992), Hidi and Harackiewicz (2000), and Krapp (2003) interesting situations, "situational interest," can build to create sustained "personal interest." The students' perceptions of hands-on activities as interesting can be

interpreted as situational interest in those activities. Situational interest might be an important factor in generating sustained personal interest, demonstrated in high ratings of interest in science or interest in teaching science.

In addition to inquiry based hands-on activities, students were exposed to several discrepant event activities and demonstrations during the semester. Experiencing novelty and surprise in those activities and demonstrations might help preservice teachers' development of interest and attitude toward science and science teaching. This intervention in the course supports Piaget's (1964/2003) ideas on equilibration and Festinger's (1957) theory of cognitive dissonance that learning new things is satisfying and motivational. Throughout the semester, participants were involved in many science activities from various science subjects. This intervention is consistent with Ames' views (1992) on task motivation: that experiencing many different types of activities is motivational by providing relevance to ranges of students in the classroom.

What Aspects of the Course Contribute to ParticipantsParticipants' Interest in Teaching Science and Choice to Teach Science?

Clusters of significant correlations were found among the preservice teachers' ratings of various aspects of the methods course at the end of the semester. Among those correlations, four clusters were found. The clusters of intercorrelations are: (a) intercorrelations among interest in teaching science and various aspects of the course; (b) intercorrelations among fun, interest, and learning; (c) intercorrelations among experiencing inquiry in the methods course, usefulness of reading assignments, learning a lot about teaching through inquiry, and feeling prepared to teach through inquiry; and (d)

intercorrelations among field assignments, evaluation of the way the classroom teachers taught, and the frequency of teaching in the field.

Finding high mean ratings and high correlations on methods course variables (enjoyment, fun, student input, learning to teach science as inquiry, and feeling prepared to teach through inquiry) suggests that fun, involvement, and enjoyment with the course activities were all important features of the science methods course. This supports intrinsic motivation theory (Deci, Vallerand, Pelletier, & Ryan, 1991; Ryan & Deci, 2000) that doing or engaging in activities that are fun, engaging and interesting motivates people without external rewards or pressures.

High intercorrelations among ratings of the methods course on whether it was fun and interesting and whether the participants learned a lot suggest that these dimensions tend to vary together and influence or promote each other. This finding is consistent with other research that found high intercorrelations among students' ratings of course activities on fun, interest, and learning (Jarrett, 1998; Bulunuz, Jarrett, & Bulunuz, 2001) and research studies that found a relationship between interest and learning (Krapp, Hidi, & Renninger, 1992; Hidi & Harackiewicz, 2000; Ainley, Hidi, & Berndorff, 2002; Krapp, 2004; Naceur & Schiefele, 2002). In the present study, experiencing fun (playfulness) in the methods course could have promoted students' interest and perceptions of learning from the class. Alternatively, learning a lot of science content they did not previously understand might have promoted interest. Or, the provision of interesting material might have increased the sense of fun and the perception of learning a lot. A final interpretation might be that the material in the class, designed to be fun while clarifying difficult science topics and making learning interesting, was successful.

High intercorrelations were also found among experiencing inquiry learning in the course, usefulness of the course reading assignments on inquiry, field assignments with children (discovery tub and learning stations), learning a lot about teaching through inquiry, and feeling prepared to teach through inquiry. These associations among experiencing inquiry learning in the methods course, engaging in inquiry teaching in the field practicum, and learning and feeling prepared to teach through inquiry supports the premise of Bandura's (1974, 1989, 1993) modeling theory, that learning occurs by observing a modeled behavior. The course attempted to model ways in which teachers can teach through inquiry. The reading assignments in this course not only provided understanding about inquiry science teaching but also included many practical ideas and examples on how to implement inquiry science teaching in the classroom with materials that are inexpensive and readily found in children's environments.

There is no correlation between participants' ratings of their field experiences and their *interest in teaching science* or *feeling prepared to teach science through inquiry*. There is a high correlation between whether participants *liked the way the [mentor] teacher taught science* and whether the participants *got to teach a lot of science*. Table 20 shows low means on both variables indicating that the participants did not like the way the mentor teacher taught science and did not get to teach a lot of science. Since participants' ratings of the inquiry aspects of the course were high, low ratings of the mentor teachers suggest that either they were teaching little or no science or they were not employing inquiry methods. This finding suggests that the school placement did not align with the methods course. The low agreement by the participants on the statement, "I got to teach a lot of science," is consistent with previous research findings (Anderson,

2002; deLaat & Watters, 1995; Fulp, 2002; Weiss, 1997), that science is taught very little in elementary schools. Further research should explore what interns and student teachers do not like about the way mentor teachers teach science.

That there was no correlation between how the classroom teachers taught and the participants' interest in science and interest in teaching science suggests that the teacher had neither a positive nor a negative effect on participants' desire to teach science. Although the classroom teacher might not have modeled inquiry teaching, implementing inquiry-based activities with children appeared to be useful for the preservice teachers' learning to teach science through inquiry. This finding agrees with the following research in methods courses (Hubbard, & Abell, 2005; Reiff, 2002; Zembal-Saul, Haefner, Avraamidou, Severs, & Dana, 2002) that concurrent practice in field placements with children is an important factor for understanding how to teach science through inquiry.

To answer what aspects of the course contributed to participants' interest in teaching science, various course variables that might add to initial interest in science in predicting interest in teaching science were considered for the regression analysis. The best predictors of interest in teaching science were fun in the methods course and the participants' initial interest in science. Even though several aspects of the methods course (e.g., learning a lot and student input) were highly related to interest in teaching science, they did not enter the regression equation as predictors of interest in teaching science. One explanation for this is the high intercorrelations among fun and other aspects of the methods course. The finding that fun in the methods course predicted interest in teaching science supports the view that playful involvement with science (Laszlo, 2004; Piaget, 1964/2003; Pearce, 1999; Resnick, 2004) is a salient motivator for learning and teaching

science. Fun can be critical in breaking the unproductive cycle in science education (in which teachers who don't enjoy science prepare the next generation). In order to enhance preservice teachers' interest in science teaching, science methods courses need to find ways to motivate students, especially those with negative previous science experiences and attitudes toward science. Initial interest in science entered the regression equation, but its effect on interest in teaching science was lower than the effect of fun in the course.

When the preservice teachers were asked on Science Teaching Survey II to choose whether they would or would not accept a teaching position where they would teach science, only four out of 53 participants said they would not take the science position. This suggests that the course was successful in developing motivation to teach science. The main commonalities among these four students were that all of them had low initial interest in science. None of them could remember elementary school science experiences, and each had only a few activities related to science outside of the classroom. Their answer that they would choose the position that did not include science teaching could reflect that the course did not compensate for these four students' low initial interest in science. However, their answer could also mean that they have a special interest in the other subjects they would teach in the non-science position. Follow up interviews could have determined the reason for their responses.

Implications

Increases in interest in science and desire to teach science through inquiry suggest that the fun and interesting course activities at varying levels of inquiry had a major effect on the students. If prospective teachers are already interested in science, learning about science pedagogy might be sufficient for teaching them methods of teaching

science. However, especially if preservice teachers are not highly interested in science, a methods course that focuses on engaging their interest and sense of fun and that teaches them things they did not know before can be effective in building their desire to teach science. Such a course also models ways of teaching that could be crucial in building interest in elementary school children. High intercorrelations among course ratings and field assignments suggests that by implementing activities with children, preservice teachers can experience success in teaching through inquiry, even if the mentoring classroom teacher is not teaching that way. Methods courses should include field opportunities, so participants can practice what they are learning.

Finding that fun was the best predictor of interest in teaching science implies that a science methods course should provide a playful and risk-free learning environment. In this environment, preservice teachers should have the freedom to explore their "wonderings," curiosity, and questions. Activities should allow students to experience a sense of playfulness and excitement. The classroom atmosphere should be positive, friendly, and supportive, creating a learning environment where participants should be able to engage actively with scientific phenomena and discuss their understandings with friends and instructors.

Further research

One construct that was not studied in this research was self-efficacy, or confidence. Finding high positive correlations between participants' feeling prepared to teach science as inquiry and other aspects of the course (interest in teaching science, and learning about inquiry teaching in the course) indicates that further research should investigate self-efficacy, confidence in teaching science.

Most of the participants said that they were interested in teaching science and that they felt prepared to teach through inquiry. At the end of a course, preservice teachers may be enthusiastic and highly motivated. However, when they become teachers, do they actually implement inquiry science teaching in their classrooms? Is their interest in teaching science enduring, or do challenges of school system pressures (e.g., testing) undermine their interest in teaching science? Do highly motivated and less motivated participants differ in their science teaching once they have their own classrooms? Longitudinal research would be needed to determine whether high or low motivation shown in a methods course has long term effects on teaching.

The final ratings of the course showed clusters of intercorrelations, with many of the variables also correlated with interest in teaching science. Path analysis, which was not an element of this research design, could be used to create a model of how the various aspects of the course and initial interest in science, itself affected by background variables, might predict interest in teaching science.

This study relied on of the use of surveys to examine the effectiveness of the course in influencing interest and attitudes. In order to better understand the meaning of survey ratings, mixed methods research would be useful. Focus group interviews or individual interviews could be employed to help interpret participants' ratings. Also, to better understand the effect of the field placement, additional data collection tools could be included, such as observations in the field placements, interviews with preservice teachers and their mentor teachers, and analysis of artifacts, such as lesson plans, reflections, and children's work.

Strengths of the Study

The study included two sections of the same science methods course taught by two different instructors. Having two sections provided a large enough sample from which to draw statistical conclusions, and having two different course instructors increased the generalizability of the findings in that the positive outcomes of the course did not seem to be dependent on the appeal or style of one particular instructor. That there were no differences between sections on course ratings supports generalizability.

Several new measurement tools were developed for the study. The Science Background Experiences Survey, piloted with doctoral students, has the potential to measure both formal and informal science experiences in further research. The rubric developed to rate all the course activities on level of inquiry is a good start for examining course activities by level. Reliability analysis on coding of activities by level found an acceptable correlation (.84) between two raters as well as fairly high percentage (76%) of absolute agreement. Another strength of the methodology is that activities were rated on a weekly basis, while the activities and the feelings they invoked were fresh in the minds of the participants.

The course had many positive aspects that were implemented similarly in the two sections. These aspects include inquiry activities at various levels, inclusion of important science content, and concurrent field placements at various grade levels. The readings and course activities provided background information on what science is, how it should be taught, the processes of inquiry, and how to use materials that are readily found in children's environments. In their field placements, the preservice teachers had opportunities to actually practice inquiry with children.

Weaknesses of the Study

This research also had weaknesses. The study lacked a control group to control for threats to internal validity, such as history, maturation, and testing (Campbell & Stanley, 1963). History refers to the possible effects of events occuring between the first and second measurement. Maturation refers to developmental changes between pretest and posttests. Testing refers to the effect of taking an initial test upon answers on a second test. The sample was a convenience sample with only two cohorts of undergraduates available. In this case, it was impossible to randomly assign students to the two cohorts. Also, the two instructors shared the same teaching philosophy, so it would not have been ethical to insist that one teach in a "traditional" way in order to have a comparison.

In creating the means of the activities in each inquiry level, there were only six activities at the highest level of inquiry compared to 23 activities at the lowest level. An activity that was particularly liked or disliked in the highest level of inquiry group could have had a disproportionate influence on the mean. Future research that examines inquiry level should ensure that the number of activities to be included at each level of inquiry be more nearly equal.

Some of the surveys have no reliability statistics: i.e., the Science Background Survey, the Activity Rating Survey, and the Course Rating Survey. Due to the nature of these surveys and the timing of research, an analysis of reliability was not possible. Therefore, there is a possibility that some of the questions may have been confusing.

The findings of the study relied on quantitative analysis of survey answers. The researcher had been trained only in quantitative methods and therefore designed a

quantitative study. Quantitative research was appropriate for answering the questions posed in this study. However, a mixed methods study with student interviews, analysis of students' artifacts from methods classes and field assignments, and videotapes or observations in the field might have added insights into the meanings behind students' self-reported background and course experiences.

Conclusions

This investigation was based on the analysis of preservice elementary teachers' background science experiences, weekly ratings for the motivational qualities of the course activities, pretest and posttests on interest in science and attitude toward science and science teaching, and analysis of various features of the methods course.

The analysis of preservice teachers' background science experiences indicated that some of the preservice teachers came to the methods course with poor science experiences and low interest in science. Some of them could not remember anything about their elementary school science experience and experienced few science related activities in their childhood/youth. On the other hand, more students with high interest in science not only could remember about elementary school but also had rich experiences with out-of-school science activities. The findings of this research suggest that preservice elementary teachers can be prepared to teach science in a way that teaches them instructional strategies while capturing the interest of those students who have poor prior science experiences at home, at school, or in the community. Being exposed to a variety of instructional science teaching strategies and participating in many hands-on activities and projects in a playful and risk-free, collaborative environment seemed to compensate for poor background science experiences. Preservice teachers should be able to

experience the excitement and joy of doing science themselves and of sharing inquiry experiences with children in their field experiences.

This research shows the importance of varying inquiry levels of the activities in science methods courses. Having found statistically significant differences among levels of inquiry of activities suggests that allowing preservice elementary teachers to explore their curiosities, questions and wonders seems to be enjoyable and satisfying for them. On the other hand, the means for fun, interest, and learning were considerably above neutral for lower inquiry level activities. This finding suggests that preservice teachers also value these lower level experiences, probably learning, through hands-on experiences, much content in a short period of time. There appear to be advantages in providing activities that allow students to experience various levels of inquiry.

Students come to science methods courses with a range of attitudes toward science and interest in science (e.g., positive and less positive experiences, and high and lower interest in science). This research suggests that negative/neutral prior experiences, attitudes, and interests can be altered toward more positive ones. In the methods course, students experienced novelty, surprises, playfulness, enjoyment, and active involvement. They had many experiences they considered positive, including engaging in enjoyable activities, reading about inquiry in practice, and implementing hands-on inquiry activities in the classroom. In this study, the best predictor of interest in teaching science was having fun in the methods course. Therefore, experiencing fun science experiences has an important role in developing interest and motivation in teaching science. From an MIT Media Lab report (Page, 2002, p. 2) comes the assertion: “When children are engaged, they learn. When they are happily engaged, they learn even more.”

This dissertation suggests that many of the prospective teachers were “happily engaged” in their science methods course. Hopefully, happily engaged teachers who are interested and enthusiastic about teaching science will make science an important, memorable subject in their own classroom and in the lives of their students.

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APPENDICES

APPENDIX A

Science Background Experiences Survey

Last 4 digits of SS#____________________ Date ___________________

1. How would you describe your general **elementary school science experience?**

I enjoyed science in elementary school.

Strongly disagree	1	2	3	4	5	strongly agree

If you honestly can't remember anything, check here and skip the rest of this question:
___ cannot remember anything about elementary school science.

How would you generally describe your **best year in elementary school science**?

a. Not fun	1	2	3	4	5	Fun
b. Boring	1	2	3	4	5	Interesting
c. Textbook/worksheet based	1	2	3	4	5	Hands-on
d. Teacher dominated	1	2	3	4	5	Much student input
e. Did not learn much	1	2	3	4	5	Learned a lot
f. Memorization emphasis	1	2	3	4	5	Understanding emphasis

Comments:

2. Identify the science course you liked best in your **middle school (or junior high - approximately 6th-8th grades).** Give a detail to identify the course (identify it by subject area, grade level, or name of teacher, etc.). If none were great pick the least bad.
Course ______________________________________

I enjoyed that middle school science course.

Strongly disagree	1	2	3	4	5	strongly agree

How would you generally describe this course?

a. Not fun	1	2	3	4	5	Fun
b. Boring	1	2	3	4	5	Interesting
c. Textbook/worksheet based	1	2	3	4	5	Hands-on
d. Teacher dominated	1	2	3	4	5	Much student input
e. Did not learn much	1	2	3	4	5	Learned a lot
f. Memorization emphasis	1	2	3	4	5	Understanding emphasis

Describe how typical this was of your middle school science experiences and give any further comments:

3. Put a check mark **by high school science courses** taken. Rank them in order, with number one being the one you liked best.

Check		Rank
____ biology		____
____ physics		____
____ earth science		____
____ chemistry		____
____ AP courses, specify	____________________	____
____	____________________	____
____	____________________	____
____ others, specify	________________________	____
____	________________________	____
____	________________________	____

How would you describe the high school science course you ranked as number one (above)?

I enjoyed that high school science course.

Strongly disagree	1	2	3	4	5	strongly agree

How would you generally describe this course?

a. Not fun	1	2	3	4	5	Fun
b. Boring	1	2	3	4	5	Interesting
c. Textbook/worksheet based	1	2	3	4	5	Hands-on
d. Teacher dominated	1	2	3	4	5	Much student input
e. Did not learn much	1	2	3	4	5	Learned a lot
f. Memorization emphasis	1	2	3	4	5	Understanding emphasis

Describe how typical this was of your high school science experiences and give any further comments:

4. What experiences have you had as a student participating in science fairs?

____none ____one year ____ more than one year

Comment about your experiences and whether they were at the elementary, middle, or high school level. Also comment on whether you had experience at the regional or state level.

5. Put a check mark by each **college/university science course** taken. Also put a check mark if it was a lab course. Rank the two courses you liked best in order, with number one being the course you liked best.

Check	with lab?	Rank	Check	with lab?	Rank
___Biology I	____	____	___Physical science I	____	____
___Biology II	____	____	___ Physical science I	____	____
___Chemistry I	____	____	___ Physics I	____	____
___Chemistry II	____	____	___ Physics I	____	____
___Earth science I	____	____	___ Meteorology	____	____
___Earth science II	____	____	___ Others	____	____
___Astronomy	____	____	___	____	____

How would you describe the college/university science course you ranked as number one?

I enjoyed that college/university science course.
Strongly disagree 1 2 3 4 5 strongly agree

Describe the course in the following dimensions:

a. Not fun	1	2	3	4	5	Fun
b. Boring	1	2	3	4	5	Interesting
c. Textbook/worksheet based	1	2	3	4	5	Hands-on
d. Teacher dominated	1	2	3	4	5	Much student input
e. Did not learn much	1	2	3	4	5	Learned a lot
f. Memorization emphasis	1	2	3	4	5	Understanding emphasis

Describe how typical this was of your college/university science experiences and give any further comments:

6. I felt **my parents** were supportive in establishing an interest in science in me (examples: purchased dissecting kits or telescope, pointed out aspects of nature, went on trips to museum or nature walks, initiated discussion).
Strongly disagree 1 2 3 4 5 Strongly agree

7. **School field trips** were an important part of my science experience.
Strongly disagree 1 2 3 4 5 Strongly agree

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

Strongly disagree 1 2 3 4 5 Strongly agree

9. Following is a list of activities and experiences. Put a √ before the ones that were part of your childhood/youth and a second √ before the ones that were an **important part** of your childhood/youth. Add any other childhood/youth activities to the bottom. Put a **star** after any of these activities that you enjoy now.

___LEGO bricks or LEGO robotics
___ Board games
___ Building with wooden block
___ Computer games
___ Game Boy, etc.
___ Computer programming
___ Taking things apart
___ Playing school
___ TV nature or science programs
___ Chemistry kit
___ Microscope or telescope
___ Planting in a garden
___ Care of animals (pets/farm animals)
___ Care of house plants
___ Mixing up "kitchen chemicals"
___ Exploring the outdoors
___ Playing on playgrounds
___ Riding a bike
___ Playing in sand

___ Visits to science museums
___ Visits to history museums
___ Visits to zoos, nature centers, aquaria
___ Play with doctor/nurse kits
___ Risky play (making explosives, etc.)
___ Making science collections (rocks, insects, etc.),
___ Making non science collections (dolls, stamps, etc.)
___ Making models (e.g. airplanes, boats)
___ Camping
___ Star gazing
___ Snorkeling or SCUBA diving
___ Beach combing
___ Science club
___ Scouting
___ ________________
___ _________________

APPENDIX B
Science Teaching Survey I

Last 4 digits of SS#____________________ Date____________________________

Carefully read each of the following statements. Some statements are about science teaching, and some describe feelings about science. You may agree with some of the statements and disagree with others. After you have read each statement, decide on your level of agreement or disagreement and circle the appropriate letter on this answer sheet.

SD= Strongly Disagree; D=Mildly Disagree; U=Uncertain; A=Mildly Agree; SA=Strongly Agree

1. Science is fun to study
   SD D U A SA

2. I get a lot of personal satisfaction when I solve a problem by doing my own testing
   SD D U A SA

3. I do not have ability to think scientifically
   SD D U A SA

4. Science is a fun subject to teach
   SD D U A SA

5. When I teach science I will emphasize science process skills.
   SD D U A SA

6. When I teach science I will have students plan and conduct their own experiments.
   SD D U A SA

Also answer the following questions, circling a number to represent your feelings between low and high and between disagree and agree.

7. What is your overall interest in science?
   (Low) 1 - 2 - 3 - 4 - 5 (High)

8. What are your feelings about the statement, "Science is Fun?"
   (Disagree) 1 - 2 - 3 - 4 - 5 (Agree)

APPENDIX C
Activity Rating Survey

Last Digit of SS#______________ Date______________

Please rate the activity you have completed so far on the following dimensions. In the comment section, state why you rated as you did and/ or what aspect of the activity was most fun, interesting, etc..

1st week
1. Paper helicopter

I found uninteresting	**1**	**2**	**3**	**4**	**5**	I found interesting
It wasn't fun	**1**	**2**	**3**	**4**	**5**	I was fun
I didn't learn anything new	**1**	**2**	**3**	**4**	**5**	I learned a lot

Additional comments:

2. Exploration with magnifying glass

I found uninteresting	**1**	**2**	**3**	**4**	**5**	I found interesting
It wasn't fun	**1**	**2**	**3**	**4**	**5**	I was fun
I didn't learn anything new	**1**	**2**	**3**	**4**	**5**	I learned a lot

Additional comments:

3. Exploration with science kit

I found uninteresting	**1**	**2**	**3**	**4**	**5**	I found interesting
It wasn't fun	**1**	**2**	**3**	**4**	**5**	I was fun
I didn't learn anything new	**1**	**2**	**3**	**4**	**5**	I learned a lot

Additional comments:

APPENDIX D
Activity Classification Rubric
For identifying inquiry level of course activities, with examples.

Representations of classification rubric for class activities

Level	Description
0	not represent any form of inquiry
1	predefined question, method, and answer
2	predefined question, but method and answer is left open
3	question, method and answer is left open

Level 0	**Level 1**
Hands-on activities primarily designed to teach or clarify a concept or model a fun activity that could be done with young children. Level 0 activities involve participation but not necessarily questioning. Examples: students complete a Moon phase calendar by: cutting out photographs of the Moon in different phases; mounting them on monthly calendar on the proper date; and labeling each of the eight major Moon phases. (Bell, Smetana, & Binns, 2005).	There are questions but they do not require data collection –simply observations and inference or trial and error. Example: Students go to the web library to find newspapers accounts describing the impact of El Nino on the California coast. They have to summarize what they find in a report. (Bell, Smetana, & Binns, 2005).
Level 2	**Level 3**
Instructor asks questions and answer left open to students. Example: Instructor asks "Can you light the bulb by using small piece of wire, and battery?" and leaves how to do it open to preservice teachers. Then preservice teachers try by themselves to light up a bulb. In the extension of the activity, instructor asks whether they can find a way to light bulb brighter or dimmer. Minds of our own (1997)	Both questions and data collection and analysis or come up with solution or answer. Example: A physics teacher provides a variety of materials, such as spheres, ramps, meter sticks, tape, and wooden blocks. After they experience materials, she gets into the dialogue with students to learn their experiences, curiosities and their interest. In this dialogue, the teacher elicit their questions and encourage to design and experiment to test their ideas and discover different aspect of activity. For example, one group of students may want to investigate how the height of the ramp influences the distance a sphere travels before it stops (Martin-Hansen, 2002).

APPENDIX E

Activity Coding Manual

(Activities are in chronological order)

Level of inquiry	Name of the activity	Description of activity
3	Paper helicopter	Instructor demonstrated whole class how to make a paper helicopter. Then students observed their helicopters; pose questions, design experiments to answer their questions. They also encouraged designing their own paper helicopters. Students used different kinds of paper, paper clips, and markers in the activity.
2	Magnifying glass explorations	Instructor asked whole class to explore their environment and looked at the different things in the classroom to find out how it looks different when they look through magnifying glass. Instructor asked them to look at their hand, penny, dollar bill, hair, etc..
3	Exploring science kit	This was a whole class activity in which students had choice to work in a group or individually. Instructor passed out the science kits and asked students to discover how the materials in the science kit interact with each other. Students freely explored the science kit with bulb, batteries, magnifying glass, compass, e-motor, magnets, short and long wire, droppers, etc,...
2	Lighting up a bulb	The instructor asked class to find a way to light up a bulb by using short wire, battery, and bulb in their science kit.
3	Making electromagnet	Instructor asked students how to make and electromagnet by using long wire, battery and nail. Then they were asked whether they can think of a way to make electro magnet stronger.
2	Water drips on penny	Instructor demonstrated how to drip water on a penny by using dropper. Then the instructor asked whole class to predict how many drips of water they can fit on a penny. Then instructor asked them to compare their observations with their group and encouraged them to ask questions and design an experiment to test answer their own questions. Instructor provided the following materials for students to ask and answer their questions: glass and plastic dropper, pennies, paper towel, different kinds of liquid such as water, cooking oil, vinegar, coke etc…

2	Exploration with thermometers	Instructor provided a sample of questions to whole class that students may interested to explore or they can pose their own questions to design experiment to test it by using their thermometers.
2	Mealworm discovery	Instructor provided materials and meal worms to whole class to experiment and learn about it. Instructor provided sample of questions that students may want to answer or they have choice to ask their own questions.
2	Coloring & mixing colors with e-motor	Instructor demonstrated whole class how to mix colors on a paper card by using electric motor. Then students experimented with different colors and patterns to see how it looks while it was spinning on electric motor.
0	Ocean waves	In a center, students observed weaves by using a glass pan with water on the overhead and "ocean in the bottle" kit which is consists of a water and mineral oil in a rectangular bottle. They draw their observations.
0	Mapping the ocean floor	In a center, instructor provided materials (e.g. ruler, shoe box represent ocean floor, graph paper) and procedure to map ocean floor. They measured the depth of box by using the holes on the shoebox and graphed it.
0	Ocean puppet show	Instructor provided books and puppets about sea creatures. Students asked to read the books to get ideas and make up a puppet show.
0	Density of sea water	Student read written instruction that explains why the things easily float in sea water than fresh water. Then they asked to place an egg in a cup then add salt until it floats.
0	On the beach: beach combing	Students were asked to match the pictures and the objects from the beach and they also asked to identify the objects by looking at the book.
1	Dissection of sea creatures	In this center, students were provided octopus, scissors, and anatomy chart. They were asked to write what they learn about octopus by dissecting.
0	Ocean currents	In a center, a pan of warm water and colored ice cubes provided to students. They asked to observe the ice cubes in warm water and compare the density of cold and hot water. They also provided the information that temperature difference in the poles and equator causes ocean currents.
0	Sea products	In a center, a box of products from super markets was provided and students were asked to sort them as sea products and those do not.
0	Observing sand	In a center instructor provided several sand samples, microscopes, and book. Students were asked to look at under microscope and describe the sand samples.
0	How much of	In a center, students were asked to throw the globe ball

	earth is ocean?	back and forth and record whether their thumb touching land or ocean. Then they were asked to calculate the percentage of the earth that is ocean.
2	Oil spills	The rationale for this activity is to demonstrate the environmental damage of oil leaks into water. In this center, students were provided a bowl of water mixed with oil, and food colorings. Students were asked to try to remove oil by using dropper, cotton balls, feather etc.
1	Shell museum	In this center, a collection of shell and shell books were provided. Students were asked to identify a least one of the shell and write information about it such as how rare, what and how it eats, whether people eat it, etc.
1	Tsunamis	In this center, students were asked to answer the following questions for the Indian Ocean Tsunami Dec. 26, 2004 by searching on-line: (1) what are the danger signs that tsunami is imminent? (2) Where was there greatest loss of life? (3) Why were so many people killed in that tsunami? (4) What kind of help is still needed?
2	Static electricity	In this center provided various materials to explore static electricity such as balloon, cans, plastic pipe, plastic tube salt in it, wool shirt, etc. Instructors posed some example questions they may want to try. For instance, what would happen if you rub balloon to wool shit and get it closer to the materials in the center.
3	Electricity & magnetism	In a center, instructor provided compass, coils, and magnets to see the relationship between electricity and magnetism. Then they freely experiment with simple motor by using different types and number of magnets and batteries or hand operating generator, on the speed of simple motor.
1	Chirping chick	In an instruction sheet, students were asked to hold the chick in their hand see if it starts to chirp. Instructor told them whether the chick chirps when they make a circle with their group. Then they were asked to think of another ways to chirp chicks.
0	Magnetic rods & balls	In this center, students were provided with tub of magnetic rods and balls with instruction sheet. In the instruction sheet, they were asked to create simple and complex geometric, shapes and patterns or build bridges, globes, pyramids, etc. Also they were asked to compare the strength of geometric shapes and modeling molecules.
0	Magnetic toys	In this center, there were various magnetic toys such as magnetic tennis balls, buzzing magnets, etc. students played with these materials freely.
1	Sorting with	In this center, a bag of materials and magnets were

	magnet	provided in a center and students were asked to sort the materials into two piles: the one is attracted by magnet and the other does not. They were also asked to answer following questions: (1) what do the things attracted to a magnet have in common? (2) Why should magnets be kept away from computer and disks?
0	Making up games with magnets	In this center, students played with cars run with magnet power, magnetic fishing poles, and fishes, magnetic dancers, and mysterious box. Instructions sheet provided both how to make up game and how to play with it by using magnets
0	Observing magnetic field	In this center, students were provided with instruction and materials such as wood, Styrofoam, aluminum, paper clips, iron fillings. They were asked to test wood, Styrofoam, aluminum to see whether magnetism pass through and also they were asked to observe the patterns magnetic field by using styrofoam plates or overhead slides with iron fillings.
2	Cutting magnetic field	This center, a floating paper clip floating on overhead projector to the magnet clamped on top of the projector, set it up by the instructor. The instructor demonstrated how to cut magnetic fields with a scissor and provided more materials such as papers, cartoon, metal plates, and aluminum foil for students to see whether magnetism go through those materials. Students experimented with those different materials.
3	Instant snow	This activity was a whole class activity. Each table provided with instant snow (sodium polyacrylate), water, vinegar, alcohol, salt, thermometer, etc. students have freedom to pose their own questions, design investigations and answer their questions. Students worked collaboratively in groups for this activity. They also provided plenty of time to finish their investigations.
2	Great balls of goop	With this activity students mixed white glue and borax solution together to produce goop. First students mixed glue and borax solution with water with a ratio written on board by the instructor. Then students were encouraged to experiment with different ratio of these materials to make different kinds of goop.
2	Water gel crystal	This activity was a whole class activity. Each group provided with gel crystal (polyacrylamide polymer), food coloring, thermometer, droppers, hot and cold water, etc. The instructor told students that these polymers have strong affinity to water that takes up a lot of water easily. Then students freely explored and posed their own questions to investigate properties of water gel crystal.

1	Cartesian diver	Instructor asked students to fill a plastic bottle with water. Then they were asked to adjust the amount of water in plastic dropper which it barely floats in a cup of water. Then they put the dropper in a bottle and sealed the bottle with a cap. They were asked to squeeze the sides of the bottle. Then they were asked to explain what happened?
1	Floating soda cans	In this center, students were asked to test various canned drinks, fruits to see which one floats and sinks. Before they test they were asked to make a prediction and then they were asked to explain their observations.
2	Designing aluminum foil boat	In this center, standard size piece of aluminum foil and marbles with a tub of water were provided to students. In the instruction, they were asked to make a boat that will hold the most marbles before it start to sink.
2	Dancing raisins	In this center, students were provided with water, Alka-Seltzer and raisins. They were asked to drop raisins into a cup of water and predict what will happen. Then they add Alka-Seltzer to see what will happen? Instructor also asked them whether they can find a way to dance raisins faster in a jar.
2	Color spreading: Chromatography	This was a whole class activity. Student provided with coffee filters with a black dot, droppers, and a cup of water. Instructor showed class how to do color spreading activity by dripping water. Next step, instructor provided various markers and liquids (alcohol, mineral oil, vinegar). Students posed their own questions and experiment with these materials.
2	Energy beads	This is a whole class activity. Each student was provided a bead bracelet. Instructor told informed students that the beads detect UV light. Then instructor gave freedom students to experiment with the beads. Some of the students went outside of the building to see what will happen if they put the beads under sun. They took their sun glasses to test how much their glass filter UV lights. Some of the students experiment in the classroom with overhead, fluorescent light, and UV lamp.
1	Exploring prisms and lenses	In this center, students provided different kinds of prisms, lenses, and flash lights and laser pointer. Instructor showed students how to experiment with the lenses and prisms to see how light behaves when it passes from one medium to another. They observed rainbow by using the light of overhead. Students also asked to experiment with the focal point of the convex and concave lenses by using laser pointer.
0	Colored	In this center, students provided with an instruction in

	shadows	which they mix blue, red and green lights. They also asked to observe the shadow of their hand on white board.
1	Kaleidoscope	In this center, many kaleidoscopes and taped mirrors provided students to look through. They were asked to find out the relationship between angle of the mirror and the number of images.
0	Crayon rock cycle	In this center, by using shaved crayons, aluminum foil, and hot plate students made sedimentary, metamorphic, and igneous rock. An instruction sheet provided the procedure to make the representative/not real three types of rock. No questions asked in the instruction sheet.
0	Rock sorting	In this center, various rocks, books, and box of labeled rocks were provided. In the instruction, students were asked to match various rocks with the ones in the box with labels. They also asked to place those rocks correctly on the figure that represents rock cycle.
1	Wind: movement of air in the balloon	In this center, students were asked to inflate a balloon and compare the air pressure in the balloon and air in the room. Next they were asked to experiment with the balloons by unpiching the balloon's mouth. They were asked to observe and explain their observation in relation to wind formation on earth.
1	Wind inflated bags	In this center, students were provided with connected bags with a tube. The instruction sheet provided procedure, questions to answer. Students answered the following questions: (1) If these bags just sit there, what would happen to them after a while? (2) what would happen if the air in the bag is put under pressure?
1	Wind: sinking of icy-water	This center was a model for "why the winds blows" by using water. In the instruction sheet, students asked to observe colored ice cubes in a tub with warm water. Based on their observations, they asked the following questions: (1) which water is heavier, worm or cold? (2) cold air and warm air interact the same way, explain why?
0	Prevailing wind	In this center, instruction sheet and materials provided. In the instruction sheet, the materials, procedure, and questions provided. Also, the instruction sheet provide students hints to make connection between global wind and the movement of liquid in globe.
1	Modeling reasons for seasons by using Styrofoam balls and flashlight	In this center, the instruction sheet provided the step by step procedure to understand the reasons for seasons. Students were asked to experiment with two models. One with represent tilted position of earth to the Sun, and the other one with right angle to the sun. They were asked to

		write their observation and connection between these two activities.
0	Using people as models for reasons for seasons	This is a whole class activity. The instruction told student orally which one person in the center represents the "sun" the rest of the people represents the "earth" in the circle. As they were revolving around the sun they were asked determine which seasons in the North America.
1	How warm is slanted versus direct sunlight?	In this center, the instruction sheet provides all the procedure to determine the effect of slanted versus direct light on temperature. Students asked to make observations and explain their observations.
1	Soil formation	In this center students provided two types of soil. They were asked to identify the materials in these two samples by using microscope and magnifying glass. They were asked to describe the difference between these two types of soil.
1	Food chain: toad & mealworm	This was a whole class activity. Students observed toads by touching and holding in their hands. Instructor asked students the difference between toad and frog. Then students feed the toad with mealworms and crickets.
0	Rock in soil	In this center, the instruction sheet provide information two basic soil formation, physical and chemical weathering. Then students were asked to make a sand with by shaking and observe with magnifying glass.
0	The cup phone	In this center, two cup phones provided to students. Instructor told them how to use it and what to try.
0	Singing with light catcher	In this center, light catcher was provided and instructor demonstrated to whole class how it works. Then students freely explored the vibrations pattern on the wall while they were talking or singing.
2	Pecking woodpecker	This was a whole class activity. Activity sheet and instructor assisted students how to hold two papers on top of one another curl and uncurl the top paper by rubbing back and forth with pencil. Next, students were asked to draw their own design. Finally, we discussed that this was a primitive example of how the movie works, with one still image after the other. The eye and brain merge the images.
1	Ping pong ball & fluorescent protector tube	In this center, hair dryer, florescent tube protector, ping pong balls were provided. Students freely explored the balls over the hair dryer, and in the test tube. Instructor demonstrated whole class how the ping pong balls move upwards by blowing with hair dryer. Then students experimented freely. They were encouraged to ask questions and make explorations.
1	Mystery bottles	This is a demonstration activity. Instructor demonstrated

		activity in a dialogue and questioning with students. First students asked to predict in which bottle the balloon can be inflated inside the bottle. Then they were asked to explain why two balloons react differently.
1	Paper ball on the neck of bottle	In each table, a bottle and a paper ball were provided and instructor asked them to place and blows it inside the bottle. Then they were asked to explain their observations.
0	Suction cups and pads	In this center, students provided with suction cups and pads. Students were asked to push in suction pad/cup on a desk or a window then try to pull it back. The main purpose of this activity is to let students experience the air pressure.
1	Test tube in a test tube	In this center, instruction sheet provide the procedure and questions for students to answer. Students followed the procedure and tried to answer questions in the instruction sheet.
1	Marshmallow in a syringe and bottles	In this center, students provided an instruction sheet to follow. They were asked to put marshmallow or small a balloon into syringe or bottles with fizz keeper. They were asked to observe while they were pushing the plunger or pumping extra air into the bottle. They were asked to explain what happened to the marshmallows or balloon.
1	The inverted glass of water	In this center, all the materials (transparent glass, index cards, water, and soda) and procedure were provided in the instruction sheet. Students asked to observe and explain their observation. Also, they were asked to try and answer the following questions: (1) what will happen if the cups filled with half way with water? (2) what will happen if the cup is filled with carbonated drinks instead of water?
1	Linked syringes	In this center, a kit which is consist of two plunger linked by flexible tube. Students were asked to pull and push the plunger and see what happens. Then they were asked to explain their observations.
1	Mysterious hot test tube	Before demonstrating activity, instructor asked students to predict what will happen when hot test tube inverted in a cup of water. Then students were asked to explain what happened? What was in the test tube besides little water before heating?
1	The balloon on the hot flask	The instructor demonstrate activity with a dialogue with students in which students were asked to predict each step what will happen and then they were asked to explain their observation. Students asked the following questions: (1) what is in the flask besides the water? (2)

		What happens to the air in the flask when water boiling? (3) How the balloon inflated inside the flask?
1	Boling warm water in syringe	The instructor demonstrated activity in a dialogue to students. Warm water boiled in a syringe by pulling the syringe. Students asked to predict what will happen? Then they were asked to explain their observation.
1	Blowing a ping pong ball with a funnel	Before demonstrating activity, in each step instructor asked students to predict what would happen when instructor blow upward or downward. Then students asked to explain their observation.
1	Rolling soup cans	This activity is done as whole class activity. In this center, students were asked to roll soup cans down a ramp and compare which one goes farthest. Then they were told that even tough all of the cans have the same weight and diameter why the solid soup cans goes further than liquid soup cans? The instructor helped students to answer this question in through discussion.
1	Inertia	This is a demonstration. In this activity, instructor asked students' predictions and then they were asked to explain their observations. The instructor asked the questions and students tried to answer the questions based on their observations. For example, students predict which one is hard boiled or raw egg by observing their spin rate. egg was hard boiled and raw demonstrated students that hard boiled egg spins faster than raw egg. Then instructor demonstrated that raw egg continues spin even it stopped by touching the finger.
0	Phases of the Moon	Instructor provided a box which is model to explain phases of the Moon. In this center, students were asked to look through the holes around to box to observe the phases of the Moon.
3	Science Fair Project	Students work in groups and the have freedom to explore topic that they are interested. From posing questions to communicating result all were done by participants. Instructor guided their investigations when it is needed.

APPENDIX F

Science Teaching Survey II

Last 4 digits of SS#____________________ Date____________________________

Carefully read each of the following statements. Some statements are about science teaching, and some describe feelings about science. You may agree with some of the statements and disagree with others. After you have read each statement, decide on your level of agreement or disagreement and circle the appropriate letter on this answer sheet.

SD= Strongly Disagree; D=Mildly Disagree; U=Uncertain; A=Mildly Agree; SA=Strongly Agree

1. Science is fun to study
   SD D U A SA
2. I get a lot of personal satisfaction when I solve a problem by doing my own testing
   SD D U A SA
3. I do not have ability to think scientifically
   SD D U A SA
4. Science is a fun subject to teach
   SD D U A SA
5. When I teach science I will emphasize science process skills.
   SD D U A SA
6. When I teach science I will have students plan and conduct their own experiments.
   SD D U A SA

Also answer the following questions, circling a number to represent your feelings between low and high and between disagree and agree.

7. What is your overall interest in science?
   (Low) 1 - 2 - 3 - 4 - 5 (High)
8. What are your feelings about the statement, "Science is Fun?"
   (Disagree) 1 - 2 - 3 - 4 - 5 (Agree)
9. What is your overall interest in teaching science?
   (Low) 1 - 2 - 3 - 4 - 5 (High)

10. Suppose the following happens when you are ready to take a teaching position:
    You have been offered two jobs, both at the same grade level. You like both schools. The principals are equally positive. The schools are about the same distance from your house. The pay is the same. The only major difference between the positions is that in Job A you would be teaching science among other subjects, but in Job B you would be teaching other subjects but not science. If everything else is equal, which job would you choose?

____ Job A, that includes teaching science

____ Job B, that does not include teaching science

Appendix G
Course Rating Survey

Last 4 digits of SS#___________________ Date__________________________

1. I enjoyed this science methods course.

Strongly disagree	1	2	3	4	5	strongly agree

How would you generally describe this course?

a. Not fun	1	2	3	4	5	Fun
b. Boring	1	2	3	4	5	Interesting
c. Textbook/worksheet based	1	2	3	4	5	Hands-on
d. Teacher dominated	1	2	3	4	5	Much student input
e. Did not learn much	1	2	3	4	5	Learned a lot
f. Memorization emphasis	1	2	3	4	5	Understanding emphasis

2. I experienced inquiry learning in this course.

Strongly disagree	1	2	3	4	5	strongly agree

3. I learned a lot about teaching through inquiry in this course.

Strongly disagree	1	2	3	4	5	strongly agree

4. I feel prepared to teach elementary school science using inquiry methods.

Strongly disagree	1	2	3	4	5	strongly agree

5. The course reading assignments were useful for understanding inquiry science teaching.

Strongly disagree	1	2	3	4	5	strongly agree

6. The assignments with the children in my field placements were useful.

Strongly disagree	1	2	3	4	5	strongly agree

7. a. In my **first field placement**, I liked the way the teacher taught science.

Strongly disagree	1	2	3	4	5	strongly agree

b. In my **first field placement**, I got to teach a lot of science.

Strongly disagree	1	2	3	4	5	strongly agree

8. a. In my **second field placement**, I liked the way the teacher taught science.

Strongly disagree	1	2	3	4	5	strongly agree

b. In my **second field placement**, I got to teach a lot of science.

Strongly disagree	1	2	3	4	5	strongly agree

Comments or suggestions:

APPENDIX H

INFORMED CONSENT LETTER

Georgia State University
Department of Early Childhood Education
Informed Consent

Title: Development of Interest in Science and Interest in Teaching Elementary Science: Influence of Informal, School, and Inquiry Methods Course Experiences

Principal Investigators: Faculty Supervisor: Olga S. Jarrett
Student Principal Investigator: Mizrap Bulunuz

I. **Introduction/Background/Purpose:**

There is little research examining how preservice elementary teachers develop interest in science and interest in inquiry science teaching. This dissertation study has three parts. The first part of the study identifies various science background experiences that predict students' initial interest in science. The second part connects level of inquiry and personal ratings of activities in the course. The third part ascertains the effectiveness of the course in the development of positive interest/enjoyment with regard to science and science teaching. Potentially, the participants in the study are the 53 undergraduate preservice teachers.

II. **Procedures:**
In this course you were asked to fill out various surveys. Initially you completed Science Teaching Survey I in which you rated your interest and enjoyment with science. During each class you rated the class activities (learning stations and discovery tubs) on fun, interest, and learning quality. Toward the end of the semester, you filled out a Science Background Experiences Survey. At the final session of the course, you filled out Science Teaching Survey II and a Course Rating Survey. Completing the surveys took from 1-2 minutes for the activity ratings up to 20 minutes for the background survey. All surveys were done in class.

III. **Risks:**
There are no expected risks to you from participating in this research. The surveys are kept in a secure place by Dr. Jarrett, and your instructor will not be able to match identifying information with your answers.

IV. **Benefits:**
The purpose of the first part of this study is to ascertain the connection between the quality and type of background science experiences and preservice teachers' interest in science. A finding that childhood experiences are important factors would have implications for choice of toys, exposure to informal experiences, and early childhood schooling. Importance of science in upper grades and college and ratings of preferred high school and university courses would have implications for content preparation in teacher preparation. The second part of the study explores the relationship between motivational variables, *fun, interest,* and *learning,* and the inquiry levels of course activities. A positive relationship between the inquiry level of the activities and these motivational variables would suggest the need to include activities with higher levels of inquiry in teacher preparation programs, both to capture the interest of the teachers and to model how they can make science more engaging for the children.

1

APPROVED *Consent Form Approved by Georgia State University IRB April 27, 2006 - April 26, 2007*

The third part of the study evaluates the effectiveness of the science methods course in the development of interest in science, interest in teaching science, and choice to teach science A finding that students are more interested and motivated at the end of the course and that course variables positively contribute to interest in teaching science would suggest that active engagement with fun, interesting inquiries should be incorporated into science methods courses. You have benefited personally through opportunities to reflect while answering the surveys. A report of the findings will be available if you request it.

V. **Voluntary Participation and Withdrawal:**

Filling out the surveys and participating in the various instructional interventions were part of the course experience. By signing this consent letter, you are granting permission for your survey answers to be used in the research. Your participation in this research is voluntary. You have already received your grades in this course and whether or not you agree to have your answers used in the research therefore can have no effect on your grade. Withdrawal from the study without adverse consequences is possible until all identifying information is removed from the data sheets (see following section). After that, it will impossible to remove data.

VI. **Confidentiality:**

You have written the last four digits of your social security number rather than your name on the surveys. Dr. Jarrett is storing the data in a secure location in her office and your answers will not be accessible to your instructor. Once Dr. Jarrett matches the surveys with the permission letters, the last four digits will be removed and a new code number assigned for computer entry purposes. You will not be identified in any way when we present this study or publish its results.

VIII. **Contact Persons:**

If you have any questions or additional concerns about this study please contact Dr. Olga S. Jarrett (ojarrett@gsu.edu) or Mizrap Bulunuz (ecembbx@langate.gsu.edu), both at (404) 651-2584. If you have any questions or concerns about your rights as a participant in this study, you may contact Susan Vogtner in the Office of Research Integrity at 404- 463-0674 or svogtner1@gsu.edu.

IX. **Copy of Consent Form to Subject:**

We will give you a copy of this consent form to keep.
If you are willing to volunteer for this research, please sign below.

__________________________________ ____________
Subject Date

__________________________________ ____________
Principal Investigator Date