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Museum -based learning: Informal learning settings and their role in student motivation and achievement in science

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MUSEUM-BASED LEARNING: INFORMAL LEARNING SETTINGS AND THEIR ROLE IN STUDENT MOTIVATION AND ACHIEVEMENT IN SCIENCE

By

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ABSTRACT

This study examined changes in student motivation and achievement in science in relationship with a visit to the IDEA Place Experiment Gallery. The study was based on the pretest-posttest control comparison group design with four treatment groups: control, exhibit, lesson, and exhibit/lesson. The sample was 228 sixth grade students from a public north central Louisiana school who were randomly assigned to one of the four experimental groups. Pretest, posttest, and delayed posttest measures of intrinsic motivation and achievement in science were determined using the Children's Academic Intrinsic Motivation Inventory and an achievement test written to measure areas of science incorporated in the Experiment Gallery exhibits. The data were analyzed using a one way Analysis of Variance (ANOVA), dependent *t* tests, and Pearson *r*. Statistical analysis revealed: (a) no significant differences in motivation or achievement on pretest and posttest scores between groups and, (b) no significant relationships between motivation level and achievement between groups on the posttest. Significant differences were found within groups for (a) the lesson group in motivation, and (b) the exhibit group in achievement from pretest to posttest and from posttest to delayed posttest. A significant relationship between level of motivation and science achievement was revealed for the exhibit group on the delayed posttests. There were no other significant findings to support that the effects of the treatment led to any long term effects on motivation or achievement within any of the four experimental groups.

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Author Julie A. Holmes

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There are so many people to thank for their love and support through this arduous process. I hope that my words convey the sincere gratitude that I feel. First I am thankful for the grace of God that gave me the knowledge and strength to do all that was required of me. I am also thankful for all the prayers sent in my behalf.

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My best friend, Mary, deserves an Honorary Doctorate and a Humanitarian of the Year Award. From the onset, she has been supportive by taking care of the house and pets when I could not, and she made a great "test hag" when I needed help studying. She would quietly tread about when I was writing and always fixed things when all seemed hopeless. I owe you big time, Mary.

And for you future doctoral students, keep a few things in mind: (a) watch your use of ampersands, (b) look out for those singular/plural mix-ups, and (c) data is a plural term. I do not know how many times I corrected those mistakes! And finally, it has been found useful to have extra print cartridges on hand…

CHAPTER ONE

Introduction/Problem

In January of 2001, quality education for America's youth became a top priority when President George W. Bush sent his No Child Left Behind plan for education reform to Congress. The resulting legislation, the *No Child Left Behind Act of 2001* (US Department of Education, 2002), (a) outlined stronger accountability of schools for improved student achievement, (b) expanded local control, (c) promoted strengthening teacher quality, and (d) emphasized using teaching methods that have been shown to be effective in improving student achievement. American schools' accountability relies heavily upon high stakes testing to measure of student achievement. In the section entitled Accountability for Results of the *No Child Left Behind Act of 2001,* it is specified that each state will be responsible for creating assessments that will measure what students should know and be able to do in reading and mathematics for third through eighth grade. The legislation further mandates that student progress and achievement will be assessed according to these tests and that every child will be tested every year. Therefore, administrators and teachers are continually searching for strategies that will help them reach the goal of improved student performance.

While most of the emphasis on student achievement has traditionally centered on reading and mathematics, other subject areas are being considered as integral components for overall improvement in students' test scores. Science, for example, has taken on more importance in the advancement of student achievement. As an illustration, since 1993, the National Science Foundation (NSF) has sought to improve student achievement in mathematics and science in 21 urban school districts (Hoff, 2001, July 11). A comprehensive approach of professional development for teachers and standards-based teaching resulted in higher test scores, as well as an increase in minorities enrolling in advanced level courses.

However, most American students are not excited about science, according to Ye, Wells, Talkmitt, and Ren (1998). These researchers investigated and compared American and Chinese secondary student achievement, their attitudes toward science, and various other factors that may contribute to their science learning. The results that are pertinent to this study showed that American students take science classes because they are required, dislike science because of too much memorization, and find the mathematics in science to be difficult. The reason that students feel this way about science is due, in part, to the methods that teachers use to teach science as well as to their poor science background knowledge (Havasy, 2001, November 7). Hoff (2001, November 28) stated that teaching science by memorizing facts and vocabulary words is inappropriate because students are not required to connect this knowledge into a cohesive picture of how the world works and how we come to know it. Havasy (2001, November 7) also claimed that science education to most adults was synonymous with passive learning and memorization.

So, how do teachers get students interested and motivated to learn science? Havasy (2001, November 7) stated, "We need a revolution in the way we teach science" (p. 49). She suggested that to increase learning in science, teachers need to give students a reason to want to learn science. Connections need to be made between science and the world in which students live, or, in other words, science needs to be related to the students' real world experiences. When science is practical, it is more dynamic and memorable to students.

The revolution that Havasy (2001, November 7) alluded to is inquiry-based learning in science. She noted that the same information that is taught using traditional teaching methods can be taught, often more effectively, through inquiry-based learning. Not only does student achievement improve in science when using inquiry-based teaching methods, but interest and motivation are also stimulated (Fouts & Myers, 1992; Freedman, 1997). Inquiry-based learning guides students' natural curiosity by encouraging investigation and discovery. This, in turn, can make science relevant in students' lives.

Alternative learning environments other than the classroom also need to be considered by teachers. Informal learning settings, such as libraries, museums, and zoos, can provide teachers with another venue in which to improve student achievement, support interest, and develop motivation to learn more about a particular area of study (Bartels, 2001, September 19). Often these types of settings are considered an afterthought in the education reform movement, although they are viewed as valuable public education environments, according to Bartels. This is, he stated, "a case of missed opportunity" (p. 45). In terms of science museums in particular, Bartels claimed that they support inquiry-based learning and a shift in students and teachers' attitudes "from a third person relationship (science that others do), to a first person relationship (science that I can do)" (p. 45). Informal science institutions also have unique features that makes them advantageous to educational reform, such as promoting science in an accessible form, creating direct experiences, and providing support for teachers.

Purpose of the Study

The purpose of this study was to examine whether there are changes in student motivation toward science and achievement in science when informal learning settings, namely a visit to a science museum, are used. The researcher also wanted to determine if different levels of intrinsic motivation affected the quality of learning, that is, do students who are assessed as having certain levels of motivational attitudes toward science experience superficial learning or deep learning of content. Finally, through the course of the study the researcher observed if different levels of intrinsic motivation could be created in groups of students by using different methods of instruction.

Justification for the Study

Science education came to the forefront of K-12 curriculum in the United States in 1957 when the Soviet Union launched the first man-made satellite, Sputnik I, to orbit the Earth. This prompted the federal government to make a significant investment in curriculum to train future scientists to further the United States space program (Hoff, 2000). In 1958, Congress passed the National Defense Education Act, which gave the National Science Foundation (NSF) money to invest in curriculum development. With financial support from the NSF, curricula were rewritten in physics, biology, chemistry, and mathematics. Hoff stated that the reasoning behind the push for curricular change was the assumption that schools were not teaching the theory supplementing the discipline. Science textbooks only showed simple functions of everyday objects while ignoring basic theory.

It was at this point, in the early 1960s, that NSF funded projects focused on giving students learning experiences to be active participants in their learning (Hoff, 2000). The intent was to have students who were able to apply what they had learned in many situations. Thus, inquiry-based science was born and science became a main topic of concern. The executive director of the National Science Teachers Association, stated that one of the most important outcomes of the NSF's science initiatives was that it made science a standard part of the curriculum in elementary school. In addition, the NSF provided a series of professional development courses to train teachers how to use the new curricula.

Open education was at the forefront from the late 1960s until the mid 1970s. This style of teaching typically stressed giving choices to students and allowed free experimentation, exploration, and hands-on learning activities (Bradley, 2000). Curriculum was a minimal concern, and the process of learning was the main goal, not the knowledge acquired. The main idea was to have students who believed that they were really scientists and who internalized the subject content so that they could really accomplish something with what they knew.

In 1983, the federally commissioned report *A Nation at Risk* brought out inadequacies in American schools, and the NSF was brought into curriculum development again. Goals were also set for American schools to produce students who were able to master challenging subject matter and to be first in the world in mathematics and science achievement (Manzo, 2000). This led to the advent in the late 1980s of translating these goals into academic standards that outline what students should know and be able to do. At the same time, a resurgence occurred in the development of elementary science curriculum leading back to the use of hands-on, developmentally appropriate activities (Frederick & Shaw, 1999).

During 2001, the NSF awarded grants for informal science education, instructional materials development, and teacher enhancement. These projects range in length from one to five years with awards of $25,000 to nearly $6 million (NSF, 2001). Other associations have been formed that are concerned with science issues as well. For example, the American Association for the Advancement of Science, concerned with reforming science, mathematics, and technology education, began Project 2061 to identify what is most important for the next generation to know and be able to do and what would make it become literate in science (Nelson, 1999).

History of the Science Museum

The history of the science museum can be traced back to the Age of Enlightenment, when Francis Bacon (1561-1626) proposed to develop a museum of discoveries, including a portrait gallery of famous inventors (Salmi, 1993). Europe can be credited with two of the earliest science museums in the world. The Ashmolean Museum at Oxford was established in 1683 through gifts of private collections (Lycos, Inc., 2002c). Rene Descartes also developed a proposal for a museum that would showcase scientific instruments and models of mechanical devices, which led to the establishment of the Conservatoire des Arts et Metiers in Paris in 1794 (Salmi). In the United States, the first science museum was founded by the Charleston, South Carolina, Library Society in 1773 (Lycos, Inc., 2002a).

According to Salmi (1993), the advent of the hands-on interactive science museum can be traced to the late 1920s and 1930s, when educational philosophy in the United States revolved around the theories of Dewey and Kilpatrick. These two educators are considered to be the founders of progressive educational practice (Olson, 2000b). They believed that students learned by putting their thoughts into action. The interactive concept agreed with the importance of the learner being actively engaged in the learning process in their philosophies. Prior to this time, Salmi reported that traditionally, exhibits were labeled with "hands off!" signs, which led to the new style of exhibit being called "hands-on" (p. 33).

While most of the science museums in the world are located in North America and Europe, Lycos, Inc. (2002b) noted that major cities in Australia, New Zealand, Africa, and Latin America also have excellent facilities with collections in local natural history and ethnology. Currently, the Association of Science-Technology Centers (ASTC, 2002) reported having 445 members in 43 countries, with 355 of these members in the United States. Overall, these institutions serve more than 177 million people annually.

Science centers also can be considered as an "integral part of global educational infrastructure" (ASTC, 2002, p.1). In a survey conducted of its members in 2000, ASTC found that of the 169 museums reporting data, 17 million schoolchildren were served each year through field trips and outreach programs. Because not all science centers are members of ASTC, it can be assumed that the actual number of school-aged children who annually participate in and have experience with science centers would be much higher than reported.

The contemporary science museum is seen to have three functions: (a) exhibition of collections, (b) sponsoring research, and (c) education (Lycos, Inc., 2002c). Many museums provide guided tours, classes, and lectures, and collaborate with schools by loaning exhibitions and conducting special programs for children. The significance of this study in the contribution of the science museum's functions of research and education are appropriate. The results of this study could add to the body of knowledge about informal learning settings and museum-based learning, help make these settings more effective as contributors to the goal of improved student achievement, help students develop better attitudes and become more intrinsically motivated toward science.

The significance of this study also refers back to many of the topics aforementioned. Both federal and state governments are pushing public schools toward a standards-based reform. Accountability ratings in the PK-12 public schools are the focus of many news stories (Galley, 2001, September 19; Hasten, 2002, May 3; Hill, 2002, July 20; Olson & Robelen, 2002, July 10; Richard, 2001, November 28). The textbook is most likely the major tool teachers depend on for guidance in instructing students in various subjects. Manzo (2000) stated, "Teachers rely on them [textbooks] to organize lessons and structure subject matter" (p. 147). Now they are finding that textbooks and materials that they have relied upon so heavily in the past as the body of content that needs to be taught, rarely adequately match the adopted standards. This is mainly because the needs of the states with the largest textbook adoptions, namely California, Texas, and Florida, exert the most leverage on textbook publishing companies, even though they strive to make them marketable to all (Manzo). In order to meet the demands of teaching toward the content standards and meeting school accountability score achievement goals, teachers need to consider alternative sources and methods in which to adequately teach students the specified body of knowledge. Miettinen (1999) stated,

> The object of school learning is primarily the school text, now mainly in the form of grade-specific standard textbooks and packaged materials. To expand the limits of school learning, new kinds of objects-societal activities, knowledge in use-and a corresponding collective subject, a network of learning, are needed. (p. 342)

Educators are beginning to realize that mathematics and reading are not the only areas in which students need effective teaching methods to help them achieve. Hoff (2001, November 28) reported that in 2000, high school seniors' scores on the federal science exam fell from 1996 and the scores posted by fourth and eighth graders showed no change from 1996 to 2000. It is apparent that teachers need assistance in improving student achievement in science. Science museums have the potential to be a significant and valuable adjunct to the formal education setting of the classroom (Borun, 1983). Museums and other informal learning settings can be like an informal classroom (Bartels, 2001, September 19). Specifically, science institutions can create direct experiences with scientific phenomena that would not be accessible to students in the typical public school. Borun noted that the visual and kinesthetic learning experiences provided by participatory science museums are qualitatively different from classroom lessons. The three-dimensional aspects displayed in science museum exhibits allow for active exploration of scientific principles using real objects. They can also act as a significant support system to the PK-12 schools by providing professional development for teachers and resources to assist teachers in supplementing current adopted science textbooks in order to more fully meet curriculum requirements.

The results of this study will help administrators and teachers to consider these alternative learning settings when looking for effective methods to help students learn. It is also significant to note the lack of student interest in science (Ye et al., 1998). Science museums can provide an exciting environment to spark interest in science and ultimately have the potential to influence motivation and impact student achievement.

Theoretical Framework

The study was based on the activity theory model. This theory has historical origins from three distinct areas: (a) German philosophy, (b) the works of Marx and Engels, and (c) the cultural-historical psychology of Soviet Russian psychologists Vygotsky, Leont'ev, and Luria (Engestrom, 1999). Activity theory is based upon several dimensions. Engestrom defines activity "as an object-oriented and cultural formation that has its own structure" (p. 21). Various forms of activity can be seen as being goal-directed or object-related. Activity can also be viewed as tool-mediated (object-based) or sign-mediated (language-based). Internalization, or the process of being able to do a task at an instinctive capacity, is a strong construct that dominates activity theory.

Within this section, the development of activity theory by Vygotsky will be reported, along with the work of Leont'ev that expanded activity theory. Finally, a contemporary model of the theory as developed by Engestrom will be discussed; the model illustrates the components and interrelations of an activity system.

Vygotsky

Lev Vygotsky (1896-1934) was a prominent Russian psychologist whose work centered on cognitive growth and development. Vygotsky began his career in psychology by giving lectures at a teacher's college, even though he never had any formal training in psychology. From this, he became known as a new, unexpected voice with a fresh perspective in the newly emerging field of Soviet psychology (Kozulin, 1990). In the early 1920s, Vygotsky worked with Alfred Luria and Alexei Leont'ev. The result of this work was the discovery of patterns in cognitive growth that could be compared to the work of Piaget.

To understand Vygotsky's theory, it is essential to have an initial framework of his perspective of cognitive development. Vygotsky believed that there is a continual interaction between instruction and development (Howe, 1996). He viewed learning not as the cause of development but as the process whose outcome was development (Hausfather, 1996). Kozulin (1996) stated that Vygotsky believed that behavior and the mind needed to be thought of in the context of purposeful and culturally worthwhile activity and not as a biological response. The environment is the driving force that determined development, and, according to Vygotsky, is a major factor in creativity (Good & Good, 1999). He also believed that development was gradual, that cognitive competence steadily grew as a child aged. In summation, Vygotsky can be described in two distinct fashions. He was an environmental determinist, believing that language and social interactions are critical in the developmental process. The historical attributes of human behavior are drawn extensively from the experiences of previous generations, according to Vygotsky's view. The social character of being human combined with the accessibility to interpersonal communication also allows for a wealth of experiences to be drawn upon from others (Kozulin, 1990). Vygotsky can also be known as a continuous theorist, believing that cognitive development persists in a continual upward progression.

According to Vygotsky, motor activity and perception are interconnected. Thus, every perception incites activity. This is a key point in defining Vygotsky as an environmental determinist. The social environment of the child determines to a great extent the perceptions of the world that are developed and the activities in which the child chooses to engage. In a cyclic fashion, this in turn contributes to the specialized reasoning abilities that the child develops and assimilates into his or her repertoire of thinking skills.

Another critical element of Vygotsky's theory is cognitive development as a socially dynamic process. Vygotsky viewed cognitive activity as social activity (Hood-Holtzman ,1996). Vygotsky maintained that children learn through their interaction with people and objects (Good & Good, 1999). Vygotsky (1978) stated that imaginary play is a specifically human form of conscious activity. Play, in essence, is the child's memory put into action. What the child has perceived in his or her environment directs the actions the child may take within certain settings.

In learning, Vygotsky believed a host of internal processes are aroused in the child, which can only function through interaction with the environment and in collaboration with other people and peers. Learning drives development and creates what Vygotsky termed as the zone of proximal development (ZPD). It is within the ZPD that Vygotsky's theory of learning and development finds its continuity and makes clear its importance to educational practices (Hausfather, 1996).

Vygotsky (1978) defined the ZPD as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86). Dever, Zila, and Manzano (1994) described the parameters of the zone by the lower boundary being what the child can do on his or her own. The upper boundary of the zone is the level where a child needs guidance in order to accomplish a task. The gap between these parameters is the ZPD, where learning can be stretched beyond what the child can accomplish independently.

Kozulin (1990) also stated that the ZPD taps into psychological processes that are in the midst of development. The zone may be filled with informal concepts which, with the established reasoning of an expert (an adult or more capable peer), can be incorporated with present knowledge, making a transition from the known to the unknown. Ferrara, Brown, and Campione (1986) also mentioned that the size of the ZPD could vary. Those children who possess a wide ZPD are efficient learners that require minimal assistance, while those children with a narrower ZPD will tend to need much more assistance.

Leont'ev

Alexei Leont'ev (1904-1979) started his lifelong career in psychology at Moscow State Lomonosov University (MSLU) in 1921, studying psychology in the historical-philological department (Marxists.org Internet Archive). Upon graduation in 1924, Leont'ev began working closely with Vygotsky. In 1950, Leont'ev was appointed head of the psychology department at MSLU and remained faculty dean and head of the department until his death in 1979.

Leont'ev studied memory and attention and developed his own theory of activity. While Vygotsky's theory of activity takes into account the importance of social interaction within an activity context, Leont'ev believed that activity is a collective system incited by an object and motive and is realized through an individual's actions initiated by goals (Marxists.org Internet Archive). He brought activity theory into its second generation by explaining the distinction between collective activity and an individual activity. Activity, action, and operation became the foundation of Leont'ev's three-level model of activity (see Figure 1).

Level	Oriented toward	Carried out by
Activity	Object/Motive	Community
Action	Goal	Individual or Group
Operation	Conditions	Routinized Human or Machine

Figure 1: Leont'ev's Three Level Model of Activity (Center for Activity Theory and Developmental Work Research, a)

Leont'ev's first level of the model shows that the person demonstrates his or her individuality through social activity under social situations that necessitate the goals and motives of the activity. Leont'ev (1978) stated that it did not matter whatever kind of conditions and forms of activity happened, the activity cannot be isolated from social relations and is included in the systems of relationships within society. These same conditions carry within themselves motives and goals of his or her activity. In other words, "Society produces the activity of the individuals forming it" (p. 51).

The development of activity transforms the needs of the individual and creates new needs (Leont'ev, 1978). The activity of people transforms the world in conjunction with their needs and the needs that the world determines for them (Axel, 1997). The object acts as a major determinate of the direction of activity, according to Leont'ev. The difference in objects is the main instrument that separates one activity from another. The object in the activity, as noted in Figure 1, is its true motive (Leont'ev). Thus, Leont'ev stated, the idea of activity is connected to the idea of motive in that "all behavior is motivated" (p. 40) and "activity does not exist without a motive" (p. 62).

The second level of Leont'ev's model revolves around the action itself. There is a difference between activity and action; they are *non-coinciding* (Leont'ev, 1978). One action may actually bring about various other activities and may carry over from one activity to another. The action, therefore, is the primary component of activity. The action is the manner of comprehending the activity and, as a result, fulfills the motive. Atkinson (1964) added that all ideas have a relationship with some path of action. The actions that effect activity, according to Leont'ev, are stimulated by its motive but actually appear to be directed to a goal. The distinctive feature of an action, in Leont'ev's perspective, is the fact that it is always goal-oriented and it aims at satisfying a specific goal.

The operational part of activity theory of Leont'ev's model refers to the specific circumstances that surround the performance of the action. Operations form the means by which the action is carried out. This is driven by the tools and conditions of the action that are at hand and are dependent upon them. Leont'ev (1978) stated that the activity of each person depends on his place in society and on the conditions in which he or she lives. This circumstance contributes to the unique, individual circumstance. Not only does the individual accommodate his or her activity, but Leont'ev stated that social conditions also contribute to the goals and motives of the individual.

The routinized human/machine refers to that which is automatic. The reference to the machine is that a machine will perform tasks in a routine manner. The routinized human refers to the things that a person will do in an automated way.

Engestrom

Yrjo Engestrom (b. 1948) earned his doctorate in education from the University of Helsinki. He is the director of the Center for Activity Theory and Developmental Work Research, which is located at the University of Helsinki, and he is a professor of communication at the University of California at San Diego. His work is grounded in the cultural historical activity theory of Vygotsky and Leont'ev. In his earliest research, Engestrom developed a theory of expansive learning. He has conducted research in schools, as well as hospitals, courts, banks, factories, and other work sites.

Leont'ev never graphically expanded the original model of activity theory proposed by Vygotsky into a model of the collective activity system. It is here that Engestrom enters the picture of activity theory. Engestrom developed a model (Figure 2) that reflects the collective activity system and developed the theory of learning activity and the theory of learning by expanding.

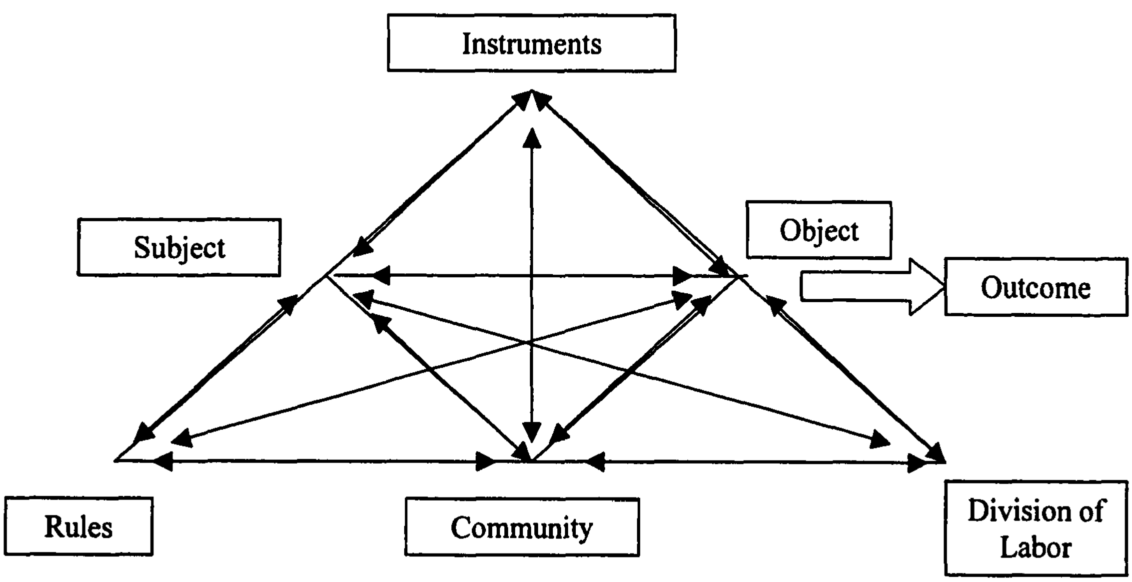

Figure 2: Engestrom's Structure of a Human Activity System
(Center for Activity Theory and Developmental Work Research, b)

The subject in Engestrom's model takes into account not only the individual, but also the larger group of which the individual is a member. The object still remains as the central issue in this model of activity theory because it is the connecting factor of the individual's actions to the collective activity (Engestrom, 1999). The instruments are also referred to as mediating artifacts in some diagrams of Engestrom's model (Engestrom, 1999). The rules are the policies of the organization and the guidelines that are acceptable. The division of labor concerns the differences that the group may hold, such as different languages, disciplines, nationalities, and schools of thought. The community is comprised of all persons who are motivated by activity theory around the world.

The arrows in the model show that all the components of the activity model interact with one another. Also, the activity system does not exist in isolation. It interacts within a network of other activity systems. Rules may be from one activity system, for example, while outcomes may be produced for other activity systems. This model makes it possible to analyze a multitude of relations within the activity system.

In Engestrom's (1987) model, each of the outer sub-triangles is labeled with the three dominant aspects of human activity: (a) production, (b) distribution, and (c) exchange. Production correlates with the uppermost sub-triangle, distribution with the lower right sub-triangle, and exchange with the lower left sub-triangle. Each of these sub-triangles has the potential to be an activity of its own. The central sub-triangle is labeled consumption, because it is a function of the other three sub-triangles.

Research Questions/Hypotheses

The following six research questions were investigated in this study:

1. Is student motivation in science related to museum-based learning?
2. Is student achievement in science related to museum-based learning?
3. Do different kinds of motivation affect the quality of learning (deep, lasting learning of content or superficial, short term learning) in science?
4. Do different treatment conditions create different levels of motivation toward science in groups of students?
5. Do different treatment conditions create different levels of science achievement in groups of students?
6. Are the effects of museum-based learning long lasting in terms of intrinsic motivation and science achievement?

In conjunction with these research questions, the following hypotheses were tested:

1. There will be a significant difference in intrinsic motivational levels between students who experience museum-based learning and those students who do not experience museum-based learning.
2. There will be a significant difference in achievement in science between students who experience museum-based learning and those students who do not experience museum-based learning.

3. There will be a significant relationship in the students' level of intrinsic motivation and the quality of learning (deep, long lasting learning of content or superficial short term learning) with regard to the treatment they experience.
4. There will be a significant difference between the levels of intrinsic motivation toward science that students possess as a result of the treatment they received (control, exhibit, lesson, exhibit/lesson).
5. There will be a significant difference between the levels of science achievement that students possess as a result of the treatment they received (control, exhibit, lesson, exhibit/lesson).
6. There will be a significant difference between the long-term assessment of the level of intrinsic motivation that students possess as a result of the treatment they received (control, exhibit, lesson, exhibit/lesson).
7. There will be a significant difference between students who experience different treatments (control, exhibit, lesson, exhibit/lesson) and the long-term assessment of science achievement.

Definitions

For the purposes of this study, the following terms are defined:

Academic extrinsic motivation-This term depends on the needs satisfied by external reinforcers. These actions are performed, not because of interest in the behavior, but because they are instrumental in achieving some other goal (Deci, Vallerand, Pelletier, & Ryan, 1991).

Academic intrinsic motivation- This term is defined by Gottfried (1985) as, "enjoyment of school learning characterized by an orientation toward mastery, curiosity, persistence, and the learning of challenging, difficult, and novel tasks" (p.631). Behavior that is intrinsically motivated is done for its own sake, because joy and satisfaction are derived from the activity (Deci et al., 1991).

Achievement- Achievement, as operationally defined by this researcher, is the gain in knowledge in science, demonstrated by an improved score on the researcher-designed achievement test.

Activity-A systemic formation and unit of analysis for human sciences. It is a collective system driven by an object and a motive and is realized through actions driven by goals (Leont'ev, 1978). Activity, in conjunction with this study, concerned the actions the participants completed within the study (lesson, exhibits, and posttests), the objects that incited their activity, and the motives and goals associated with the actions.

Activity theory- An interdisciplinary approach to human sciences that originates in the cultural-historical psychology school, initiated by Vygotsky, Leont'ev, and Luria. It takes the object-oriented, artifact-mediated collective activity system as its unit of analysis, thus bridging the gulf between the individual subject and the societal structure (Engestrom, 1999).

Deep learning of content-Salmi (1993) refers to deep learning as meaningful learning. This is associated with intrinsically motivational attitudes, such as curiosity, interest and problem-based learning.

Docent-an explainer in a museum (Gilbert & Priest, 1997) or "a person who serves as a well-informed guide, as in a museum" (Reader's Digest Oxford Complete Wordfinder, 1996, p. 422).

The Experiment Gallery-The Experiment Gallery was designed and constructed by the Science Museum of Minnesota through support of the NSF. It consists of more than 25 interactive exhibits based on five theme areas: (a) electricity, (b) light and optics, (c) mechanics, (d) sound and waves, and (e) weather, plus an Activity Station that provides visitors the opportunity to experience fun hands-on science activities supervised by the IDEA Place staff.

The IDEA Place-The IDEA Place (Investigate, Discover, Explore, Ask) is a children's mathematics and science museum that functions as part of Louisiana Tech University's science and technology education center (SciTEC). The IDEA Place opened for the first time in April 1994. Since then, more than 40,000 K-12 students from north Louisiana, Arkansas, and Mississippi have visited the IDEA Place. The IDEA Place also manages the planetarium and houses the NASA Educator Resource Center (ERC) for Louisiana.

Informal learning settings-The NSF (2001) defines informal learning as the lifelong process in which every person acquires knowledge, skills, attitudes, and values from daily experiences and resources in his/her environment. It occurs outside a formal classroom setting and is not part of a school program, activity, or assignment. Some informal learning settings listed by Salmi (1993) include science centers, museums, libraries, art museums, zoos, and mass media.

Long term assessment-The researcher defined long-term assessment as the delayed posttests for motivation and achievement administered one month after the treatment.

Motivation- To stimulate a person's interest in an activity whereby goal-directed behavior is instigated and sustained (Schunk, 1990). This term, as operationally defined by this researcher, is assessed by the participant's score on the *Children's Academic Intrinsic Motivation Inventory* (Gottfried, 1985).

Museum-based learning-This term is also referred to as museum education. It is the learning that takes place through a visit to a museum (Borun, 1983).

Psychological tools- A mental tool, which extends our natural capability to remember. The connections made through the use of tools cause the transformation to higher mental processes (Vygotsky, 1978).

Semiotic mediation- This is the process by which natural lower forms of mental behavior are transformed into higher, cultural forms of behavior through the use of what Vygotsky (1978) called *signs* or *psychological tools*. Mediators can be signs and symbols, but they can also be individual activities and interpersonal relations (Kozulin, 1990). These signs and tools give one control over his or her mental behavior. They allow one the power to change and regulate natural forms of thinking and behavior, which is a unique human trait.

Superficial learning-This term is referred to as surface learning by Salmi (1993). Surface learning is easily aroused by extrinsic motivational factors such as only learning the material to pass a test and then quickly forgetting it.

CHAPTER TWO

Review of the Literature

Science plays a central role in our economic lives, as well as our cultural and political lives (Centre for the History of Science, Technology, & Medicine, n.d.). The sciences impact all aspects of the industrialized society in the processes used to manufacture goods and provide us with the information that we depend upon to make wise consumer choices. Modern medicine is immersed in science, and technology as an integral part of people's daily lives. Yet, despite the growth of the roles of science and technology in society, a science literate population barely exists (Nelson, 1999). School curricula in science needs to emphasize depth of knowledge, not the breadth of information that is the current trend (Eylon & Linn, 1988; Nelson 1999). Screven (1993) reported that formal resources are sought to fulfill science educational needs, yet informal settings offer virtually untapped potential for communicating scientific information, correcting misconceptions, and improving cognitive skills and attitudes toward science. The review of the literature will specifically provide an explanation of the theories that support the study and many of the issues mentioned above as they apply to this study. The role of the theoretical framework for the study, activity theory, will be reported first and its effects on student motivation and achievement. Inquiry-based science will be explored, and its role in student motivation and achievement in science will also be reported. Field trip experiences and museum-based learning, and the effects of museum-based learning on motivation and achievement in science will also be discussed.

Activity Theory

This study is based on activity theory. This theory has historical origins from three distinct areas: (a) German philosophy, (b) the works of Marx and Engels, and (c) the cultural-historical psychology of Soviet Russian psychologists Vygotsky, Leont'ev, and Luria (Engestrom, 1999). Activity theory is based upon several dimensions. Engestrom defines activity "as an object-oriented and cultural formation that has its own structure" (p. 21). Various forms of activity can be seen as being goal-directed or object-related. Activity can also be viewed as tool-mediated (object-based) or sign-mediated (language-based). Internalization, or the process of being able to do a task at an automatic skill, is a powerful construct that dominates activity theory.

Within this section, the development of activity theory by Vygotsky will be reported, along with the work of Leont'ev that expanded activity theory. Finally, a contemporary model of the theory as developed by Engestrom will be discussed; the model illustrates the components and interrelations of an activity system.

Vygotsky

Lev Vygotsky (1896-1934) was a prominent Russian psychologist whose work centered on cognitive growth and development. Vygotsky began his career in psychology by giving lectures at a teacher's college, even though he never had any formal training in psychology. From this, he became known as a new, unexpected voice with a fresh perspective in the newly emerging field of Soviet psychology (Kozulin, 1990). In the early 1920s, Vygotsky worked with Alfred Luria and Alexei Leont'ev, and the result of this work was the discovery of patterns in cognitive growth that could be compared to the work of Piaget.

Eventually, Vygotsky's work came to the United States in the early 1960s (Good & Good, 1999). He has been referred to as one that "possessed Mozartian genius, yet lived in a time and place that was not receptive to Mozarts" (p. 1, Best Practices in Education). While Vygotsky's work has been recognized in other disciplines, the application of his theory is somewhat recent in education. He is considered to have pioneered developmental psychology and made significant contributions to child development and education (Good & Good).

To understand Vygotsky's theory, it is essential to have an initial framework of his perspective of cognitive development. Vygotsky believed that there is a continual interaction between instruction and development (Howe, 1996). He viewed learning not as the cause of development but as the process whose outcome was development (Hausfather, 1996). Kozulin (1996) stated that Vygotsky believes that behavior and the mind need to be thought of in the context of purposeful and culturally worthwhile activity and not as biological response. The environment is the driving force that determines development, and, according to Vygotsky, is a major factor in creativity (Good & Good, 1999). He also believed that development was gradual, that cognitive competence steadily grew as a child ages. In summation, Vygotsky could be described in two distinct fashions. He was an environmental determinist, believing that language and social interactions are critical in the developmental process. The historical attributes of human behavior are drawn extensively from the experiences of previous generations, according to Vygotsky's view. The social character of being human combined with the accessibility of interpersonal communication also allows for a wealth of experiences to be drawn upon from others (Kozulin, 1990). Vygotsky can also be regarded as a continuous theorist, believing that cognitive development proceeds in a continual upward progression, not in stages. Daniels (1996) identified his reliance on a genetic, developmental assumption as one of the three major themes of Vygotsky's theoretical approach.

By the mid 1920s, Vygotsky had determined the problem that he would concentrate on for the remainder of his brief career as a psychologist: what is uniquely human behavior (Kozulin, 1990). The theory he developed was based on numerous interrelated components. Based upon his perspective of cognitive development, Vygotsky's theoretical approach claims that a person's higher mental functions are rooted in socially mediated activity, and the use of psychological tools (Daniels, 1996; Hausfather, 1996: Kozulin, 1990). For the purposes of this study, the areas of mediated activity, use of psychological tools, and the concept of the zone of proximal development will be discussed.

Perception

In his book *Mind in Society*, Vygotsky (1978) stated that concepts are meaningful to children based on their memory due to their perception of the world. Memory is the process of an individual actively storing and retrieving information. Kozulin (1990) stated that understanding human remembering is of principal importance. For the young child, to think means to recall from the memory. Later developmental stages reflect modifications in the thinking process, and a reversal in this pattern occurs. In adolescents, to recall means to think using abstractions and establishing and finding relationships that are logical.

Vygotsky (1978) also argued that the influence of play in the child's cognitive development is monumental. Play is a compilation of recollections about the world surrounding the child, the application of these memories to imaginary situations, and the actions the child chooses to take in response to the environment. Good and Good (1999) acknowledged that play extends the Zone of Proximal Development (which will be discussed later) and is the exhibition of imagination. Kozulin (1990) also acknowledged the importance of play as a powerful basis of a child's potential for mastering symbolism.

According to Vygotsky, motor activity and perception are interconnected. Thus, every perception incites activity. This is a key point in defining Vygotsky as an environmental determinist. The environment of the child determines to a great extent the perceptions of the world that are developed and the activities in which the child will engage. In a cyclic fashion, this in turn contributes to the specialized reasoning abilities that the child develops and assimilates into his/her repertoire of thinking skills.

A final point that Vygotsky (1978) made about perception is that "any learning a child encounters in school always has a previous history" (p. 84). He named these previous experiences within the informal environment of the home *everyday concepts*. Things learned within the formalized setting of school were called *scientific concepts*, which do not necessarily relate to scientific knowledge. The reference to scientific concepts by Vygotsky is due to the scientific nature of their organization (Kozulin, 1990). Everyday concepts emerge spontaneously from the child's own thoughts and observations on the immediate world that surrounds him or her. These concepts are very contextual, unsystematic, and unorganized. Scientific concepts originate from very structured, specialized activity, and are categorized by their logical, hierarchical organization. Shepardson (1999) noted that everyday concepts alter scientific concepts and vice versa, causing change in the overall conceptual system. Howe (1996) described the everyday-scientific concept that everyday concepts develop from concrete to abstract, while scientific concepts develop from abstract to concrete. She also described the child's understanding as proceeding in a zigzag manner, making the everyday concepts fit the scientific concepts and applying the scientific constructs to everyday experiences.

Social and Object Action

Another critical element of Vygotsky's theory is cognitive development as a socially dynamic process. Vygotsky views cognitive activity as social activity (Hood-Holtzman, 1996). Vygotsky believed that children learn through their interaction with people and objects (Good & Good, 1999). Referring again to the importance of play, Vygotsky (1978) stated that imaginary play is a specifically human form of conscious activity. Play, in essence, is the child's memory put into action. What the child has perceived in his/her environment directs the actions the child may take within certain settings. Vygotsky also stated that play was actions in imaginary circumstances teaching the child to guide his or her behavior by perception and meaning. The child learns social roles through modeling and observing what is naturally occurring in his or her environment and then imitating it. Vygotsky also added, "Human forms of practical and abstract intelligence occur when speech and practical activity converge" (p. 24). The concept of activity could then be seen as an awareness of culture in a child's behavior expressed within the characteristics of gesture, play and speech systems and as a powerful source of mastering symbolism (Kozulin, 1996). Schaffer (1996) concluded that enough proof exists to suggest that cognitive systems are open to social influences and that this interaction provides an effective environment for the extension of learning.

Vygotsky believed that words shaped activity into a particular structure. This structure is continually reshaped as language allows a child to go beyond his or her previous actions and to plan future actions. Social interactions can also support a child's thought processes about events occurring in the environment (Shepardson, 1999). Wertsche and Tulviste (1996) called this the general genetic law of cultural development. This term defines the cultural development of a child appearing on two levels: on a social, interpsychological plane, then on an intrapsychological, inner plane. This building of consciousness from the outside through relationships with others unified Vygotsky's theory of behavior and the mind (Kozulin, 1996). With a supportive environment, what the child can do with help today will be done independently at a later time (Hausfather, 1996). The social environment supports the child and allows a transfer from the interpsychological plane to the intrapsychological plane, or what Vygtosky termed as internalization.

Internalization describes the process of transformation of behaviors to higher cultural forms as a process going from the external to the internal and is the essential element in the development of higher mental functions (Kozulin, 1990). Vygotsky believed that behaviors had to occur within a social context through the use of signs before the behavior could become internalized and become a part of the individual. In the instructional process, internalization was demonstrated by Dixon-Krauss (1996) in an example of a child raising her hand to ask the teacher about an unfamiliar word. The unknown word is the object that regulates, or controls, the activity of the child. The hand raised acts as a sign or communication to the teacher. The activity now becomes regulated by another (the teacher) as she offers prompting to help the child. The child then can decode the word and continue reading. Raising her hand becomes a psychological tool, a gesture that she can use at anytime and is within her control. Thus, it has become internalized and self-regulated.

Semiotic mediation was another major Vygotskian principle that is highly correlated with the concept of internalization (Dixon-Krauss, 1996). This is the process by which natural lower forms of mental behavior are transformed into higher, cultural forms of behavior through the use of what Vygotsky called *signs* or *psychological tools*. Mediators can be signs and symbols, but can also be individual activities and interpersonal relations (Kozulin, 1990). These signs and tools give one control over his or her mental behavior. They allow one the power to change and regulate natural forms of thinking and behavior, which is a unique human trait. As an illustrative example, a note written to oneself to remember something important acts as a tool, which extends one's natural capability to remember. The connections made through the use of tools cause the transformation to higher mental processes.

The Zone of Proximal Development

In learning, Vygotsky believed a host of internal processes are aroused in the child, which can only function through interaction with the environment and in collaboration with other people and peers. Learning drives development and creates what Vygotsky termed as the zone of proximal development (ZPD). It is within the ZPD that

Vygotsky's theory of learning and development finds its continuity and makes clear its importance to educational practices (Hausfather, 1996).

Vygotsky (1978) defined the ZPD as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86). Dever et al. (1994) described the parameters of the zone by the lower boundary being what the child can do on his or her own. The upper boundary of the zone is the level where a child needs guidance in order to accomplish a task. The gap between these parameters is the ZPD, where learning can be stretched beyond what the child can accomplish independently. Vygotsky also believed that only the true progress of a child's reasoning skill could be determined by discovering the difference between independent accomplishments and the child's performance when helped by an adult through instruction in the ZPD (Kozulin, 1990).

Kozulin (1990) also stated that the ZPD taps into psychological processes that are in the midst of development. The zone may be filled with informal concepts which, with the established reasoning of an expert (an adult or more capable peer), can be incorporated with present knowledge, making a transition from the known to the unknown. Ferrara et al. (1986) also mentioned that the size of the ZPD could vary. Those children who posses a wide ZPD are efficient learners that require minimal assistance, while those children with a narrower ZPD will tend to need much more assistance.

Most likely the expert in this case will be a parent or a teacher. Shepardson (1999) stated that "Teachers mediate children's learning through roles that they enact within the context of the activity: facilitator; guide and supporter; active participant; and evaluator"

(p. 622). For the ZPD to be effective, Hausfather (1996) noted that the teacher not only needs to be a willing supporter of learning but also the learner must be a willing recipient of learning.

Those who enter together into social interactions through the concept of learning within the zone come with various perspectives and differing interpretations and understandings of the task at hand (Hausfather, 1996). Although each child is an individual with unique qualities, there are common threads among children, such as knowledge and skills. Collaborative construction of knowledge happens when each individual accepts partial understanding of the other's perspective. Therefore, learning within the zone hinges upon possessing aspects of shared activity when those involved are interpersonally occupied (Hedegaard, 1996). This is the basis for scaffolding.

Jerome Bruner's definition of scaffolding, a term introduced in the 1970s, employs many of the processes that Vygotsky deemed as crucial for development through the ZPD. Scaffolding can exist in three forms: mediators, language, and shared activity. Mediators, or cultural artifacts, are both conceptual (such as language) and material (Hausfather, 1996). How language may take on an interpersonal or an intrapersonal role in this process has already been discussed. Shared activity refers to how the expert may help the learner clarify his or her knowledge.

Leont'ev

Alexei Leont'ev (1904-1979) started his lifelong career in psychology at Moscow State Lomonosov University (MSLU) in 1921, studying psychology in the historical-philological department (Marxists.org Internet Archive). Upon graduation in 1924, Leont'ev began working closely with Vygotsky. Even after he was appointed to a psychological institution in Kharkov, Leont'ev maintained a working relationship with Vygotsky. In 1950, Leont'ev was appointed head of the psychology department at MSLU and remained faculty dean and head of the department until his death in 1979.

Leont'ev studied memory and attention and developed his own theory of activity. Vygotsky's theory of activity takes into account the importance of social interaction within an activity context. The use of artifacts and the processes of internalization that occur because of these interactions are, according to Leont'ev, activities of a collective system incited by an object and motive and are realized through an individual's actions initiated by goals (Marxists.org Internet Archive). He brought activity theory into its second generation by explaining the distinction between collective activity and an individual activity. Activity, action, and operation became the foundation of Leont'ev's three-level model of activity (see Figure 1).

Activity, Object/Motive, and Community

All psychological acts are part of and the result of activities, according to Leont'ev (Hyden, 1984). Activity unifies and mediates one's relationship to the world around him. This was the missing link that Leont'ev (1978) referred to when he stated:

> [There is a need] to devise a trinomial formula to replace the stimulus-response model. [This] needed to include a middle link or term-the activity of the subject, and correspondingly, conditions, goals and means of that activity-a link that mediates the ties between them. (p. 50)

Activity, in Leont'ev's theory, is that link between the individual and the world, supplying objective information about the world surrounding the individual and also forming the basis for subjective reflection (Hyden, 1984). Hyden also stated that

Leont'ev thought that activity went "from object to activity and from activity to subjective reflection" (p. 37). In Vygotsky's understanding, instruction was the directive that brings forth new activity and development as the restructuring of consciousness through the activity (Axel, 1997). To Leont'ev, however, the person shows his or her individuality through social activity under social situations that necessitate the goals and motives of the activity. Leont'ev (1978) stated that the kind of conditions and forms of activity were irrelevant. The activity cannot be isolated from social relations and is included in the systems of relationships within society. These same conditions carry within themselves motives and goals of his or her activity. In other words, "Society produces the activity of the individuals forming it" (p. 51).

The development of activity transforms the needs of the individual and creates new needs (Leont'ev, 1978). The activities of people transform the world in conjunction with their needs and the needs that the world determines for them (Axel, 1997). The object acts as a major determinate of the direction of activity, according to Leont'ev. The difference in objects is the main instrument that separates one activity from another. The object in the activity, as noted in Figure 1, is its true motive (Leont'ev). Thus, Leont'ev stated, the idea of activity is connected to the idea of motive in that "all behavior is motivated" (p. 40) and "activity does not exist without a motive" (p. 62). There is no such thing as an objectiveless activity in the activity system (Center for Activity Theory and Developmental Work Research, a). The motive can be unconscious or conscious, according to Leont'ev. The nature of activity is, therefore, influenced by its object and motive (Miettinen, 1999). Finally, needs direct an individual's activity, and it is possible that the object itself can be motivational (Leont'ev).

Similarities exist in what Stroebe (1980) stated about attribution theory and Leont'ev's activity theory, "Attributions affect future behavior" (p. 119). People tend to interpret experiences on a consistent basis and change their self-concept in agreement with new experiences. The likely outcome of an action, according to Stroebe, is derived from past experiences with similar tasks. If one has not had a similar experience in the past, one will base his or her expectations on the general impression of relevant experiences. Atkinson (1964) made a similar assertion when he wrote that the cumulative effects of prior experience, perception, and other factors influence the direction of behavior. Leont'ev theorized that people's activities change the world in conjunction with their needs and the nature of the activity is influenced by its motive and object. Future activities for an individual may depend on their attributions, their needs, their motives, and the object. Referring to past experiences with the object, Leont'ev (1978) wrote, "In order for a sensible visible or aural image of an object to appear in a man's head, it is necessary that an active *relationship* be established between the man and the object" (p. 20, italics in the original text). Gorlitz (1980) wrote about the complex set of relations involved in a person's attributions when he stated that attributions "guide the formation of one's expectancies as to a situation's future development and that determines the actor's motivation and concrete plans of action" (p. 222). In other words, past experiences tend to guide the perceptions of the activities in which one chooses to participate, and the motivation and needs of the individual all play a part in the activity of the individual within social contexts.

Action, Goal, and Individual or Group

The second level of Leont'ev's model revolves around the action itself. There is a difference between activity and action; they are *non- coinciding* (Leont'ev, 1978). One action may actually bring about various other activities and may carry over from one activity to another. The action, therefore, is the primary component of activity. The action is also the manner of comprehending the activity and, as a result, fulfills the motive. Atkinson (1964) added that all ideas have a relationship with some path of action.

The actions that affect activity, according to Leont'ev, are stimulated by its motive but actually appear to be directed to a goal. The distinctive feature of an action, in Leont'ev's perspective, is the fact that it is always goal-oriented and it aims at satisfying a specific goal. As Leont'ev (1978) stated in his book *Activity, Consciousness and Personality*:

> For the subject himself, perception and achievement by him of concrete goals, mastery of means, and operations, of action is a method of conforming his life, satisfying and developing his spiritual and material needs, which are objectivized and transformed in the motives of his activity. (p. 91)

This statement refers to the uppermost level of the model as well as the second level. The achievement of goals through certain operations and actions help fulfill the individual's life and his or her part in society. This is accomplished completely through the motives of the activity. Weiner (1980) made a similar point regarding attribution theory; " A central assumption of attribution theory...is that the search for understanding is the 'spring of action'. Attributional inferences are retrospective, summarize a number of experiences...and are tied to self-esteem and self-concept" (p. 40). The search for understanding can be thought of as the goal to which Leont'ev referred and causes the individual to be motivated into action. Weiner also stated that many experiences, self-esteem, and self-concept are interrelated. This could be interpreted as the search for understanding (Leont'ev's goal), which stimulates one into action, is motivational, and is based on the individual's past experiences and perceptions of self.

Atkinson (1964) also referred to the perceptions of self when he discussed what a person likes, wants, or desires and what is a source of personal gratification and satisfaction. He stated, "This is what we are attracted to, seek, choose, and enjoy. We dislike and turn away from what is offensive...That *within* an individual rather than *without* incites him to action" (p. 5). This is in agreement with Leont'ev's model. The upper level states that activity is oriented toward the object and motive, the motive being within the individual. The action, being the primary component of the activity, is what the individual is attracted to. Leont'ev may disagree, however, with Atkinson's statement. The lower portion of the model, operations, is oriented toward conditions, which fall outside the individual. Also, the object in the upper portion of the model would be outside the individual. Therefore, there may be factors within and without of the individual that incites him or her into action.

Atkinson (1964) discussed the fundamental interest in studying motivation as identifying and understanding the effects of all the substantial concurrent influences which decide the direction of the individual's action as well as its vigor and persistence. He also stated that the psychology of motivation should explain the appeal of specific goals. These remarks coincide with the premises of Leont'ev's model. Each component of the model, activity, action, and operation, and the orientations of each of these are the substantial concurrent influences that Atkinson argued directed action. These statements by Atkinson are especially applicable to the proposed study. It will be interesting to see how the treatments influence the individual's action and its vigor and persistence.

The final level of Leont'ev's model implies that either the individual or a group carries out the action and goal. Leont'ev stated that whatever the conditions and forms of human activity, it is not isolated from social relations and society. While the individual acts as an individual at times, all actions are based within the scope of society, according to Leont'ev, which gave his impression of activity theory the label of a collective activity system.

Operation, Conditions, and Routinized Human or Machine

The operational part of activity theory in Leont'ev's model refers to the specific circumstances that surround the performance of the action. Operations form the means by which the action is carried out. This is driven by the tools and conditions of the action that are at hand and are dependent upon them. Leont'ev (1978) stated that the activity of each person depends on his or her place in society and on the conditions in which he or she lives. This circumstance contributes to the unique, individual circumstance. Not only does the individual accommodate his or her activity, but also Leont'ev stated that social conditions also contribute to the goals and motives of the individual.

The routinized human/machine refers to that which is automatic. The reference to the machine is that a machine will perform tasks in a routine manner. The routinized human refers to the things that a person will do in an automated way. Leont'ev used the example of learning to drive a car to illustrate this point:

> Initially every operation, such as sifting gears, is formed as an action subordinated specifically to this goal and has its own conscious 'orientation basis'. Subsequently this action is included in another action...for example, changing the speed of the car. Now shifting gears becomes one of the methods for attaining the goal, the operation that effects the change in speed, and shifting gears now ceases to be accomplished as a specific goal-oriented process: Its goal is not isolated. For the consciousness of the driver, shifting gears in normal circumstances is as if it did not exists. He does something else: He moves the car from a place, climbs steep grades, drives the car fast, stops at a given place, etc. Actually this operation [of shifting gears] may, as is known, be removed entirely from the activity of the driver and be carried out automatically. Generally, the fate of the operation sooner or later becomes the function of the machine. (p. 66)

Engestrom

Engestrom (b. 1948) earned his PhD in education from the University of Helsinki. He is the director of the Center for Activity Theory and Developmental Work Research, which is located at the University of Helsinki, and he is a professor of communication at the University of California at San Diego. He was also the director of the Laboratory of Comparative Human Cognition from 1989 to 1995. He work is grounded in the cultural historical activity theory of Vygotsky and Leont'ev. In his earliest research, Engestrom developed a theory of expansive learning. He has conducted research in schools, as well as hospitals, courts, banks, factories, and other work sites. He is currently working on a project funded by the Academy of Finland, entitled *Mastering Change in Learning*

Organizations. The project is a comparative analysis of Finnish, American, Japanese, and Chinese workplaces in terms of work transformation.

Leont'ev never graphically expanded the original model of activity theory proposed by Vygotsky into a model of the collective activity system. It is here that Engestrom enters the picture of activity theory. Engestrom developed a model (Figure 2) that reflects the collective activity system and developed the theory of learning activity and the theory of learning by expanding.

The Components of a Human Activity System

Engestrom's model takes into account not only the individual but also the larger group of which the individual is a member. Engestrom (1999) used himself as an example by showing how in preparing a speech for a conference he considered himself as a member of a group of scholars interested in activity theory. In this way, he no longer considered himself as just an individual.

The object still remains as the central issue in this model of activity theory because it is the connecting factor of the individual's actions to the collective activity (Engestrom, 1999). In his personal example, Engestrom stated the central issues of activity theory act as the object in the model. The outcome, then, is twofold. In the process, new meanings of activity theory are developed in preparation of the speech and new patterns of interaction are formed. The process of the object leading to the outcome "functions as the motive of this activity and gives broader meaning to my actions" (p. 31).

The instruments are also referred to as mediating artifacts in some diagrams of Engestrom's model (Engestrom, 1999). In the example, Engestrom identifies the instruments as the resources that he used to prepare the speech, such as the works of Leont'ev and Vygotsky, and other publications.

The rules are the policies of the organization and the guidelines that are acceptable. Referring again to his speech illustration, Engestrom (1999) reported that the rules constituted of the statutes of the organization to which he was giving the speech and the overall conventions of scientific collaboration. The division of labor concerns the differences that the group may hold, such as different languages, disciplines, nationalities, and schools of thought. The community is comprised of all persons who are motivated by activity theory around the world.

The arrows in the model show that all the components of the activity model interact with one another. Also, the activity system does not exist in isolation. It interacts within a network of other activity systems. Rules may be from one activity system, for example, while outcomes may be produced for other activity systems. This model makes it possible to analyze a multitude of relations within the activity system.

In Engestrom's (1987) model, each of the outer sub-triangles is labeled with the three dominant aspects of human activity: (a) production, (b) distribution, and (c) exchange. Production correlates with the uppermost sub-triangle, distribution with the lower right sub-triangle, and exchange with the lower left sub-triangle. Each of these sub-triangles has the potential to be an activity of its own. The central sub-triangle is labeled consumption, because it is a function of the other three sub-triangles (Engestrom, 1987).

Learning by Expanding

Engestrom (1987) defined school as the central socially organized institution with human learning as its purpose. "School-going", as he called it, "is the natural birthplace of learning activity" (p. 49). School going became an activity required of all by the 1920s in the United States when all 50 states had enacted compulsory education laws (Olson, 2000a). Engestrom (1987) defined the structure of learning activity as follows:

> [First] human learning begins in the form of learning operations and learning actions embedded in other activities...[Second] learning activity has an object and a systemic structure of its own. In the network of human activities, learning activity will mediate between science/art on the one hand and work or other central productive practice. [Third] the essence of learning activity is production of objectively, societally new activity structures (including new objects, instruments, etc.) out of actions manifesting the inner contradictions of the preceding form of the activity in question. Learning activity is *mastery of expansion from actions to a new activity*...learning activity is an *activity-producing activity*. (p. 70-71, italics in the original text)

The initial object for the primary school child is the development of learning activity itself. This means that the student is to expand his/her learning actions occurring within the activity of school going into the new system of learning activity. The motive here for the student is to learn how to achieve the skills, knowledge, and ability to solve problems "by expanding the task into objectively novel activity systems" (Engestrom, p. 78), which results in the creation of tasks and problems out of a larger activity context. The second statement of the quotation refers to the sub-triangles in the model and the statement made earlier about the network of activity systems and how one component of the model may drive the activity system and another component from another activity system may influence other systems. The third statement in the quotation above suggests the effects of instruction in Vygotsky's zone of proximal development. With the assistance of an expert, the learner produces new activity structures, and creates an expansion from his/her actions to a new activity, namely the new level of knowledge mastered in the activity.

Activity Theory and Motivation

An ongoing qualitative research project by Down (2001) focuses on the concept of transfer of learning across different working situations in vocational education, work-based learning, and situated learning programs in Australia. In-depth interviews were conducted in a previous study and were analyzed using a matrix developed by Engestrom (1999, as cited in Down).

This matrix is based on learning within a framework of activity theory. The rows of the matrix ask the following questions: (a) Who is learning? (b) Why do they learn? (c) What do they learn? and (d) How do they learn? The columns of the matrix are labeled as follows: (a) activity system as unit of analysis, (b) multi-voicedness, (c) historicity, (d) contradictions, and (e) expansive cycles. The activity system refers to the artifact mediated, object-oriented system (according to the theoretical framework). The second concept, multivoicedness, refers to the multiple viewpoints, traditions, and interests that are inherent in a community of learners. Historicity is defined as the changes that take place over time to activity systems. Contradictions are the sources of change and development. The final concept, expansive cycles, refers to the transformations that activity systems go through to encompass a broader scope of possibilities than the previous activity system, due to the object and the motives of the activity.

Analysis of the previous data revealed that multivoicedness emerged as internal when the participants were learners and external when they were the facilitators of learning. Down (2001) planned to reinterview the participants to see if this finding would lead to expansive learning about their perceptions of learning for transfer.

Through this analysis, Down (2001) also developed a model to describe learning for transfer. Her review of literature led her to the concept of learning through experiencing difference rather than through the recognition of similarity. It is in this way that activity systems become motivational. When questioning occurs due to experienced difference, this generates puzzlement. This, in turn, leads to interest, motivation, and exercises the imagination. Similarity limits the depth of learning and discourages learners to leave their comfort zone of learning. She also refers to this phenomenon as patterned learning and linear logic. The learning that is experienced informally is more of a trial and error approach. We accept that we will make mistakes, but we will learn from our mistakes. This leads to variation of context as well as lateral, innovative thinking. The failure to learn happens because the concept is too hard or the risk is too great in relation to the motivation to learn within the learner (see the report of the study by Booth [2001]).

The overall conclusion of the concept of the learning for transfer model of Down (2001) is that educators need to shift from instruction as provision of information to facilitation of learning. In this way, learners undo and reform their existing understandings into different forms, thus allowing them to apply knowledge in multiple settings. In this way, learning of content is deeper and more meaningful than before, since it is experienced in a different way. This leads to more interest and motivation.

Down (2001) planned to continue her research by producing and distributing an electronic questionnaire. It will be used to test the validity of her findings.

Deci et al. (1991) reported on the self-determination theory of motivation. In their review of pertinent literature, these authors stated that motivation, development, and performance are most effective within social contexts that provide individuals with the chance to satisfy their need for competence, relatedness, and autonomy. Competence is defined by Deci et al. as understanding how various internal and external outcomes are attained and being sure to produce the desired outcome in performing tasks. Relatedness is described as developing satisfying connections with other people in society. Autonomy refers to one's capacity to be self-initiating and self-regulating of one's actions.

Activity theory is related to what these authors reported. The strongest connection lies in the social manner of relatedness. Hood-Holtzman (1996) stated that, in terms of Vygotskian theory, cognitive activity was thought of as social activity. Leont'ev took this farther in his model of activity theory, in that it was a collective system incited by object and motive and realized by a person's actions that are initiated by goals. Leont'ev also stated that all behavior is motivated and activity does not exist without a motive.

Activity Theory and Achievement

An analysis of Vygotsky's views on learning and those of several other Soviet psychologists was completed by Bol (1984), who explained how these findings could positively influence education. First, he differentiated between learning processes and learning activity. Learning processes are the automatic changes that take place in the acquisition of knowledge, while learning activity is specifically created by the individual because the situation is sought out for the purpose of learning. According to Bol, "Under these circumstances, learning is intentional and can be considered a kind of self-programming activity. Now, this activity underlies learning activity, which is motivated by the theoretical orientation of the subject toward reality" (p. 192). Therefore, learning activity develops zones of proximal development, which were discussed in Chapter 1.

Play is the most important activity in the younger child (three to seven years old), while learning activity is most important for the older child (seven to ten years old). During play, certain important cognitive developments occur, which lead to the occurrence of learning activity. Imagination in play and fantasy transfer from being materially oriented thinking to internal, mental thinking (Bol, 1984). Once the child is able to use ideas in his/her mind, he/she possesses the ability to imagine activities that can hardly be mastered yet. This creates a zone of proximal development and the basis for the development of learning activity has been formed.

In order to foster learning activity to the level of learning for development, Bol (1984) recommended that educators use a systematic organization of teaching and learning activities. He reported how to develop learning activity according to the theories of Vygotsky and Galperin. The step-by-step process begins by introducing the students to some area of activity in order to give the students a mental picture of what they are going to learn. Learning models need to be developed that show the theoretical structure of objects in a concrete manner, and that also help students focus to certain features and units of objects that are essential to the content to be taught. Bol used the example of teaching students to differentiate between different species of birds. A learning model could be constructed to focus on certain aspects of birds, such as the bill, eyes, legs, and wings. The next step involves material acting, the process of students practicing the method of analysis by actual observation. In the example, the students would have the opportunity to measure form and proportion of birds by using samples. Thirdly, verbal action should take place, which calls for the students to vocalize their descriptions. The major focus here is to have students reflect upon their activities. When students can verbalize their observations, they are ready for other forms of analysis, such as functional analysis. Bol stated that this is the process of synthesizing material into new combinations. The next step involves inner speech, where the former step has been internalized. This mental acting, as Bol called it, should be externalized again by combining theoretical notions into new constructions. The students in the example may be challenged to draw and describe a bird that could live in a given environment. Once the cycle is completed, a new cycle can begin. The educational outcome of this process would be deep learning of content through the activities of learning.

In a study by Lompscher (1984), theoretical thinking and its formation through instruction were studied. Theoretical thinking is defined as the search for deep structure, which leads to a higher degree of consciousness. It also fosters a higher value of the cognitive method and higher goals in the motivational structure. This is in contrast to empirical thinking, which looks for immediate results in seeking cognition and motivation, thus producing a lower level of reflection.

Lompscher (1984) was interested in finding whether elementary students could display theoretical thinking skills. He hypothesized that this would be possible, because the developmental age of the students was appropriate, according to Piaget's theory. Of the several studies reported by Lompscher two are relevant to the proposed study.

The first consisted of fifth grade students who were assigned to three groups: (a) control, (b) traditional instruction, and (c) experimental instruction. The experimental group received instruction in a physics course that focused on deductive thinking strategies, ascending from the abstract to the concrete. The traditional instruction group was taught the physics content following typical instruction in physics for a sixth grade class. Finally, the control group received no instruction in physics, since the topic was not introduced until the sixth grade. All other instructional subjects were unchanged for all groups (Lompscher, 1984).

Upon completion of the physics course, participants in all groups were asked to solve the well-known Tower of Hanoi problems with 4 discs. The task requires that the tower be moved from point A to point C, using point B as an intermediate field, and a minimal number of moves must be used to solve the problem. Participants were allowed up to 10 trials to discover the solution.

The data were reported using histograms and descriptive statistics. Less than 10% of participants in the experimental instruction group could not find a solution to the problem, approximately 42% reduced the number of mistakes from trial to trial, and approximately 52% discovered the answer in the first or second trial. Approximately 30% of those in the traditional instruction group could not solve the problem, nearly 50% improved from trial to trial, and approximately 20% could solve the problem within two trials. The control group had more than 40% who could not solve the problem, approximately 40% who improved from one trial to the next, and 20% that could solve the problem in one or two trials. Data were not analyzed to determine if significant differences between groups existed.

The verbalizations of participants in each group were analyzed for metacognitive awareness of the method used for solving the problem. In the experimental group, 20% of the participants who solved the problem were able to give a generalized explanation of the method they used, although in the control group only 5% who could solve the problem could explain their thinking processes. Lompscher (1984) admitted it is only a tendency but that these results could lead one to believe that theoretical thinking was developed with the experimental group.

The second relevant study of Lompscher (1984) involved fourth grade students receiving instruction in a course on syntax. Five different types of tasks were included: (a) reproducing facts, (b) identification and reproduction of general relations and techniques for sentence analysis, (c) explanation and argument of facts, (d) generalization of facts, and (e) concretization and construction of sentence structures. The experimental group received instruction in the course that focused on theoretical thinking strategies, ascending from the abstract to the concrete. In this study, however, two control groups were used. One was of the same age as the experimental group (fourth graders), and the second was older students (eighth graders) who were near completion of a whole grammar course that was part of the regular, traditional curriculum and contained similar material.

Data were reported using histograms. In each of the five types of tasks listed above, the experimental group outperformed the two control groups. It would appear that these differences were significant, however, Lompscher (1984) did not analyze the data using inferential statistics.

These groups were then assigned a similar situation as in the first study. All received a problem unrelated to the syntax course. The task involved a problem where a man wants to cross a river and transport a goat, a wolf, and a cabbage to the other side. The boat is very small; however, the man can only take one of them at a time. He has to make the journey several times and has to take care that he does not leave two passengers together who would eat each other. Participants were allowed six attempts to find the optimal answer of seven moves. The results were somewhat similar as in the first study. The experimental group reached the optimal solution quickly while the control groups submitted a gradually increasing number of optimal solutions and also a large number of non-optimal solutions (Lompscher, 1984).

Lompscher (1984) described how the experimental methods used were applicable to learning activity as "a special human activity directed towards the acquisition of social knowledge and competence…This activity presupposes an active subject having certain learning aims and motives and performing certain learning actions with the objects to be acquired" (p. 335). The learning activity, in the cases presented, is directed toward the acquisition of the theoretical contents and forms of social knowledge and competence that are organized by general traits and relations of concept systems and strategies.

Inquiry-based Science

An action research project was conducted by Booth (2001) to analyze student performance and opinion about inquiry-based science laboratory activities versus traditional step-by-step laboratory activities. Booth wanted to discover which type of laboratory activity the students would benefit from more. He began the study by modifying two laboratory exercises that he currently used to teach the concepts of diffusion and osmosis. The first laboratory exercise, the *Egg Lab*, demonstrates the diffusion of water into and out of a shelled egg. The egg is placed in various solutions that cause water to go into or out of the egg. The second laboratory exercise, the *Potato Lab*, illustrates the osmosis of water in a cell. Pieces of potato are put into pure water and salt water, which result in increased or decreased mass. The laboratory activities were modified as follows. The students that participated in the inquiry-based laboratory activity had to create their own procedure and data tables for the situation given. They were given a control and required to find the answer to five key questions using a method of their own design. The traditional laboratory activity gave step-by-step instructions of how to complete the exercise.

Booth (2001) taught four sections of biology. He chose two classes to complete the inquiry-based *Egg Lab* and the remaining two classes would complete the traditional *Egg Lab*. Immediately after completing the lab, the class was given a five-question quiz to assess the basic understanding of diffusion and osmosis. The next day, the process was reversed. Those classes that completed the inquiry-based *Egg Lab* were given the traditional *Potato Lab*, and those classes completing the traditional *Egg Lab* were given the inquiry-based *Potato Lab*. Again, the classes were given a quiz that assessed the concepts of osmosis and diffusion.

Data were analyzed using descriptive statistics. The average score was 55% for the students completing the inquiry-based *Egg Lab*, while the average score was 62% for the students completing the traditional *Egg Lab*. For the students completing the inquiry-based *Potato Lab*, the average score was 74%, and for the students completing the traditional *Potato Lab*, the average score was 82%. Data were not analyzed to determine if significant differences between groups existed.

The second aim of the study was to elicit student opinions about how they felt about inquiry-based science. The students were asked two questions: (a) Do you feel that you have learned more from this style of lab than you would have from a traditional, step-by-step lab? and (b) Would you like to do more inquiry-based labs in the future? The results showed 57% of the students replied that they felt they had learned more from the inquiry-based science labs; 46% wanted to do more inquiry-based labs in the future, 36% did not, and 12% wanted to some of the time, and 6% stated that they did not care.

Booth (2001) stated that the findings were exactly opposite of what he anticipated. He felt that the students were used to the traditional procedure, and found that the majority of them had never done a lab in the true inquiry-based mode before. He thought that the students' inexperience and frustration over the inquiry-based lab factored into the results on the quiz scores. Down's (2001) findings support this belief. She reported that learning could be terminated at any point due to the situation becoming too hard or the risk too great in comparison with the motivation to learn. Booth felt that if students had more experience in the inquiry-based method, that the quiz scores would be significantly higher. Booth suggested that other variables needed to be studied, such as matching student learning styles to teaching environments and using alternative assessment methods.

Huber and Moore (2001) contended that what science teachers believe to be inquiry-based science is really only limited hands-on activities. The authors noted that worksheet and textbook-based, hands-on activities are of value to novice teachers who are learning to be science teachers and manage a classroom on a regular basis. A risk is, however, that the presentation of science as a recipe to follow and filling out a worksheet results in the learner being dominated by mechanistic routines instead of acting as a true scientist. Worst of all, Huber and Moore argued that these step-by-step directions deprive students of ownership of the investigation.

Huber and Moore (2001) suggested a model for extending traditional hands-on activities into hands-on inquiry. First, the teacher should select an activity focused on the content to be learned and introduce it as a discrepant event. These events not only capture interest, but also create cognitive disequilibrium, which can be motivational. Ultimately, the students should discover this event rather than the teacher demonstrating it. Secondly, the extension could be continued by asking the students a "Can you think of..." or "Can you find a way..." question to stimulate a brainstorming session, with the teacher acting as a facilitator of the discussion. Ideas should be written down and not evaluated at this point. This is useful when working with students because they often do not know where to start (as noted by Booth [2001] with the students in his study). The brainstorming activity accentuates the creative process and helps students to move into designing an experiment. The brainstorming leads to the third part of the method, planning the inquiry. Each group selects one of the brainstormed ideas to test. They will develop hypotheses, design experiments, and define dependent, independent, and control variables. Huber and Moore (2001) also stressed that the students should not only be provided with opportunities to practice inquiry-based science but also be taught certain aspects of the nature of science. Finally, the students should conduct the inquiry they have designed and interpret and present the results of their findings.

Havasy (2001, November 7) would strongly agree with this report by Huber and Moore (2001). As previously mentioned, Havasy stated that science instruction needs to be revolutionized. The method proposed by Huber and Moore would support the revolution in science instruction and help students to develop the scientific skills needed to function in the inquiry-based classroom. Down (2001) would also support this method. These types of true inquiry-based activities would encourage the experience of difference, rather than recognition of similarity. The discrepant event mentioned earlier creates the puzzlement that leads to interest, motivation, and use of imagination.

Inquiry-based Science and Attitudes and Motivation Toward Science

Paris, Yambor, and Packard (1998) conducted a study to assess the effects of an extracurricular science program and students' interest and achievement in biology. Their research was based on the following research questions: (a) Do students' attitudes about studying science in school and pursuing scientific activities beyond school become more positive after being in the program? (b) Do students become more proficient at using scientific reasoning to solve problems after participation in the program? (c) Do students learn and remember the content of the biology lessons? (d) Are there gender differences in students' attitudes and problem-solving, and does a hands-on biology program affect boys and girls differently, (e) Which features of the hands-on learning activities did teachers perceive to be valuable for students? and (f) What were students' individual, affective responses to different components of the program?

The program, Hands-On Biology, was based on student discovery of science through laboratory activities, experiments, and personal projects. The conceptual framework of the Hands-On Biology program was correlated with research on students' academic motivation. The research cited by Paris et al. (1998) showed that engaging, situated activities promote intrinsic motivation and self-regulated learning. Six foundational aspects of the framework were (a) constructing personal meaning, (b) choice, (c) challenge, (d) control, (e) collaboration, and (f) consequences that promote self-efficacy. Personal meaning was constructed through program activities by allowing the students to select laboratory experiences, and build on their own previous experiences by creating personal projects. “Choice leads to commitment, deep involvement, and strategic thinking with tasks” (p. 269), according to Paris et al. The program fostered challenge by allowing student choice of performing experiments, reading books, or exploring exhibits so they could choose challenging tasks. Student autonomy was developed by letting students chose and monitor their own projects, allowing choice in laboratory activities, and developing students’ understanding that they had control of their actions and learning. Collaboration was experienced in the program by the students having teachers and docents to provide assistance when necessary. Absence of grades and the de-emphasis of competition served to foster increased feelings of self-efficacy. The weekly activities included three 45-minute sessions, involving ten topics in biology. Two lessons per week included a discovery table with biological artifacts and a variety of hands-on activities. The third session was an open lab time, where students could complete portfolios, explore the artifacts table, and work on their projects for the biology night activities.

The research design was not clearly defined but appeared to be a one-group pretest-posttest design. The participants were given pretests and posttests for the attitudinal and achievement measures, however there was no control group and no random assignment. The sample selection was not clearly defined, either. The participants were 184 third through fifth grade students from a mid-western city (58 third graders, 60 fourth graders, and 66 fifth graders). There were 91 males and 93 females in the sample.

Data were gathered using quantitative and qualitative measures created by Paris et al. (1998). An interest scale of 40 Liker-style items, an open-ended paper and pencil assessment designed to assess problem-solving skills, and weekly quizzes were used to evaluate students' content knowledge from the Hands-On Biology program. Data on validity or reliability were not reported for any of the tests created by Paris et al. (1998), except for the interest scale, which was reported as Crombach's alpha curriculum = attitudes at .84. Three teachers were interviewed informally to gather information on teacher perceptions on the strengths and weaknesses of the program. Finally, case studies were conducted with two students from each class to assess the personal effects of the program.

Results for the affective aspects of this study will be reported in this section, and the achievement results will be reported in the next section. In regards to the interest scales, enthusiasm toward science was greater in younger students than in older students. Attitudes about science improved from pretest to posttest at all grade levels for boys and for girls, except for those of girls in fifth grade. The teacher interviews reflected that they thought Hands-On Biology was a positive influence on their students because of the stimulating activities and the wide variety of topics. Another theme that emerged from the teacher interviews was that the inquiry-based activities generated a great deal of excitement in the students. The mystery activities, where students had to guess the identity of an animal when given some artifact, plus the hands-on experiences led the students to be motivated to gather more information and to talk to peers about their ideas and observations. The case studies of the students showed positive attitudes as well. The students exhibited excitement about the activities, enjoyed being able to have some independence in terms of choice, enjoyed working together, and found the family biology night as a great motivator to design challenging projects.

Case studies on inquiry-based science and student attitudes and interest in science careers was the focus of a study conducted by Gibson (1998), whose purpose was to assess the long-term effects of the Summer Science Exploration Program (SSEP), conducted at Hampshire College in Massachusetts from 1992 to 1994. The program's goal was to encourage a greater interest in science and scientific careers among middle school aged students through the use of inquiry-based learning activities. Gibson randomly selected 157 past participants of SSEP. Also, 22 participants were selected randomly to participate in follow-up interviews. For comparison purposes, 35 students who had applied but were not selected to participate in the program were given post-surveys.

Two quantitative surveys were used to assess current interest and attitudes in school science activities and likes and dislikes of certain career activities. The participants were given the survey prior to the start of the SSEP program. Post-surveys were administered in fall 1996, several years after the students participated in the program. Also, 500 non-SSEP students in grades 7-12 completed the surveys to study the impact of school science on students' attitudes and interests in science careers. Data from the surveys were analyzed by analysis of variance, and *t*-tests were run to determine significant differences among groups. Qualitative data from the interviews were coded and analyzed with content analysis software.

The quantitative results of the surveys revealed a significant difference between the SSEP and non-SSEP students' attitudes toward science and science careers on both the pre-survey and post-survey. The SSEP participants maintained a higher positive attitude toward science and a greater interest in science careers those who did not attend and those who applied but were not accepted to the program. Qualitative results revealed that more than three fourths of the students interviewed reported how the SSEP increased their interest in science. This was found to be related to the activities they did at the camp, they felt enjoyment from the activities, enjoyed the hands-on aspects of the activities, that the content was interesting. The camp provided an enjoyable atmosphere. Participants also said that they wished there were more hands-on activities in their science classes at school that were relevant to their lives. Other factors found to influence the students' attitudes toward science were parents, teachers, school programs, television, and science clubs. The hands-on inquiry-based aspect of this program clearly made a long-term impact on the participants and gave them a positive attitude toward science and science-related careers.

Inquiry-based Science and Achievement in Science

Freedman (1997) investigated the use of a hands-on laboratory program to improve student achievement and attitudes toward science. It was hypothesized that attitudes toward science has a role in student achievement, rather that the opposite. The research design consisted of the posttest only control group design. The participants were randomly assigned to one of 20 physical science classes, with six of the classes containing students with limited English proficiency (LEP). Next, classes were randomly assigned to treatment or control treatment conditions. The sample for the study consisted of ninth grade students enrolled in a large urban high school.

The laboratory experience involved a cooperative, small group activity in which the students interacted with materials and equipment to observe and record the results. The experimental groups received the laboratory experience once a week, while the control groups did not. All classes stayed with the adopted course of study for the district and used the same textbook, and covered the same body of content during the study.

Student achievement was measured in three fashions: (a) a mid-term exam, (b) a final exam, and (c) the final grade for the course. The mid-term and final exams were district-created and curriculum-referenced tests designed to measure achievement in the physical science course. Student attitude was measured using a Q-sort survey. Data were analyzed through use of a one-way analysis of variance to compare the groups in achievement and attitude toward science. To determine the effects of the laboratory experience with achievement and attitude, an analysis of covariance was used.

The results revealed significant results both in achievement and attitudes toward science. Groups that experienced the treatment scored significantly higher on achievement; showed a positive, moderate correlation between their attitudes toward science and their achievement in science; and scored significantly higher on achievement of science knowledge after adjustment of the scores on the covariable of attitude toward science. No significant differences were found in achievement or attitude toward science for the LEP groups. Freedman (1997) concluded that the laboratory experience positively influenced the students' attitudes toward science, which led to achievement gains.

Frederick and Shaw (1999) focused on the effects of manipulative use on science achievement, attitudes, and journal writing in fourth grade students. This study involved the use of Full Option Science System (FOSS) kits through an inquiry-based program called Hands-on Activity Science Program (HASP). The FOSS kits were developed and nationally tested with funding from the NSF.

The research design was a one-group pretest-posttest design. The sample consisted of 20 fourth grade students. Fifty-five percent of the participants were male, 55% were White, 45% were Black, and were of middle to upper class socioeconomic status. It is not clear, however, how the students in the sample were selected, nor how many different classes they came from. The same teacher, who had received training in the use of the FOSS kits, presented Science instruction for the classes. The unit selected for the study was on electricity and circuits, and a 15-item test (included in the kit) was used as the pretest and posttest measure. Also, Frederick and Shaw (1999) developed a 12-item modified Likert scale attitude survey that was used as a pretest/posttest measure. Content analysis of the students' journal entries was also conducted.

A two-tailed *t*-test showed significant differences between the pretest and posttest scores. The attitude scale data were analyzed with descriptive statistics calculated separately for each item. The results showed that the use of the manipulatives in the FOSS kits increased positive responses toward science in several ways. The students reported that science was their favorite subject, they liked to read about science, that science was fun, and they looked forward to science group activities.

Achievement gains were also demonstrated in the Hands-On Biology program conducted by Paris et al. (1998). The assessment measures, reported previously, consisted of a four question open-ended problem-solving evaluation and 15- point weekly quizzes. The scores for both measures were aggregated, and the open-ended questions were analyzed individually as well. The results of the open-ended assessment revealed that the scores on the posttest were significantly higher than the pretest. Girls scored higher than boys in all grades, and the scores improved at each successive grade level. The individual problem analysis showed significant improvement from pretest to posttest on all questions, and that the students in third grade scored lower than the students in fourth and fifth grade. The mean scores on the weekly quizzes were as follows: (a) third grade 11.8, (b) fourth grade 11.7, and (c) fifth grade 12.5 out of a total of 15 possible points. Paris et al. indicated that these scores showed that the participants learned and remembered most of the content presented in the program.

Field Trip Experiences and Museum-based Learning

Teachers and museum educators are challenged to improve the quality of learning experienced by visitors to museum exhibits. Learning in such a setting has been referred to as informal learning by the National Science Foundation (2001). This is the lifelong process in which every person acquires knowledge, skills, attitudes, and values from daily experiences and resources in his/her environment. It occurs outside a formal classroom setting and is not part of a school program, activity, or assignment. Some informal learning settings listed by Salmi (1993) include (a) science centers, (b) museums, (c) libraries, (d) art museums, (e) zoos, and (f) mass media. For the purposes of the proposed study, the researcher will refer to informal learning as museum based learning. This is the learning that takes place through a visit to a museum (Borun 1983), and may be referred to as museum education in other literature.

The purpose of the case study by Gilbert and Priest (1997) was to find what exactly was involved for participants to socially construct knowledge through a visit to a science museum. The sample consisted of 30 students in the fourth grade and their teacher from a state primary school in a small eastern English city. The class had just completed a unit on healthy eating and was on a visit to the Science Museum in London. The teacher met with museum officials before the visit to arrange for the class to tour the "Food for Thought Exhibit." This was because of the unit just completed and the fact that the students lived in a wheat-growing region and would bring a wide range of informal learning experiences to the visit.

When the class arrived at the museum, the students experienced a whole group activity, involving examining a wheat grain closely and observing the properties of flour. The students were divided into small groups with an adult to accompany them through the exhibits. The groups were free to explore the chosen exhibits in the gallery for one hour in any order they chose. The adult guides were allowed to answer any questions asked by the students, but were not to instruct them to any extent if possible. Upon returning to school, the teacher made notes of events that could be helpful in planning follow-up activities for the students.

Priest (Gilbert & Priest, 1997), acting as a participant observer, collected fieldnotes through observations and interviews with the students. Threads were drawn from the data analysis and particular themes emerged. One theme was recognition of an object as being familiar. This led to discussion within groups and shared knowledge of prior experiences. Second was the introduction of an element of surprise and the provision of an associated task. The whole group activity was used as an example. The museum docent, an explainer and museum educator, threw handfuls of wheat to the students, which was unexpected, and then asked them to examine the wheat grains. Then the docent asked the students to take some flour and mix it with water. This got the students interested and discussion began amongst them of the activity and what they were observing. The students shared a new experience, which caused the construction of new mental models. Inserting a question to focus attention was another theme that emerged. In one case, students were busily grinding wheat into flour. They were not paying attention to the flour they were making but to the effort of the work involved in turning the grinder. The adult asked a question to direct attention to the concept of energy being needed in order to grind the wheat into flour. The help of the question prompted a link between key ideas. Finally, five types of discourse continuation emerged in the analysis: (a) post-visit activities were suggested, (b) the generalized and the particular are linked, (c) sustained attention was provoked, (d) exhibit text was successfully consulted, and (e) unobserved closure (Gilbert & Priest, 1997).

In their discussion, Gilbert and Priest (1997) commented that the critical incidents that continued the discourse where related to links. These links were perpetuated by prior activities at school and in the museum, from experiences being had at the museum, between objects in the exhibits, and present and future activities.

Field trips can be thought of as an endeavor to increase learning by changing the learning setting. However, the novelty of the setting may detract from imposed task learning. In a study done by Martin, Falk, and Balling (1981), the goal was to analyze the effects of a novel environment on behavior on a field trip. The study was designed to compare the learning and behavior of participants in novel or familiar settings. A within-subjects design was employed to try and observe additional evidence that the individual's relation to his or her environment is affected by novel settings.

The field experiment was conducted during the Summer Ecology Program for children. A total of 63 participants, ranging in age from 10 to 13, were included in the study. Of them, 33 (14 females and 19 males) had been in the program in previous years and were defined as the repeater group. The remaining 30 (10 females and 20 males) had not participated in the program before, and thus, comprised the novice group. There were seven groups with between six and twelve children in each. These groups each came for one week at a time.

Each of the participants was required to engage in structured tasks that taught ecological concepts in a familiar environment and a novel environment. One task was a series of soil texture and hardness tests, which taught the concept of soil changes accompanying plant succession. The second task involved measuring foliage height, which taught the concept of plant community changes during succession. Both activities were conducted in much the same manner in both settings.

Pretests were given to determine participants' general knowledge of ecology. These were taken in both environments (familiar and novel). In the novel environment participants also completed a posttest measure of their general knowledge of that type of setting. The Summer Ecology Program schedule consisted of two days in the participants' regular schoolyard, one day in a natural area, and the last day in the home environment. The experimental data were collected on day two in the familiar environment and day three in the novel environment. In the novel environment, an observer also scored the behavior of one participant who was not a direct participant of the activity at a given moment. The group members rotated through various jobs involved in each activity, but due to the group's size, there were not enough jobs for all group members at the same time. Therefore, some members were left to watch the activity taking place. Posture (tense versus relaxed) and facial expression (positive to negative) were used and thought to reflect the type and presence of arousal. Gaze direction was used to assess the allocation of attention. Not all subjects were rated in this manner because smaller groups would have everyone engaged in the activity the entire time. Fourteen novice setting and 19 familiar setting participants were rated.

Data from the pretest and the posttest were standardized by using *T*-scores within each setting. The resulting scores were then analyzed by a 2 x 2 analysis of variance with two within subject factors: test time (pretest or posttest) and setting (familiar or novel). The results showed no overall main effect for test environment. Task-related concept learning did occur, and had a significant main effect for testing time. Also, a significant interaction emerged between environment and test time. Overall the participants showed a reduction of conceptual learning in the novel setting as compared to the familiar setting. The participants did show a significant increase in knowledge of the novel setting, although the researchers noted that the effect was not strong. The repeater group showed a strong effect for overall concept learning, and demonstrated similar amounts of task-related concept learning in both environments. The repeaters failed to demonstrate learning about the novel setting, however, this group's pretest mean was not significantly different from the mean of the novice group, which did show significant learning, suggesting a ceiling effect (Martin et al., 1981).

In terms of behavior ratings, none of the behavior dimensions correlated significantly with the pretest of conceptual task material for the novice group. The proportion of time spent in social interactions and the proportion of time with a positive facial expression were significantly negatively correlated with the task concept posttest. This negative correlation may mean that interaction between participants might have been more important than the task at hand. For the repeaters, however, the social interaction and facial expression ratings were marginally significant. Repeaters who interacted more with group members and showed more positive facial expressions tended to score higher on the setting posttest. Thus the results show that novel environments can be poor settings for imposed task learning (Martin et al., 1981).

Similar findings were reported in four studies conducted by Balling and Falk (1980). Participants for the first study were 15 children who lived in a wooded area and 15 children who lived in an urban area. The participants were given a pretest followed by a field trip, which contained a hands-on activity on ecology in a woodland area, and then given a posttest. The tests contained questions about concepts taught in the field trip lesson and general questions about wooded settings. Results revealed that the children from the wooded area scored significantly higher on the general knowledge of wooded areas part of the pretest than the urban group of children. Both groups scored poorly on the conceptual knowledge portion of the pretest. On the posttest, both groups showed significant gains in knowledge of the setting, however, only the children living in a wooded area showed any conceptual learning associated with the task done on the field trip.

A similar study was done with different populations (higher socioeconomic status) and testing was done for each participant in a familiar setting and a novel setting (Balling & Falk, 1980). Participants were formed in two groups; as 28 novices, who had never been to the natural area before, and 33 repeaters, who had had at least one visit to the natural area. All were given a pretest and a posttest that dealt with the science activities that they did and the general setting. One activity was completed in their schoolyard and one activity was completed in the natural area. Similar results were reported for this study as was for the first study. All children showed significant gains from the pretest to the posttest on the conceptual material presented in their familiar setting. Only those children who were familiar with the natural setting showed improvement in task learning in the natural setting.

A third study by Balling and Falk (1980) looked at the effects of environmental novelty, learning and the number of relevant learning examples available at the site. The researchers hypothesized that certain learning environments may have so many examples as to be too complex and therefore be distracting. The sample tested consisted of 425 fifth and sixth grade children from urban, suburban, and rural schools. Participants were given a pretest and a posttest on conceptual learning and asked about their opinions about the field trip experience. They were taken either to a small park near a busy street in a large city, a park in a quiet residential area, or to a forest. In each setting, the students participated in science activities on the biology of trees. Analysis revealed that all groups showed significant learning gains, but at varying levels across groups. There was a significant effect depending on place of residence. Urban students performed more poorly than the suburban and rural students, while students who performed the activity in the forest setting were superior to those who performed the activity in one of the parks. Overall, the urban and suburban children had more examples and high novelty in the forest setting and learning was better for them there. The rural children found the novelty of the forest setting to be low, with novelty in the suburban area to be moderate and the example level to be moderate and learning was best for them there.

The fourth study was similar to the previous studies and placed third and fifth graders in familiar and novel settings (Balling & Falk, 1980). Participants were given a pretest and divided into two treatment groups in each grade level. Half of the students at each grade level completed an activity about trees in a wood just behind their school, while the other half of the students at each grade level completed the same activity in a wooded nature center that had not been experienced before as a class. A posttest was given one day after the activity and one month after the activity. All groups showed significant learning gains from pretest to posttest that persisted through the delayed posttest. Fifth grade students who went to the nature center (novel setting) achieved the highest scores followed by third graders in a familiar setting. Behavioral observations revealed that the third graders to be more off-task in the familiar setting. The opposite was true for fifth graders.

From these four studies, Balling and Falk (1980) developed a qualitative model of the relationship between variations of novelty of setting, learning, and non-task behaviors. It posits that non-tasks behaviors are highest when the novelty of the setting is so low that it is boring, or so high that it may be threatening. On-task behavior is highest when there is moderate novelty to the setting.

Museum-based Learning and Motivation Toward Science

A study by Borun (1983) was conducted jointly at the Franklin Institute Science Museum and the Boston Museum of Science (for the purposes of this review, only the Franklin Institute study will be reported). She wanted to examine the learning that takes place during a science museum visit that transferred to the classroom. The research questions were as follows: (a) What are the cognitive outcomes of a visit to a museum exhibit? (b) What are the affective outcomes of a visit to a museum exhibit? (c) Is classroom learning facilitated by a visit to a museum exhibit? and (d) Does measurement of museum-based learning depend on a match between the nature of the learning experience and the test mode? The following hypotheses were tested: (a) students visiting an exhibit will score significantly higher on the science achievement test than the students in the control group; (b) students will perceive an exhibit as significantly more enjoyable and motivating than a classroom learning experience; (c) students attending a lesson following a visit to a museum exhibit will score significantly higher on the science achievement test than those students only attending the lesson; and (d) students visiting a museum exhibit will score higher on an authentic test than on a traditional paper and pencil test.

The research design was a posttest only control group design. The participants were 416 fifth and sixth grade students from suburban public and parochial schools. They were randomly assigned to one of four experimental groups: (a) control, (b) exhibit, (c) lesson, or (d) exhibit/lesson. The participants were also randomly assigned to one of two cognitive testing groups: verbal or visual. Participants in the experimental groups were also given a five-item affective questionnaire after treatment so that the enjoyment and interest in treatments could be compared.

After a brief orientation, participants joined their assigned groups and museum educators acted as group leaders escorting the groups through the appropriate sequence of activities. The sequence was as follows: (a) control- posttest, exhibit, lesson; (b) exhibit-exhibit, posttest, lesson; (c) lesson- lesson, posttest, exhibit; and (d) exhibit/lesson-exhibit, lesson, posttest. The exhibit consisted of five hands-on displays in the Simple Machines section. The group leader gave no instruction, and the participants were allowed to spend up to 15 minutes in the exhibit area. The lesson, Simple Machines Lecture, was written at a fifth grade level to correlate with the same concepts displayed in the exhibit. The same person conducted the lesson in a museum classroom each time.

Instrumentation involved the following: (a) demographic data sheet, (b) affective questionnaire, and (c) the cognitive tests. The results of the cognitive tests will be reported in the next section of the literature review.

Descriptive statistics, independent *t*-tests, and correlated samples *t*-tests were used to analyze the affective questionnaire data. The three treatment groups liked the exhibit significantly better than the lesson (each of these groups was questioned on the treatment they received prior to testing). The exhibit was preferred over the lesson. Participants in the exhibit group also felt they had learned more from the exhibit than those in the lesson group felt that they learned from the lesson. Finally, the exhibit group was significantly higher than the lesson group and the exhibit/lesson group in motivation (Borun, 1983).

The most pronounced findings of the study were in the affective domain. Museum exhibits were perceived to be fun and enjoyable by students and were more interesting than a classroom lesson. The evidence for a motivational effect is apparent, because a significant proportion of the students wanted to learn more about simple machines. Borun (1983), however, conducted no delayed analysis.

In a study by Salmi (1993), motivation was the main element to be measured in an informal education environment, namely a science center. He wanted to determine if different types of motivation affected the quality of learning from the science center, whether different treatments could create different types of motivation in students, and whether students learn new information from a visit to a science exhibition. Salmi defined motivation as (a) situational, (b) instrumental, or (c) intrinsic. Situational motivation and instrumental motivation are related to extrinsic motivation. Situational motivation grows from a new situation, is temporary, and is based on external factors. In other words, it is a short-lived. Instrumental motivation is based on wanting of a reward or the avoidance of punishment. The only interest is to complete something, and there is no interest in any deeper meaning of the subject at hand.

It was hypothesized that those participants who were in the intrinsically motivated group would be connected to deep learning oriented. The instrumental and situational motivated groups would be surface-learning oriented. It was also hypothesized that learning is achieved through a science museum visit, different types of motivation affect the quality of learning, and different types of motivational treatments can lead to different kinds of learning motivation.

This study tested six school classes of seventh grade students who were chosen at random ($N = 168$). Three groups were formed: Group I was treated to have intrinsic motivation; Group II was treated to have instrumental motivation; and Group III was treated to have situational motivation. Intrinsic motivation was created for Group I through the use of a pre-lesson. The students were given a question about their own health and told to make observations of the exhibit. They were told that the reason for the test after the science center visit was to get their feedback so the science center could design exhibits from their point of view. The instrumental motivation for Group II was also created with a pre-lesson. They were told during the pre-lesson and at the science center that they would be taking a test on the exhibit and the pre-lesson that would affect their grade. The situational motivation for Group III was created by the external factors of the visit itself: a novel situation with attractive equipment, a temporary situation and a change from the regular school routine. They had no pre-lesson and were not told of the science center visit until two days prior to the trip.

All groups received the same guided tour for 60 minutes of the "Pulse" exhibition at the Science Center Foundation. Then the students toured the exhibit on their own for 30 minutes. The students were then assessed in several fashions. First was the general motivation test (Rosenfeld-type standard test), which was given as the pretest, posttest, and delayed posttest for intrinsic and instrumental motivation. A specific motivation test for the exhibition experience was used as a posttest and a delayed posttest of situation motivation. The knowledge test, constructed specifically for the study, measured the cognitive learning of isolated facts and entities and was given as a posttest and a delayed posttest. The cognitive results will be reported in the next section of the literature review.

Data were analyzed using the multivariate repeated measures analysis. The results and differences between groups were analyzed separately through use of a *t*-test. The results showed that the intrinsic motivation group did best in nearly all of the cognitive tests. It was also found that the situational motivation group performed better than expected, and that instrumental motivation did not apply to informal learning. The science center appeared to be a motivating setting for learning. Salmi (1993) recommended applying these finding to formal education settings.

Museum-based Learning and Achievement in Science

The cognitive results from the Borun (1983) and Salmi (1993) studies are applicable in this category. For Borun study, the verbal test was 10 multiple choice items with four answer choices. The visual test was parallel in content to the verbal test; however, the answer choices were represented pictorially. Analysis of the data employed a 4 (treatment) x 2 (test) analysis of variance. The groups did not differ significantly in age or in number of students reporting previous visits. Each of the eight cells in the 4 x 2 design had equal numbers of girls and boys. The results showed that the experimental groups differed significantly in performance levels on both tests. The Newman-Keuls test was used to make pairwise comparisons, which indicated that the mean of the exhibit group was significantly higher than the control group, but was significantly lower than the lesson group. Participants taking the visual test scored significantly higher than those taking the verbal test, and mean scores of the treatment groups were not differentially affected by the test type (Borun, 1983).

Salmi (1993) used a knowledge test constructed specifically for the study. The test measured the cognitive learning of isolated facts and entities and was given as a posttest and a delayed posttest. Data were analyzed using the multivariate repeated measures analysis. The results and differences between groups were analyzed separately through use of a *t*-test. The results showed that the intrinsic motivation group did best in nearly all of the cognitive tests. It was also found that the situational motivation group performed better than expected, and that instrumental motivation did not apply to informal learning.

Summary

Science education has garnered a centrally important place in the curriculum in many countries (Gilbert & Priest, 1997). The theoretical framework for this study, activity theory, is supported by the findings of the literature reviewed. Inquiry-based laboratory experiences in science have been shown to improve attitudes toward science and science achievement. In activity theory, the object is central to the outcomes of the activity, and the activity can be motivational. Inquiry-based science allows students to be active participants in the learning process by manipulating equipment and materials to observe scientific phenomena. Informal learning settings, such as science museums, can also be effective in improving science attitudes, motivation toward science, and science achievement.

CHAPTER THREE

Methodology

This study was based on the pretest-posttest control comparison group design as outlined by Campbell and Stanley (1963). This design was appropriate for the study for several reasons. The pretest-posttest control comparison group design controlled for many threats to internal validity. History, maturation and testing are controlled for because they would most likely occur equally in the experimental groups and the control group. Regression was controlled for in terms of mean differences even though the scores on the pretest may be extreme. This is because of the random assignment of participants to groups. Random assignment and the total size of the sample ($N = 228$) also controlled for the effects of selection. Because the same assessment instruments were used for the pretest, posttest, and delayed posttest, instrumentation was also controlled. The only threat to internal validity in this study was attrition, because certain participants were absent from school when the pretest was administered, when the classes came to the science museum, or when the delayed posttest was given.

One threat to external validity of this study was generalization. Sixth grade students from a north central Louisiana school were the participants for this study, and it would only be possible to generalize to similar populations in similar sized communities. However, it would not be possible to generalize to other populations, such as inner city schools, high school aged students or other grade levels. Pretesting the participants may have sensitized them to the intent of the study. However, the researcher attempted to control this factor by waiting to administer the treatment until four weeks after the participants had taken the pretest.

Sample

The sample for this study consisted of 228 sixth grade students enrolled in a public north central Title I Louisiana school. According to the principal of this school (personal communication, July 22, 2002), 48% of the student body was White, 52% was Black, and 51% of the school population was male. Of the entire school population, 68% was considered at-risk and received free/reduced lunch and 6% was receiving special education services.

The community in which this school is located is the parish seat of this north central Louisiana parish. The community has a population of 22,000, and its major forms of industries are wood-related products, agriculture, and education (RLCC, 2002). The community has a university with a K-8 laboratory school, one public high school, one public junior high school, an alternative school, a sixth grade school, four public elementary schools, and four private schools. The researcher selected the sixth grade school for both the distinctiveness and generalizability of the setting. This school serves the entire sixth grade public school population from the four public elementary schools in the city, and only sixth graders attend this school. The school operates on the block schedule. There are four science teachers, each teaching three sections of classes.

Instrumentation

The researcher measured both the level of intrinsic motivation and achievement in science. Two separate measures were used to assess these areas: the Children's Academic Intrinsic Motivation Inventory (CAIMI) and an achievement test developed by the researcher, specifically to measure content knowledge of areas of science incorporated in the Experiment Gallery exhibits. The CAIMI and the achievement tests will be discussed in detail, and both were used for pretesting, posttesting, and delayed posttesting of intrinsic motivation levels and science achievement in the study.

Children's Academic Intrinsic Motivation Inventory

The researcher used the CAIMI to measure students' motivational orientation (intrinsic/extrinsic) in science and other academic areas, such as mathematics, reading, and social studies, as well as a general orientation toward school learning. The CAIMI is a 44 question, self-report inventory comprised of 122 items in the five areas listed above. Each of the subject areas contains 26 items, and the general section contains 18 items. Of the 26 items in each subject area, 24 used a five-point Likert scale, ranging from strongly agree to strongly disagree. Two items in each area require a forced response between an intrinsic alternative or a non-intrinsic choice. All 18 items in the general section used the five-point Likert scale, as described earlier. Some items are reverse-scored. Approximately half of the items require an agreement response for high motivation, while the other half require disagreement to indicate high intrinsic motivation levels (Gottfried, 1986).

The CAIMI is scored by using the boxes located to the right of each page. The arrow to the right of the ratings shows the direction of scoring. When the arrow is pointing to the right, ratings are assigned as 1 = strongly agree to 5 = strongly disagree. An arrow pointing to the left indicates reverse-scored items (1 = strongly disagree to 5 = strongly agree). Questions 43 and 44 can only be scored as 2 or 1, with question 44 scored in the normal direction and question 43 scored in the reverse-scored direction. Ratings are entered for each item in the appropriate scoring box. Each column is marked for each of the subject areas of reading, mathematics, social studies, science, and general (abbreviated as R, M, SS, Sc, and G respectively). Each column is totaled at the bottom of the page and total raw scores for each scale are totaled across pages and entered on the profile report under the rows marked Raw Scores (Gottfried, 1986).

Interpretation of CAIMI scores employs the use of normative scores (percentiles and *T*-scores) and standard errors of measurement. This facilitates interpretation of scores on individual scales and profiles. Percentiles and *T*-scores allow the user to determine a student's level of academic intrinsic motivation relative to the normative group. These normative scores also allow for comparisons across the CAIMI scales and with normative scores on other instruments. The standard errors of measurement for each of the five CAIMI scales provide for a band of interpretation, are given in terms of normalized *T*-scores (see Table 1), and are based on coefficient alpha reliability. The standard error of measurement shows that on a retest, the student's score would vary within a 68% confidence limit.

Table 1

Standard Errors of Measurement for CAIMI Scales

Reading	Mathematics	Social Studies	Science	General
3	3	2.8	3.2	4.4

For each individual profile, the raw score must be located in the correct table in the *Manual for the CAIMI* (Gottfried, 1986), by grade level. Percentiles that correspond to each raw score appear in the far left column, and normalized *T*-scores appear in the far right column. The scores are recorded in the appropriate rows on the profile sheet. The *T*-scores can then be graphed on the profile sheet. For each *T*-score, plot the band $\pm$ 1 standard error of measurement (according to Table 1 and the subject being graphed).

Reliability for the CAIMI was established through three major studies over a six-year period by Gottfried (1986). A coefficient alpha was calculated for each of the scales for the second and third studies, which reflect the current version of the assessment (see Table 2). Test-retest reliability was established over a two-month period from a random sample of participants from the first two studies. These coefficients range from .66 to .76 ($df = 83, p < .01$) for the first study and .69 to .75 ($df = 136, p < .01$) for the second study, indicating moderately high stability (Gottfried, 1986). These coefficients were reported to be consistent across grade, gender, and race for both internal consistency and test-retest reliability.

Table 2

Internal Consistency Reliability Coefficients (Alpha) for CAIMI Scales: Studies 2 and 3

Study	*N*	Reading	Mathematics	Social Studies	Science	General
2	260	.90	.89	.91	.90	.80
3	166	.92	.93	.93	.91	.83

Note. For all studies, the length of the General scale was adjusted to be equivalent to that of the subject area scales for comparison purposes.

The validity of the CAIMI has been established and developed in numerous ways. The CAIMI was developed originally on the basis of theoretical foundations of academic intrinsic motivation. The items reflect these constructs, such as curiosity and interest in novelty. The construct validity of the CAIMI has been further established through confirmation of several hypotheses that are based on theories. First, academic intrinsic motivation is positively related to school achievement. Secondly, academic intrinsic motivation is negatively related to academic anxiety. Academic intrinsic motivation was also found to be positively related to students' perception of their academic ability. Students' academic intrinsic motivation is also positively related to teacher perceptions of their motivational levels. Finally, higher academic intrinsic motivation is associated with lower extrinsic orientation (Gottfried, 1986).

Criterion-related validity was tested in four related instances. The CAIMI was first assessed regarding its relation to academic anxiety and perceptions of competence. Correlations between corresponding motivation and anxiety subject areas ranged between -.38 and -.52 ($p < .001$) compared to correlations between noncorresponding subject area scales and the general intrinsic motivation scale and anxiety. In other words, students with higher academic intrinsic motivation in a particular subject area had lower academic anxiety in that area than did students with lower motivational levels. Competency and corresponding subject were positively correlated; coefficients ranged between .49 and .62 ($p < .001$). This indicated that students with higher intrinsic motivation in a specific subject area saw themselves as more competent than students with lower intrinsic motivation in that subject area.

Another area tested for criterion-related validity was the CAIMI's relationship to achievement. Multiple correlations with all CAIMI scales showed that achievement in all subject areas was significantly correlated with the CAIMI (.24 to .44). It was also found that teachers' ratings of students' general intrinsic motivation were significantly correlated with the CAIMI, particularly with the Reading, Math, and General scales ($r = .27$, .22, and .25, respectively [$p < .01$]). Finally, the CAIMI was tested for relationship to intrinsic and extrinsic orientations. As reported in the *Manual for the CAIMI* (Gottfried, 1986), correlations were computed between the CAIMI and the *Scale of Intrinsic versus Extrinsic Orientation in the Classroom* by Harter. The data were positively correlated, ranging from $r = .17$ to $r = .64$ ($p < .05$ to $p < .001$). This showed convergent validity with another measure of intrinsic motivation.

A unique facet of the CAIMI is that it provides a means for differentiating motivation from achievement and ability (Gottfried, 1986). The CAIMI has been used to measure intrinsic motivation in studies by other researchers. Lague (1985) used the CAIMI as part of his study in which he measured the degree of educational versus training emphasis in five 4th grade classrooms. The CAIMI was also used by Neal (1989) to determine if significant differences existed in achievement, motivation, and self-esteem in sixth grade students who participated in a program designed to enhance these three areas and those who did not. Pain (1991) used the CAIMI to make comparisons in self-reported perceptions of academic competence, attributions, and intrinsic motivation between students with learning disabilities and a group of students who were considered to be average achieving. Redden (2000) used the CAIMI in her study about self-esteem and intrinsic motivation of predominately Hispanic fifth grade students in the use of two different approaches to computer usage. Riley (1995) examined the relationship between motivation and grade level, gender, race, academic achievement, and school socioeconomic status in fourth through eighth grade students in gifted education classes and used the CAIMI as one of the measures. In a study by Welcher (1995), the CAIMI was also used to explore the relationship between school type (a fine arts magnet school, a traditional elementary school, & exemplary middle school) and the achievement, motivation and attitude of seventh grade students.

A review of the CAIMI in *Mental Measurements Yearbook* (Posey, 1986) indicated that the test is written in an unusual format, and the items appear to be understandable for students in at least the fourth grade and that the scoring is very simple and did not requiring scoring keys or templates. Items were seen to be balanced, because both positive and reverse-scored items are included in the inventory. Reliability was assessed as adequate. Scores were significantly correlated with achievement tests on matched subject areas. Overall, the CAIMI appeared to be "a reliable and unique measure of the attribute labeled 'academic intrinsic motivation" (p. 2). Posey noted that the only negative aspect seemed to be the size and representativeness of the normative sample.

Achievement Measure

The researcher developed her own achievement test for this study (see Appendix A). The test was written to address specifically the five main theme areas of science incorporated within the Experiment Gallery exhibits: (a) electricity, (b) light and optics, (c) mechanics, (d) sound and waves, and (e) weather. The test was comprised of 30 multiple-choice questions in which there was only one correct response. These questions were also correlated with the sixth grade district and state content standards.

In order to establish validity and reliability for this test, the researcher conducted a pilot study on a sixth grade population similar in composition to the one used in the study. Data from the pilot study were used to determine test reliability. Analysis was completed using the Kuder-Richardson 21 formula, which yielded a reliability coefficient of .31. The test was also reviewed by science education faculty and practicing upper elementary teachers to help determine the content validity of the test.

Procedural Details

Before any data were gathered, permission from the Human Use Committee of Louisiana Tech University was obtained (see Appendix B). The assistant superintendent of schools and the principal at the school selected for the study met with the researcher and agreed to support this study (see Appendix C). The researcher met with the principal and the four science teachers at the school and discussed the study, provided human use forms (see Appendix D) for the participants, made arrangements for pretesting the students and scheduled the class field trips for approximately one month after the pretests were completed. Posttesting dates were scheduled for one month after the museum visit at another meeting (see Figure 3 for details).

Phase 1	Phase 2		Phase 3
Distribution of	Day 1	Day 2	Delayed posttests
Human Use forms	AM-Teacher A	Teacher C	
Pretesting	PM-Teacher B	Teacher D	
	Treatment/Posttests		

Figure 3: Time Line of Testing and Treatment

In order to minimize experimenter bias, the researcher instructed the four science teachers from the school in how to administer the tests in the regular classroom setting for pretesting and for the delayed posttesting. The same testing procedure was used for the posttest on site at the IDEA Place. A paraprofessional from the school was also trained to administer both tests in order to help with testing due to overlap in testing schedules during the museum visit (see Figure 4).

Control	Posttest (60 min.)	Exhibits (60 min.)	Lesson (30 min.)
Exhibit	Exhibits (60 min.)	Posttest (60 min.)	Lesson (30 min.)
Lesson	Lesson (30 min.)	Posttest (60 min.)	Exhibits (60 min.)
Exhibit/Lesson	Exhibit (60 min. split)	Lesson (30 min.)	Posttest (60 min.)

Figure 4: Procedural Schedule for the Experimental Groups

The pretests were administered to the students concerning the two areas of interest to the study. First, they completed the CAIMI) and then the participants completed the achievement test, designed by the researcher. It correlated with the Experiment Gallery exhibits. The researcher assessed all five major theme areas of the Experiment Gallery. These same tests were used for the posttest and the delayed posttest.

All sixth grade students in the school were given the opportunity to participate in the study and were randomly assigned to one of four treatment groups stratified by teacher. The researcher obtained class rosters from each of the four science teachers during the first meeting. The student names from Teacher A's roster were assigned a number from 01 to 70. A table of random numbers was used in order to place the participants into one of the four treatment groups. Groups were color-coded as red, yellow, green, and blue. A rotation method was used. That is the first name selected was placed in the red group, the second name placed in the yellow group, the third name placed in the green group, the fourth name placed in the blue group. This process was repeated until all participants in Teacher A's classes were assigned to a group. Then this method was repeated for Teacher B, C, and D's rosters. When all 280 students had been randomly assigned to a group, the four groups were then randomly assigned to one of the following treatments to be administered: (a) control group, (b) exhibit group, (c) lesson group, and (d) exhibit/lesson group. Of the 280 students, those who did not return a human use/consent form to attend the field trip were not allowed to participate. This yielded a useable sample of 228 students. Prior to treatment, some participants were randomly reassigned to the four treatment groups to have groups of equal size.

The four science teachers were scheduled to bring their students to the IDEA Place/Experiment Gallery approximately four weeks after taking the pretests. Color-coded nametags were given to the students to wear on the field trip to identify their group assignments. Student workers at the IDEA Place/Experiment Gallery had color-coded name tags to identify with which group they were working. A schedule was given to the student workers to rotate the groups properly through the treatments in the correct order and in a timely fashion. The student workers were also provided a script of the exhibits to explain to the students what could be explored at each exhibit in the Experiment Gallery.

The IDEA Place

The IDEA Place (Investigate, Discover, Explore, Ask) was approved by the Louisiana Board of Regents in 1991 as part of Louisiana Tech University's science and technology education center (SciTECH). The IDEA Place opened in April 1994, and since then more than 40,000 K-12 students from north Louisiana and Arkansas have visited the IDEA Place. Attendance has grown steadily each year, with an anticipated 2002-2003 school year attendance approaching 10,000.

Along with the IDEA Place, other science and technology resources are available. The IDEA Place in 2002 assumed the management responsibility for the university's Planetarium, which was upgraded from a Level 2 to a Level 5 facility after a $90,000 renovation project during the Summer of 2002 that enhanced and modernized the it by allowing the projection of images of the sun, moon, planets, and 3,000 visible stars. Also, the IDEA Place has housed the NASA Educator Resource Center (ERC) for Louisiana since 1999. The ERC provides teachers with free resource materials from NASA, such as posters, educator guides, and CD-ROMs. ERC staff members are also available for classroom presentations and professional development workshops for teachers.

The Experiment Gallery

The Experiment Gallery was designed and constructed by the Science Museum of Minnesota through support of the National Science Foundation. The Experiment Gallery had been touring the United States since 1997, and completed this tour in 2002. The exhibit was put up for sale at the end of its tour. The IDEA Place staff wrote grants through the Board of Regents and other sources to bid for the purchase of the Experiment Gallery and to give it a permanent home. The bid was accepted and the Experiment Gallery was installed at the IDEA Place in mid-2002.

The Experiment Gallery will serve many functions at Louisiana Tech University. It (a) provides an exciting setting for professional development, (b) an opportunity for preservice teachers to develop lessons and activities to present to PK-12 students that visit the Gallery, (c) PK-12 students with exploratory scientific phenomena, and (d) provides teachers with a low cost educational field trip opportunity that is content standards specific (The IDEA Place, 2002).

The Experiment Gallery consists of more than 25 interactive exhibits based on five theme areas: (a) electricity, (b) light and optics, (c) mechanics, (d) sound and waves, and e) weather. The Experiment Gallery also contains an Activity Station. This area provides visitors the opportunity to experience fun hands-on science activities supervised by the IDEA Place staff. Teachers are able to select from activities in which they would like their classes to participate prior to their visits, and new activities are introduced through lessons developed by preservice teachers. The Experiment Gallery also houses a resource center for teachers to provide additional materials and support to correlate classroom activities with a visit to the Experiment Gallery. Additionally, at the time of this study, on-line resources were being developed as another resource for teachers to utilize fully the Experiment Gallery to promote student achievement in science.

The Control Group

In the first portion of the visit the control group was taken to one of the testing sites at the university and completed the CAIMI and the science achievement treatment posttest. The students' science teacher administered the tests. During the second and third portions of the field trip, the control group experienced the lesson and the exhibits just as the other groups did.

The Lesson Group

The lesson group began the field trip by spending the first portion in the Activity Station in the Experiment Gallery, an area that provides visitors an opportunity to experience hands-on science activities under the supervision of IDEA Place/Experiment Gallery staff. In this particular study, students participated in a 30-minute lesson on mechanics, transfer of energy, and pendulums, which was designed by the researcher. The researcher selected a pre-service teacher who is a trained IDEA Place/Experiment Gallery staff member to instruct the lesson. The researcher worked with the IDEA Staff member to insure that the lesson was consistently taught to each group.

Once this group finished the lesson, students took the CAIMI and the science achievement treatment posttests. A paraprofessional from the school, who had been trained for the task, administered the tests to this group due to overlap of testing times with the control group. During the final portion of the trip, the students toured the exhibits in the Experiment Gallery.

The Exhibit Group

The exhibit group started by touring the exhibits of the Experiment Gallery for 60 minutes. A student worker was assigned to the group who was a trained IDEA Place/Experiment Gallery staff member. She spent the first 30 minutes introducing the exhibits to the students following a script written by the researcher. The remaining 30 minutes was free time for the students to explore any exhibits more thoroughly that were of interest to them.

Once this group finished touring the exhibits, students completed the CAIMI and the science achievement treatment posttest. The regular science teacher administered these tests to the students. The group then experienced the lesson in the Activity Station in the Experiment Gallery.

The Exhibit/Lesson Group

This group began by spending the first 30 minutes of its visit with the introductory tour of the exhibits, guided by a student worker who was a trained IDEA Place/Experiment Gallery staff member, following a script written by the researcher. Once this portion was completed, the group attended the 30-minute lesson in the Activity Station. Then this group was allowed the 30-minute free period to explore the exhibits. Finally, students ended their trip by taking the CAIMI and the science achievement treatment posttest, which was administered by a paraprofessional.

Validity and Reliability

The pretest-posttest control comparison group design controlled for many threats to internal validity. History was controlled for in this design in that general historical events that may have caused a difference in one particular group would have most likely produced a difference in the other groups (Campbell & Stanley, 1963). Campbell and Stanley also stated that maturation and testing were controlled for because they would most likely occur equally in the experimental and the control groups. These authors also noted that regression was controlled for in terms of mean differences even though the scores on the pretest may be extreme. This is because of the random assignment of participants to groups. Random assignment and the total size of the sample ($N = 228$) controlled for the effects of selection. Because the same assessment instruments were used for the pretest and the posttest, instrumentation was also controlled. The only source of internal invalidity not controlled was attrition, since certain participants may be absent from school when the pretest was administered, when the classes came to the science museum.

One threat to external validity of this study was that the sixth graders tested were from a north central Louisiana school. It may only be possible to generalize to similar populations in similar sized communities. However, it would not be possible to generalize to other populations, such as inner city schools, high school aged students, or other grade levels. Pretesting the participants may have sensitized them to the intent of the study. However, the researcher attempted to control this factor by waiting to administer the treatment until four weeks after the participants completed the pretest.

Pilot Study

The researcher developed her own test of science achievement. In order to establish validity and reliability for this test, the researcher conducted a pilot study on a sixth grade population of 116 students that was similar in composition to the one used in the study. This group of students participated in a visit to the Experiment Gallery in the fall of 2002. Using the Kuder-Richardson 21 formula, the reliability coefficient of .31 was computed. The test was written to specifically address the five main theme areas of science that are the focus of the exhibits of the Experiment Gallery: (a) electricity, (b) light and optics, (c) mechanics, (d) sound and waves, and (e) weather. The test was comprised of 30 multiple-choice questions in which there was only one correct response. All of the questions were correlated with the sixth grade content standards for this parish and state benchmarks used by the teachers in this parish. To determine content validity, the test was reviewed by science education faculty at Louisiana Tech University and practicing upper elementary teachers familiar with the parish standards and state benchmarks.

Data Analysis

Each of the hypotheses of the study was tested at the $p < .05$ level of significance. Data were analyzed in two fashions. First, the researcher conducted analysis for significant differences between the four treatment groups on the pretest for science achievement and for the CAIMI. Whether or not there were initial differences in the groups (in achievement or motivation) at the start of the study was determined by completing a simple Analysis of Variance (ANOVA). The simple ANOVA was used since there were four treatment groups, one independent variable in the study, and the participants were randomly assigned to groups. Since there were initially no significant differences in the four groups, then the posttest data for achievement and motivation were analyzed by using an ANOVA. If initial differences had existed between any of the groups in the study in achievement or motivation, however, then the posttest data would be analyzed with an Analysis of Covariance (ANCOVA). The ANCOVA would be appropriate in this case because it corrects for the initial differences in the groups on the pretest (Gay, 1996).

If the data reflected significant differences between groups, a post-hoc analysis was conducted. The researcher opted to use a Tukey for this analysis because it is more liberal than a Scheffé and because students were randomly assigned to groups.

The researcher also looked for significant differences within the groups themselves. Pretest and posttest data were analyzed in this situation by using a dependent *t*-test, because the data were being compared between the same group of participants.

To measure for a significant relationship in the students' level of intrinsic motivation and the quality of learning they experienced, the Pearson *r* was calculated. This was the correct statistic for this hypothesis because the researcher wanted to measure the degree to which a relationship exists between the two variables of level of intrinsic motivation and quality of learning and because the data are interval (Gay, 1996).

The delayed posttest data in achievement and motivation were analyzed using the same statistical procedures. Comparisons were made among groups, and by comparing each group of participants to that group's pretest and posttest scores. The effect size was calculated for significant differences found using Glass' *d* (Pedersen, 2002).

Limitations

There are limitations to this study. Attrition presented a problem, because certain participants were absent from school when the pretest was administered, and when the classes came to the science museum. Results may not be generalized to the whole population since the study was limited to sixth graders attending public school in a northern Louisiana parish. Also, it would not be possible to generalize to other populations, such as inner city schools, high school aged students, or other grade levels. Pretesting the participants may also have sensitized the participants to the intent of the study. The teachers may have instructed on this content during the time of the study, which could also have biased the results.

Summary

In Chapter 3, the research design was outlined and sampling techniques were identified. This chapter also included information on instrumentation and procedural details. In addition, steps for minimizing threats to internal validity and reliability of the research design were discussed. Also addressed were the pilot study conducted on the science achievement test, data analysis procedures, and limitations of the data.

CHAPTER FOUR

Data Analysis

The purpose of this study was to examine whether there were changes in student motivation toward science and achievement in science in relationship with informal learning settings, namely a visit to a science museum. The researcher also wanted to determine if level of intrinsic motivation affected the quality of learning. Specifically, do students who are assessed as having certain levels of motivational attitudes toward science experience superficial learning or deep learning of content? Finally, through the course of the study, the researcher observed if different levels of intrinsic motivation could be created in groups of students by using different treatments.

Data analysis indicated that there were no significant differences found in all seven hypotheses, except for the findings for the exhibit group in Hypothesis 3 on the delayed posttests, the lesson group in Hypothesis 4, and the findings for the exhibit group of Hypothesis 5. There were no statistically significant differences between the pre-CAIMI scores and the post-CAIMI scores between groups. There were also no statistically significant differences between the pre-achievement scores and the post-achievement scores between groups. No significant relationships were revealed between the level of motivation and the achievement gained between groups on the posttest.

The data analysis within each group, however, did reveal a statistically significant difference between the participants' motivational levels in the lesson group from pre-CAIMI to post-CAIMI and from post-CAIMI to delayed-CAIMI scores. It was also revealed that there was a statistically significant difference in the exhibit group participants' achievement levels from pre-achievement to post-achievement and from post-achievement to delayed-achievement. Also, a significant relationship between level of motivation and science achievement tests scores were revealed for the exhibit group for the delayed posttests. There were no other statistically significant findings to support that the effects of the treatment caused any long-term effects on motivation or achievement within any of the four treatment groups.

Data Collection

The sample for this study consisted of 228 sixth grade students enrolled in a public north central Title I Louisiana school. The pretests were administered to the students concerning the two areas of interest to the study. First, they completed the Children's Academic Intrinsic Motivation Inventory (CAIMI), designed to measure academic intrinsic motivation in upper elementary through junior high school students. Secondly, the participants completed an achievement test designed by the researcher that addressed pertinent Louisiana Content Standards for sixth grade science that correlated with the Experiment Gallery exhibits. All students in the school were given the opportunity to participate in the study and were randomly assigned to one of four treatment groups stratified by teacher. When all students had been randomly assigned to a group, the four groups were then randomly assigned to one of the following treatments to be administered: (a) control group, (b) exhibit group, (c) lesson group, and (d) lesson/exhibit group. The four science teachers were scheduled to bring their classes to the IDEA Place/Experiment Gallery approximately four weeks after taking the pretests. Students in each group followed a timetable that rotated them through the various activities (lesson, exhibits tour, and posttests) in a specific order assigned to the group according to the treatment each was to receive. Approximately one month after the field trip to the IDEA Place Experiment Gallery, the students completed the CAIMI and the achievement test as a delayed posttest measure.

Descriptive Data Analysis

The responses from the participants to the *Children's Academic Intrinsic Motivation Inventory* (CAIMI) and the achievement test were analyzed by using the SPSS Graduate Pack 10.0 for Windows, a statistical software package. The sample for this study consisted of 228 sixth grade students enrolled in a public north central Title I Louisiana school. The student body was 48% White, 52% Black, and 51% of the school population was male. Of the entire school population, 68% was considered at-risk and received free/reduced lunch and 6% was receiving special education services.

Data for participants who were absent for the pretest or the treatment (field trip) were not used, thus, resulting in groups of unequal size. Participants who did not complete the delayed posttests were assigned the median value for their treatment group. The final composition of each group in terms of gender and ethnicity is reported in Tables 3 and 4.

Table 3

Participants' Gender and Group Sizes

Treatment Group	*n*	Females	Males
Control	56	25 (44.6%)	31 (55.4%)
Exhibit	53	21 (39.6%)	32 (60.4%)
Lesson	61	38 (62.3%)	23 (37.7%)
Exhibit/Lesson	58	26 (44.8%)	32 (55.2%)
Total	228	110 (48.2%)	118 (51.8%)

Table 4

Participants' Ethnicity

Treatment Group	Asian	Black	Hispanic	White
Control	1 (1.8%)	23 (41.1%)	4 (7.1%)	28 (50.0%)
Exhibit	2 (3.8%)	25 (47.2%)	1 (1.9%)	25 (47.2%)
Lesson	2 (3.3%)	31 (50.8%)	0 (0.0%)	28 (45.9%)
Exhibit/Lesson	0 (0.0%)	34 (58.6%)	1 (1.7%)	23 (39.7%)
Total	5 (2.2 %)	113 (49.6%)	6 (2.6%)	104 (45.6%)

As displayed in Table 3, the treatment groups ranged in size from a low of 53 participants in the exhibit group to a high of 61 in the lesson group. The groups were equal initially, but due to attrition, the final number of participants with usable data in each group varied. Females in each group varied from a low of 21 in the exhibit group to a high of 38 in the lesson group. The males in each group ranged from a low of 23 in the lesson group to a high of 32 males in both the exhibit group and the exhibit/lesson group. Table 4 shows the Asian students included in the treatment groups ranged from a low of none included in the exhibit/lesson group to a high of two students in both the exhibit group and the lesson group. Black members of each treatment group ranged from a low of 23 in the control group to a high of 34 in the exhibit/lesson group. The Hispanic students included in the treatment groups varied from a low of none in the lesson group to a high of four in the control group. Finally, the White students in each treatment group ranged from a low of 23 in the exhibit/lesson group to a high of 28 in both the control group and the lesson group. These data for the groups indicated that, although many students were not included in the data analysis due to attrition, the relative composition of the sample was reflective of the entire school's population.

Statistical Data Analysis

The *Children's Academic Intrinsic Motivation Inventory* (CAIMI) was used to collect data on the participants' motivational levels toward science. The achievement test designed by the researcher was used to collect data on the participants' science achievement in relation to the exhibits at the IDEA Place Experiment Gallery. After the pretests were given for motivational levels and achievement, the responses were reported in means and standard deviations for the four experimental groups for both measures in Table 5. Statistical comparisons of the mean scores of the four experimental groups on the pretest CAIMI and achievement test were performed using a one-way ANOVA. These data are reported in Table 6 in order to show no initial differences between the four experimental groups at the onset of the study.

Table 5

Descriptive Analysis of Pretest CAIMI and Achievement Test Scores

		CAIMI		Achievement Test	
Group	*n*	Pretest Mean	Pretest *SD*	Pretest Mean	Pretest *SD*
Control	56	91.12	17.75	9.13	2.61
Exhibit	53	90.25	16.96	8.98	2.59
Lesson	61	94.31	15.24	9.38	2.54
Exhibit/ Lesson	58	88.52	17.17	8.86	2.68

Table 6

Results of ANOVA for the Pretest CAIMI and Pretest Achievement Test Scores

Source	*df*	*SS*	*MS*	*F*	*p*
CAIMI Pretest					
Between Groups	3	1054.758	351.586	1.250	.293
Within Groups	224	63027.501	281.373		
Total	227	64082.259			
Achievement Pretest					
Between Groups	3	8.735	2.912	0.429	.732
Within Groups	224	1520.331	6.787		
Total	227	1529.066			

The non-directional hypotheses of the study were tested at the $p < .05$ level of significance. The responses were reported in means and standard deviations for the four experimental groups for both measures. Statistical comparisons of the mean score within each group on the pretests, posttests, and delayed posttests for the CAIMI and the achievement test were performed using a dependent *t*-test. Statistical comparisons of the mean score between the four experimental groups on the pretests, posttests, and delayed posttests for the CAIMI and the achievement test were performed using a one-way ANOVA. Statistical comparisons of the relationship between motivational levels and science achievement were performed using the Pearson *r*. Parametric tests were used because the individual experimental group sizes were large enough to support their use.

Effect size was also calculated for any statistically significant differences that were found. Effect size is a measure of the degree to which a treatment affects the dependent variable. When the mean of an experimental group is larger than the mean of the control group, then a positive effect size is obtained. Conversely, if the control group has a mean score that is greater than an experimental group, then a negative effect size is achieved. The proper statistic to use in this case, according to Pedersen (2002) is Glass' *d*, because the researcher found significant differences using the dependent *t*-test.

Each non-directional hypothesis is restated below, followed by a discussion of the statistical analysis used to test the hypotheses.

Hypothesis Testing

Hypothesis one stated that there will be a significant difference in intrinsic motivational levels between students who experience museum-based learning and those students who do not experience museum-based learning.

The means and standard deviations for the CAIMI posttest scores are presented in Table 7. As can be seen in Table 7, the posttest means ranged from a low of 89.90 (exhibit/lesson group) to 97.70 (lesson group), and the standard deviation ranged from 13.29 (lesson group) to 22.48 (control group). An ANOVA was used to test this hypothesis. Results of this analysis appear in Table 8. The results revealed that there were no significant differences in the participants' motivational levels toward science on the posttest between the treatment groups.

The F value (3, 224) was 2.050 with a p value of .108. Because no significant differences were found, this hypothesis was rejected.

Table 7

Descriptive Analysis of Posttest CAIMI Scores

Group	*n*	Posttest Mean	Posttest *SD*
Control	56	94.11	22.48
Exhibit	53	92.57	16.51
Lesson	61	97.70	13.29
Exhibit/ Lesson	58	89.90	16.98

Table 8

Results of ANOVA Test Comparing Motivational Levels of the Experimental Groups on the CAIMI Posttest

Source	*df*	*SS*	*MS*	*F*	*p*
Between Groups	3	1894.065	631.355	2.050	.108
Within Groups	224	68996.444	308.020		
Total	227	70890.509			

Hypothesis two stated that there would be a significant difference in achievement in science between students who experience museum-based learning and those students who do not experience museum-based learning.

The means and standard deviations for the posttest achievement tests are presented in Table 9. As can be seen in Table 9, the posttest means for the science achievement posttest ranged from a low of 9.23 (lesson group) to a high of 10.11 (exhibit group), and the standard deviations ranged from 2.46 (control group) to 2.92 (lesson group). An ANOVA was used to test this hypothesis. Results appear in Table 10. Analysis revealed that there were no significant differences in the participants' achievement levels in science on the posttest between the experimental groups. The F value (3, 224) was 1.002 with a p value of .393. Because no significant differences were found, this hypothesis was rejected.

Table 9

Descriptive Analysis of the Posttest Achievement Test Scores

Group	*n*	Posttest Mean	Posttest *SD*
Control	56	9.55	2.46
Exhibit	53	10.11	2.82
Lesson	61	9.23	2.92
Exhibit/ Lesson	58	9.62	2.70

Table 10

Results of ANOVA Comparing Achievement Levels of the Experimental Groups on the Science Achievement Posttest

Source	*df*	*SS*	*MS*	*F*	*p*
Between Groups	3	22.433	7.478	1.002	.393
Within Groups	224	1671.602	7.463		
Total	227	1694.035			

Hypothesis three stated that there would be a significant relationship in the students' level of intrinsic motivation and the quality of learning (deep, long lasting learning of content or superficial short term learning) as a function of the treatment they experienced.

The Pearson *r* correlational coefficient was calculated for this hypothesis. The results are presented in Table 11, and revealed no significant relationship between the motivational levels toward science and the quality of learning (as demonstrated by the achievement test score) that participants experienced on the posttest. On the delayed posttests, the results showed no significant relationships for the control group (r = -2.52), the lesson group (r = -.017), and the exhibit/lesson group (r = .187). A significant relationship was found for the exhibit group on the delayed posttests (r = .402). Since there were no significant relationships found for the posttest, this hypothesis was rejected. No significant relationships were found for the delayed posttest for the control group, the lesson

Table 11

Results of Pearson r Tests of the Relationship Between Motivational Level Toward Science and Quality of Learning (Posttest and Delayed Posttest)

		Posttest		Delayed Posttest	
Group	*n*	*r*	*p*	*r*	*p*
Control	56	.132	.334	-2.52	.061
Exhibit	53	.234	.092	.402**	.003
Lesson	61	-.191	.140	-.017	.896
Exhibit/ Lesson	58	.152	.254	.187	.160

**Significant at $p < .01$ level

group, and the exhibit/lesson group; therefore, this hypothesis was rejected. The hypothesis was accepted for the exhibit group on the delayed posttest, because a significant relationship was shown.

Hypothesis four stated that there would be a significant difference between the levels of intrinsic motivation toward science that students possess as a result of the treatment they received (control, exhibit, lesson, exhibit/lesson).

Descriptive statistics concerning this hypothesis are reported previously in Tables 5 and 7. The dependent *t*-test was used to test this hypothesis. The results of this analysis are presented in Table 12. The results revealed that the control group had no significant difference between the pre-CAIMI to post-CAIMI scores ($t = -1.034$). The exhibit group also showed no significant difference between the pre-CAIMI to post-CAIMI scores ($t = -1.410$). The lesson group, however, did show a significant difference between the pre-CAIMI to post-CAIMI scores (t = - 2.371). Calculations revealed a small positive effect size (ES = .222). The exhibit/lesson group showed no significant difference between the pre-CAIMI to post-CAIMI scores (t = - 0.887). This hypothesis was retained for the lesson group. However, for the other three groups, the hypothesis was rejected.

Table 12

Results of Dependent t-tests Comparing Pretest and Posttest Levels of Motivation Toward Science Within Each Experimental Group

Group	n	t	df	p	ES
Control	56	-1.034	55	.306	
Exhibit	53	-1.410	52	.164	
Lesson	61	-2.371	60	.021*	.222
Exhibit/ Lesson	58	-0.887	57	.379	

*Significant at $p < .05$ level

Hypothesis five stated that there would be a significant difference between the levels of science achievement that students possess as a result of the treatment they received (control, exhibit, lesson, exhibit/lesson).

Descriptive statistics concerning this hypothesis are reported previously in Tables 5 and 9. The dependent t-test was used to test this hypothesis. The results of this analysis are presented in Table 13. These analyses revealed that there was no significant difference between the control group's pre-achievement and post-achievement test scores (t = -0.932). However, the exhibit group did show a

Table 13

Results of Dependent t-tests Comparing Pretest and Posttest Levels of Science Achievement Within Each Experimental Group

Group	*n*	*t*	*df*	*p*	ES
Control	56	-0.932	55	.356	
Exhibit	53	-2.371	52	.021*	.436
Lesson	61	.339	60	.735	
Exhibit/ Lesson	58	-1.859	57	.068	

* Significant at $p < .05$ level

significant difference between its pre-achievement and post-achievement test scores (t = -2.371). A moderate positive effect size was observed (ES = .436). The lesson group showed no significant difference between its pre-achievement and the post-achievement test scores (t = 0.339). The exhibit/lesson group also showed no significant difference between the pre-achievement test and the post-achievement test (t = -1.859). This hypothesis was retained for the exhibit group; however, for the other three groups, it was rejected.

Hypothesis six stated that there would be a significant difference between the long-term assessment of the level of intrinsic motivation that students possess as a result of the treatment they received (control, exhibit, lesson, exhibit/lesson).

The means and standard deviations for the posttest and the delayed posttest on the CAIMI are presented in Table 14. A dependent *t*-test was used to test this hypothesis. The results of this analysis are presented in Table 15. The results revealed that there were no significant differences found in the long term intrinsic motivation levels in the control group ($t = 1.609$), the exhibit group ($t = 1.657$), and the exhibit/lesson group ($t = 0.172$). The results for the lesson group, however, showed a significant difference in the long-term motivation level ($t = 3.011$). Effect size was small, but positive (ES = .316). This hypothesis was retained for the lesson group. For the other three groups, the hypothesis was rejected.

Table 14

Descriptive Analysis of the Posttest and the Delayed Posttest CAIMI Test

		Posttest		Delayed Posttest	
Group	*n*	Mean	*SD*	Mean	*SD*
Control	56	94.11	22.48	89.86	15.09
Exhibit	53	92.57	16.51	89.57	14.76
Lesson	61	97.70	13.29	93.48	16.00
Exhibit/ Lesson	58	89.90	16.98	89.60	15.46

Table 15

Results of the Dependent t-tests Comparing Experimental Groups and the Delayed Posttest Intrinsic Motivation Test Scores

Group	*n*	*t*	*df*	*p*	ES
Control	56	1.609	55	.113	
Exhibit	53	1.657	52	.104	
Lesson	61	3.011	60	.004**	.316
Exhibit/ Lesson	58	0.172	57	.864	

** Significant at $p < .01$ level

Hypothesis seven stated that there would be a significant difference between students who experience different treatments (control, exhibit, lesson, exhibit/lesson) and the long term assessment of science achievement.

The means and standard deviations for the posttest and the delayed posttest on the achievement test are presented in Table 16. A dependent *t*-test was used. The results of this analysis are presented in Table 17. They revealed that there were no statistically significant differences in levels of science achievement in the control group (t = 1.093), the lesson group (t = 0.736), and the exhibit/lesson group (t = 1.159). The results for the exhibit group, however, showed a significant difference in science achievement (t = 2.052). Analysis revealed a small positive effect size (ES = .259). This hypothesis was retained for the exhibit group. However, for the other three groups, the hypothesis was rejected.

Table 16

Descriptive Analysis for the Posttest and the Delayed Posttest Science Achievement Test Scores

		Posttest		Delayed Posttest	
Group	*n*	Mean	*SD*	Mean	*SD*
Control	56	9.55	2.46	9.09	2.29
Exhibit	53	10.11	2.82	9.38	2.94
Lesson	61	9.23	2.92	8.89	3.14
Exhibit/ Lesson	58	9.62	2.70	9.10	2.57

Table 17

Results of the Dependent t-tests Comparing Experimental Groups and the Delayed Posttest Science Achievement Test Scores

Group	*n*	*t*	*df*	*p*	ES
Control	56	1.093	55	.279	
Exhibit	53	2.052	52	.045*	.259
Lesson	61	0.736	60	.465	
Exhibit/ Lesson	58	1.159	57	.251	

* Significant at $p < .05$ level

Summary

In this chapter, data collection and analysis techniques used in this study were discussed. The overall response rate for the participants' CAIMI and for their science achievement was noted. Descriptive data were compiled for the school population and for each group in terms of gender and race. Descriptive data analysis consisted of means and standard deviations. These data were presented in tables with accompanying narrative.

The responses from the participants to the CAIMI and the achievement test were analyzed by using the SPSS Graduate Pack 10.0 for Windows, a statistical software package. Statistical comparisons of the mean score between the four treatment groups and within each individual group were conducted using the following statistical tests: dependent *t*-test, one-way ANOVA, and Pearson *r*. Statistically significant differences were determined using $p < .05$ level of significance. Effect size was calculated using Glass' *d* and was reported for any statistically significant differences that were found. Statistical analysis results were reported using tables with accompanying narratives.

The statistical analysis revealed no significant differences found in all seven hypotheses, except for the findings for the exhibit group in Hypothesis 3 on the delayed posttests, the lesson group in Hypothesis 4 and the findings for the exhibit group in Hypothesis 5. There were no statistically significant differences between the pre-CAIMI scores and the post-CAIMI scores between groups. There were also no statistically significant differences between the pre-achievement scores and the post-achievement scores between groups. No significant relationships were revealed between the motivational level and the achievement gained between groups on the posttest.

The data analysis within each group, however, did reveal a statistically significant difference between the participants' motivational levels in the lesson group from pre-CAIMI to post-CAIMI and from post-CAIMI to delayed-CAIMI scores. It was also revealed that there was a statistically significant difference in the exhibit group participants' achievement levels from pre-achievement to post-achievement and from post-achievement to delayed-achievement. Also, a significant relationship between level of motivation and science achievement tests scores were revealed for the exhibit group for the delayed posttests. There were no other statistically significant findings to support that the effects of the treatment caused any long-term effects on motivation or achievement within any of the four treatment groups. The findings, conclusions, limitations of the study, and recommendations based on the data analysis are presented in Chapter Five.

CHAPTER FIVE

Findings, Conclusions, and Recommendations

The purpose of this study was to examine whether there are changes in student motivation toward science and achievement in science in relationship with informal learning settings, namely a visit to a science museum. The researcher also wanted to determine if different levels of intrinsic motivation affected the quality of learning. Specifically, do students who are assessed as having certain levels of motivational attitudes toward science experience deep learning of content or superficial learning? Finally, through the course of the study the researcher observed if different levels of intrinsic motivation could be created in groups of students by using different treatments.

The sample for this study consisted of 228 sixth grade students enrolled in a public north central Title I Louisiana school. The pretests were administered to the students concerning the two areas of interest to the study. First, they completed the Children's Academic Intrinsic Motivation Inventory (CAIMI), designed to measure academic intrinsic motivation in upper elementary through junior high school students. Secondly, the participants completed an achievement test designed by the researcher that addressed pertinent Louisiana Content Standards for sixth grade science that correlated with the Experiment Gallery exhibits. All students in the school were given the opportunity to participate in the study and were randomly assigned to one of four treatment groups stratified by teacher. When all students had been randomly assigned to a group, the four groups were then randomly assigned to one of the following treatments to be administered: (a) control group, (b) exhibit group, (c) lesson group, and (d) exhibit/lesson group. The four science teachers were scheduled to bring their classes to the IDEA Place/Experiment Gallery approximately four weeks after taking the pretests. Students in each group followed a timetable that rotated them through the various activities (lesson, exhibits tour, and posttests) in a specific order assigned to the group according to the treatment they were to receive. Approximately one month after the field trip to the IDEA Place Experiment Gallery, the students were given the CAIMI and the achievement test as a delayed posttest measure.

The *Children's Academic Intrinsic Motivation Inventory* (CAIMI) was used to collect data on the participants' motivational levels toward science. The achievement test designed by the researcher was used to collect data on the participants' science achievement in relation to the exhibits at the IDEA Place Experiment Gallery. The responses were reported in means and standard deviations for the four treatment groups for both measures. Statistical comparisons of the mean score within each group on the pretests, posttests, and delayed posttests for the CAIMI and the achievement test were performed using a dependent t-test. Statistical comparisons of the mean score between the four treatment groups on the pretests, posttests, and delayed posttests for the CAIMI and the achievement test were performed using a one-way Analysis of Variance (ANOVA). Statistical comparisons of the relationship between motivational levels and science achievement were performed using the Pearson r. Parametric tests were used since the individual treatment group sizes were large enough to support their use.

The non-directional hypotheses for this study were tested at the $p < .05$ level of significance. Effect size was also calculated for any statistically significant differences that were found.

Findings

Statistical analysis revealed that no significant differences were found in testing all seven hypotheses, except for the findings for the exhibit group in Hypothesis 3 on the delayed posttests, the lesson group in Hypothesis 4 and the findings for the exhibit group in Hypothesis 5. No significant differences were found between the pre-CAIMI scores and the post-CAIMI scores among groups. Also, no significant differences between the pre-achievement scores and the post-achievement scores among groups were discovered. No significant relationships were revealed between the motivational level and the achievement gained between groups on the posttest.

The data analysis within each group, however, did reveal a significant difference between the participants' motivational levels in the lesson group from pre-CAIMI to post-CAIMI and from post-CAIMI to delayed-CAIMI scores. It was also revealed that there was a significant difference in the exhibit group participants' achievement levels from pre-achievement to post-achievement and from post-achievement to delayed-achievement. Also, a significant relationship between level of motivation and science achievement tests scores was revealed for the exhibit group for the delayed posttests. There were no other significant findings to support that the effects of the treatment caused any long-term effects on motivation or achievement within any of the four experimental groups. Since there were few statistically significant findings in motivation or achievement as measured in this study, the results do not appear to support the tenets of activity theory.

Discussion

In this study, seven hypotheses were tested in order to look at the various motivational and achievement aspects of museum-based learning. The first hypothesis dealt with difference in motivational levels between students who experienced museum-based learning and those who did not. As research reported earlier suggested, many students are not interested in science (Ye et al., 1998). Informal learning settings, as reported by Bartels (2001, September 19), can support interest and develop motivation to learn more about a particular area of study. It was thought that an exciting environment, such as a science museum, would lead to more interest in science. The results of this study, however, do not corroborate with the literature. For example, in the study done by Borun (1983) participants found museum exhibits to be fun and enjoyable and more interesting than classroom lessons. In Salmi's (1993) study, museums were thought to be a motivational setting for learning. In this study, no significant differences in motivation toward science were discovered among any of the treatment groups. There are several reasons for these phenomenon. First, the term *field trip* connotes a day away from school to do something fun. No previous activities occurred in the four science classes to support the idea that this was going to be a field trip to have fun with science. Secondly, the test used to measure motivation toward science, the CAIMI, contained questions that dealt with school-based aspects of science, such as liking to do homework in science and liking to do challenging problems in science. No clear questions directly asked the students about their motivation toward science and the exhibits themselves. Finally, the data showed that many of these students were highly motivated toward science at the onset of the study. Because this was the case, it would be difficult to show significant increases if motivation scores were high to begin with.

The second hypothesis dealt with significant differences in science achievement between those students who experienced museum-based learning and who did not. Martin et al. (1981) stated that field trips could be thought of as a way to improve learning by changing the environment. A hands-on science museum, which promotes inquiry-based learning, can improve student achievement (Fouts & Myers, 1992; Freedman, 1997). The researcher believed that through direct experiences with the hands-on, interactive exhibits in the Experiment Gallery there would be an impact on the achievement of the participants. The results among the four experimental groups in the study showed no significant differences in science achievement among groups. The literature reviewed, compared to the results of the study, showed some discrepancies in information about informal, museum-based learning. For example, in the study done by Gilbert and Priest (1997), some themes that emerged were recognition of familiar objects and linked discourse of prior activities at school that correlated with the museum visit, the experience at the museum, and future activities. Many of the participants in this study when asked by the student workers at the introduction to the museum if they had been to the IDEA Place before, responded in the affirmative by raising their hands. The participants, therefore, could have held a pre-conceived notion about what they were to experience, and when they discovered that the exhibit area was vastly different, due to the installation of the Experiment Gallery exhibits, the familiar may have become unfamiliar. However, the novelty of the settings and its effects on learning has been shown in studies similar to this one. Balling and Falk (1980) conducted research looking into the effects that novelty of field trip settings have on children's learning and behavior. They discovered that children who were unfamiliar with the setting in which they were expected to learn failed to learn at a significant rate and were unable to attend to the task given. They also reported that certain learning environments might have so much to be learned and may be so complex that learning is inhibited. Such findings coincide with those of this study. There are more than 25 exhibits in the Experiment Gallery. Although the student worker group leader gave the participants a short preview of each exhibit, the large number of exhibits could have been overwhelming. Plus, the time constraints due to the nature of the treatment schedule could have been a factor in these results. The science achievement test that was designed by the researcher had low reliability, and therefore could have influenced the results for this hypothesis.

Hypothesis three stated that there would be a significant relationship in the students' level of intrinsic motivation and the quality of learning (deep, long lasting learning of content or superficial short term learning) with regard to the treatment they experience. Salmi (1993) showed in his study that the treatment group that was intrinsically motivated performed the best on most of the cognitive tests given. The researcher thought that, by looking at this relationship, a better understanding of motivation and its connection to achievement would be beneficial to know. It is interesting to note that the exhibit group showed a significant relationship on the delayed posttests for motivation and achievement. Apparently, the museum experience played a role in student motivation and achievement in science for those who experienced the exhibit gallery first. Once participants returned to the classroom, the effect of the field trip was reflected in the delayed posttest scores for this group. Another interesting observation is that the same effect was not noted for the treatment group that received both the lesson and the exhibit tour. Again, the novelty of the setting could have played a role. Since the test was of low reliability and student motivation was high at the onset of the study, this may have influenced the results of the statistical analyses used to test this hypothesis.

The fourth hypothesis tested the level of intrinsic motivation toward science as a result of the treatment received. Inquiry-based science has been linked with motivation in science (Fouts & Myers, 1992; Freedman, 1997). Informal learning environments, such as a science museum, can develop motivation to learn more about science (Bartels, 2001, September 19). It was hypothesized that, dependent on the treatment received, whether experiencing the exhibits only, or the lesson only, or both, that differences in motivation would be observed. The findings revealed that the lesson group did experience a significant increase in motivation level compared to the other groups. This is inconsistent with what Borun (1983) found in her study. Her analysis revealed that, in terms of interest and enjoyment of the museum activity (in comparison to school classes), the exhibit was preferred over the lesson. This may be explained in several ways. One reflection is that the student worker who taught the lesson was a dynamic individual. Since she began working at the IDEA Place, she has been very energetic and works well with the groups of children that come to the museum. She has also taken it upon herself to learn new lessons and material that are specific requests of teachers who are bringing their students to the museum when she will be working. The enthusiasm that she conveyed could have played a role in the increased motivation toward science for the students in the lesson group. It is also interesting to note that none of the other treatment groups experienced any significant changes in motivation. This may be due to the reasons listed earlier: no prior classroom preparation, the motivation test not directly connected with aspects of the museum, and the high motivational level of the students at the onset of the study.

A significant difference between levels of science achievement as a result of the treatment received was the focus of the fifth hypothesis. Inquiry-based learning, such as the exhibits and the lesson taught in the Experiment Gallery, has been shown to be an effective teaching method (Havasy, 2001, November 7) and can be another venue to improve student achievement (Bartels, 2001, September 19). As with the fourth hypothesis, it was thought that different levels of achievement could be measured dependent upon the treatment that the participants received. This was the case with the students in the exhibit group, who showed a significant difference between their pretest and posttest scores, with a moderate, positive effect size. This occurred possibly due to the hands-on experience with the exhibits just prior to taking the posttests. The preview given by the student worker (which was scripted by the researcher) could also have played a role in the achievement gains of this group, because this ensured that the participants were exposed to all the exhibits and were given a description of what concepts could be learned at each particular station. None of the other treatment groups, however, showed significant differences in science achievement gains. It was suspected that the exhibit/lesson group should have showed the greatest gains in achievement, but it did not. The aforementioned reasons of novelty of the setting and being overwhelmed with so much to do and see in such a short time frame could have factored into the results of the science achievement test analysis.

The final two hypotheses looked at the long term results of the museum-based experience on the students' motivation and achievement gains in science. The study done by Gibson (1998) revealed that the use of inquiry-based learning activities led to higher positive attitudes toward science and science careers long after participation in the Summer Science Exploration Program. Qualitative data reported in his study indicated that the program had increased participant interest in science due to the hands-on aspects of the program and the enjoyment felt through the activities done during the camp. The researcher felt that looking at the long term effects of the museum-based learning experience on student motivation toward science would be beneficial for teachers and administrators in considering making informal learning experiences a part of regular instructional practices. In this study, the lesson group showed a significant decrease in motivation toward science on the delayed posttest. It appears that possibly the energetic student worker who conveyed a very positive attitude toward science while instructing the lesson had a positive effect for the posttest, but that the effects were not long lasting. No other groups revealed any significant, long-term effects on motivation toward science. Again, because the students scored relatively high on motivation toward science to begin with, it would be difficult to show a significant gain in motivation, and the CAIMI did not have specific questions that would apply to experiences with science in a museum setting.

The long-term effects on science achievement in conjunction with museum-based learning were important in the researcher's mind because many educators are searching for effective ways to help students learn, as Miettinen (1999) stated, to develop a learning network, with various experiences to assist student learning. Museums can be considered informal classrooms (Bartels, 2001, September 19) and be a valuable addition to formal educational settings (Borun, 1983). It was thought that if a noticeable effect on long-term achievement gains in science (such as those gains associated with the Balling & Falk, 1980, study) could be established in combination with museum-based learning, that this would be important information for teachers and administrators. In this study, the exhibit group did show a significant difference on the delayed posttest; however, the scores declined from the posttest given directly after experiencing the exhibits. This indicates that one visit to the museum did not make a sustained achievement gain occur. This could be due in part to the limited time factor and the lack of post-visit activities to reinforce what was experienced at the museum. These reasons may also explain why the other treatment groups did not show any significant differences in achievement gains. Also, the aforementioned problems with the achievement tests could have influenced these results.

Since there were few statistically significant findings in motivation or achievement as measured in this study, the results do not appear to support the tenets of activity theory. Although the museum experience allowed for social interaction between the participants and the exhibits were available for use as artifacts, the content of the exhibits themselves was not internalized by the students. This may be attributed to the large number of exhibits to be observed and the single visit to the IDEA Place. The expectation of these students to internalize the content of so many exhibits in one visit may have been too much for them to absorb (Balling & Falk, 1980).

Conclusions

Museum-based learning, as it was explored in this study, had minimal effects on student motivation toward science and achievement gains in science. Several important factors can be used for a plausible explanation for the results of this study. The unfamiliarity and novelty of the setting appeared to play a large role in the results of the study. As Martin et al. (1981) showed in their study, the novel environment of the field trip setting resulted in reduced conceptual learning, while those who were familiar with the setting showed a strong effect of overall conceptual learning. Balling and Falk (1980) developed a model based on their studies looking at setting novelty and task learning. They found that task learning is highest when the setting is somewhat novel, meaning not so familiar as to be boring but yet not so unfamiliar as to be threatening. In this study, students may have had a pre-conceived notion about the museum because most indicated that they had been there before. When they saw that the exhibit hall had dramatically changed, it could have led to a decline in task learning. These researchers suggested "a first visit can emphasize activities that will familiarize students with the setting" (p. 239). It would be interesting to compare groups of students who experience a museum setting one time with those who experience it multiple times.

The testing site for the posttest may have also been an important aspect associated with the study's results. Martin et al. (1981) found that when they administered tests in the unfamiliar context, conceptual learning declined. The same may have been true in this study. The pretests and delayed posttests were given in the students' regular science classroom. The posttests were given on site at the university. The tests were essentially timed at the university, because the groups had to stay on schedule. Administration of all measurement instruments in this study in familiar classroom settings might have altered the results.

It appears that the positive effects of museum-based learning might be increased if prior content knowledge activities were included before visiting the museum and if planned post-visit activities would build upon the museum experience. These factors were found to be important in other research (Gilbert & Priest, 1997). As stated by Miettinen (1999), a learning network needs to be established. Prior content knowledge activities coupled with multiple museum visits and post-visit activities would have a greater potential to affect attitudes toward science and achievement in science. Although the findings of this study were of little significance to the overall body of knowledge on museum-based learning, important factors emerged as discussed in this section to be considered in future research on the subject.

Limitations

There are limitations to this study. Attrition presented a problem, because certain participants were absent from school when the pretest was administered, and when the classes came to the science museum. Also, students were withdrawn from the school and new students were admitted during the time of the study. Results may not be generalized to the whole population since the study was limited to sixth graders attending public school in a northern Louisiana parish. Also, it would not be possible to generalize to other populations, such as inner city schools, high school aged students or other grade levels. Pretesting the participants may also have sensitized the participants to the intent of the study. The teachers may have instructed on this content during the time of the study, which could also influence the results. The use of a self-report instrument for intrinsic motivation levels may not have provided sufficient information to fully determine the participants' motivational levels. The achievement test may have been too difficult for the students in the study, and was also shown to have a low reliability level.

Recommendations

The following recommendations are presented to be considered for future practice:

1. Teachers should plan activities to complete in the classroom prior to the museum visit in order to build prior content knowledge. These should be based on museum exhibits of interest. This would give the students an advance organizer to help them attend to the most important aspects of the museum visit.
2. Teachers should plan for an initial visit to the facility in order for the students to become familiar with the setting. Subsequent visits can then be planned to improve concept knowledge attainment at the museum. This would help to lessen the novelty effect to the extent that students would be more apt to experience more on-task learning.
3. Post-visit activities should be planned in light of what the students experienced when they visited the museum to reinforce concepts learned at the museum site. The teacher should make notes during the visits to make sure certain students share with the entire class what they experienced with particular exhibits and also to address any misconceptions about scientific concepts that the students may have expressed during the museum visit.
4. Teachers should plan to isolate certain areas of a museum facility for the students to explore in depth, especially if the facility is large and has many

exhibits. The students may be overwhelmed if expected to gain conceptual knowledge from too many exhibits at one time. Repeated visits could be planned to focus upon other exhibit areas of interest.

The following recommendations are presented to be considered for further research:

1. The study should be repeated with other groups of sixth graders from north Louisiana schools and with other grade levels to see if these results are atypical.
2. The study should be repeated with sixth graders in other states that have access to a university-based science museum facility or to other science museum facilities. There may be differences in the effects of museum-based learning between these two types of facilities.
3. The study should be repeated using a longer treatment time with repeated experiences in a science museum. This would lessen the novelty effect of the setting and may increase on-task learning.
4. A more reliable achievement test needs to be designed to measure the science achievement objectives of the exhibits of the Experiment Gallery. Also the difficulty of the test needs to be addressed. An item analysis would be helpful to ascertain which questions were missed by most participants and consult science experts in rewording these questions.
5. A different motivation scale needs to be designed that will more accurately measure motivation in informal learning settings. The CAIMI measures the intrinsic motivation toward science (in this study) in conjunction with most areas that are associated directly with formal learning settings, such as homework and

repeating assignments. A motivation scale that measured informal concepts, such as being able to visit museums more or liking certain types of informal settings, would be beneficial.

6. The study should be repeated with all testing done in the familiar setting of the classroom and without time constraints. This would reduce the possibility of unfamiliarity of the setting playing a factor in the data collected.

APPENDIX A

Researcher Designed Science Achievement Test

Test of Science Achievement

DO NOT mark answers on this paper. Mark your answers on the answer sheet.

1. Two closed circuits have the same voltage power source, the same type of wiring, and the same wattage of light bulbs. The first circuit has a 5 ohm resistor and the second circuit has a 50 ohm resistor. Which light bulb will glow brighter?
   A. The first circuit.
   B. The second circuit.
   C. Both will glow at the same brightness.
   D. It depends on the wattage of the light bulbs.

2. Three different colored lights are projected onto a white screen-red, green, and blue. An object is placed between the screen and the lights. What color(s) of shadows are cast on the screen?
   A. Cyan, magenta, and yellow.
   B. Red, blue, and green.
   C. Only black shadows.
   D. The lights blend to make white light, so no shadows can be seen.

3. What is a Lissajous Figure?
   A. A visual method of showing sound vibrations.
   B. A visual method of showing light waves.
   C. The pattern made from a pendulum in motion.
   D. The stress pattern made on a support beam.

4. A musician uses a metronome to keep the tempo constant in music. If he needs to set the metronome for the fastest tempo, what would he do?
   A. Put the weight at the top of the metronome shaft.
   B. Put the weight in the middle of the metronome shaft.
   C. Put the weight at the bottom of the metronome shaft.
   D. Put more weight on the metronome shaft.

5. A wrench is used to tighten a bolt. Where does the most stress occur?
   A. On the handle of the wrench.
   B. In the center of the curve of the wrench.
   C. On the outer prongs of the wrench.
   D. There is equal stress on all parts of the wrench.

6. A weight of 10 grams is used as a bob on a 20 inch pendulum and its time for one full swing is 1.2 seconds. What could you say about a 20 gram weight in the same experiment?
   A. The time would be twice as long as the first experiment.
   B. The time would be over twice as long as the first experiment.
   C. The time would be shorter.
   D. The time of the swing will not change.

7. What causes the formation of dew?
   A. Rain from the day before.
   B. Moisture forming faster than it can evaporate.
   C. Very cold weather.
   D. Very warm weather

8. What effect does a resistor have on the brightness of a light bulb?
   A. The lightbulb gets brighter.
   B. The lightbulb gets dimmer.
   C. There is no change in the brightness of the bulb.
   D. The lightbulb goes out.

9. What happens when white light is passed through a prism and then through a lens?
   A. The light is separated into the visible spectrum of colors, then recombined to make white light again.
   B. The light remains white light, then is separated into the visible spectrum of colors.
   C. The light is separated into the visible spectrum of colors.
   D. The light is separated into the electromagnetic spectrum.

10. A pendulum in motion has a length of 20 inches. What happens to the swing if the length is shortened to 10 inches?
    A. There will be no change; the swing will be the same.
    B. The pendulum will slow down.
    C. The pendulum will speed up.
    D. The pendulum will stop.

11. A string is plucked on a guitar to make a high pitched sound and a low pitched sound. What is the difference in a sound wave made by a high pitched sound and a lower pitch sound?
    A. A high pitched sound has a shorter wave with peaks close together; a lower pitched sound has longer waves with peaks farther apart.
    B. A lower pitched sound has a shorter wave with peaks close together; a higher pitched sound has longer waves with peaks farther apart.
    C. Both sounds will produce the same kind of wave.
    D. The high pitched sound will produce a sawtooth wave and the low pitched sound will produce a sine (curved) wave.

12. What is the difference between a solar eclipse and a lunar eclipse?
    A. In a solar eclipse, the moon casts a shadow on the sun; in a lunar eclipse, the moon casts a shadow on the earth.
    B. In a solar eclipse, the earth casts a shadow on the sun; in a lunar eclipse, the moon casts a shadow on the sun.
    C. In a solar eclipse, the earth casts a shadow on the sun; in a lunar eclipse, the earth casts a shadow on the sun.
    D. In a solar eclipse, the moon casts a shadow on the earth; in a lunar eclipse, the earth casts a shadow on the moon.

13. When a pendulum is swinging, when does it have the most potential energy?
    A. At the top of its swing.
    B. At the lowest point of the swing.
    C. It is the same throughout the entire swing.
    D. There is no potential energy in the pendulum.

14. Why are the supports under a bridge usually curved?
    A. Because the curves distribute the stress equally over all parts of the bridge.
    B. So the ships can easily pass under the bridge.
    C. So if flooding occurs, the bridge will not be covered in water.
    D. Because the curves make more stress occur over the posts where the bridge is the strongest.

15. The pipes of an organ are of different lengths and are closed. Which statement describes the sounds produced by the different sized pipes of an organ?
    A. The longer the pipe, the higher the sound made.
    B. The shorter the pipe, the higher the sound made.
    C. The shorter the pipe, the lower the sound made.
    D. The length of the pipe does not make a difference in the sound made.

16. Light is shining through a lamp with a green filter on it to make green light. An object is put between the light and a white screen. What kind of shadow is cast on the white screen?
    A. There is a black shadow of the object on the screen.
    B. There is a green shadow of the object on the screen.
    C. There is a blue shadow and a yellow shadow on the screen.
    D. There is a red shadow of the object on the screen.

17. What is the difference between DC current and AC current?
    A. There is no difference between the two; they are different names for the same thing.
    B. DC current is used in homes because the voltage alternates; AC current is in batteries, the voltage is constant, and flows in one direction.
    C. AC current is used in homes because the voltage alternates; DC current is in batteries, the voltage is constant, and flows in one direction.
    D. AC current is used only in America; DC current is only used in Canada.

18. What is the shape of the earth's orbit around the sun?
    A. It is a perfect circle.
    B. It is almost nearly a circle; it is slightly elliptical.
    C. It is a perfect ellipse.
    D. The earth's orbit is constantly changing; it is not a fixed shape.

19. When a pendulum is swinging, when does it have the most kinetic energy?
    A. At the top of its swing.
    B. At the lowest point of the swing.
    C. It is the same throughout the entire swing.
    D. There is no kinetic energy in the pendulum.

20. The femur is the long bone in your leg from your hip to your knee. Where is this bone the thickest?
    A. At the top rounded part that forms a joint with your pelvis.
    B. At the bottom rounded part that forms a joint with your knee.
    C. In the middle of the bone.
    D. It is the same thickness everywhere.

21. A musician draws her bow across the strings of her violin. How is this like a relaxation oscillator?
    A. Energy is built up on the strings and is slowly released over time.
    B. Energy is built up on the strings and is quickly released over and over when too much pressure builds up on the strings.
    C. Energy does not build up because it is constantly released.
    D. This is not an example of a relaxation oscillator.

22. Light is projected toward a white screen through a prism to separate all the colors of white light. A small post is used to block the yellow band of light from the prism. What color(s) of light will be seen on the screen?
    A. All of the other colors-red, orange, green, blue, and purple.
    B. Only red will be seen.
    C. Only green will be seen.
    D. Only blue will be seen.

23. What would a wave look like for DC current on an oscilliscope?
    A. A sine wave (curved, like hills and valleys).
    B. A triangular wave (pointed, like a row of mountains).
    C. A flat line.
    D. One large curve (like a semicircle).

24. What causes warmer weather during the summer in North America?
    A. The earth's orbit comes closer to the sun.
    B. The sun moves closer to the earth.
    C. The earth's tilt is closer to the sun, so the sun's rays are more directed toward North America.
    D. The earth's tilt is farther from the sun, so the sun's rays are more directed toward North America.

25. A pendulum is 20 inches long. In the middle and just to the left of the still pendulum is a bar that will cross the pendulum's path when it is set into motion. What will happen to the swing of the pendulum if you pull it to the right to start it into motion?
    A. It will not swing as high on the right as on the left.
    B. It will not swing as high on the left as on the right.
    C. It will swing to the same height on the right and the left.
    D. The bar will stop the pendulum.

26. A computer graphs a pendulum's velocity versus its position every second for 2 minutes (120 seconds). What will the graph look like?
    A. Curved, like hills and valleys.
    B. Peaked, like a row of mountains.
    C. An oval-shaped spiral.
    D. A circle.

27. What type of sound would form a triangular wave?
    A. Radio transmitters and microwaves.
    B. Computer timing components.
    C. Musical synthesizers.
    D. Rotary dial telephones.

28. Light is projected toward a white screen through a prism to separate all the colors of white light. Then the separated light is focused through a double prism. What color(s) of light will be seen on the screen?
    A. Red, blue, and green, the primary colors of light.
    B. Magenta, cyan, and yellow, the secondary colors of light.
    C. All the primary and secondary colors and white light.
    D. Only white light will be seen.

29. What is a capacitor?
    A. A component that reduces the flow of electricity in a circuit.
    B. A component that increases the flow of electricity in a circuit.
    C. A component that stops the flow of electricity in a circuit.
    D. A component that can be charged and "filled" with electricity to act as a power source for a circuit.

30. What is the Coriolis Effect?
    a. The motion of warm air and water toward the equator and cold air and water to the poles of the earth.
    b. The motion of warm air and water toward the poles of the earth and cold air and water toward the equator.
    c. The formation of clouds due to the water cycle.
    d. The humidity level compared to the moisture in the air.

APPENDIX B

Human Use Committee Approval Form

RESEARCH & GRADUATE SCHOOL

MEMORANDUM

TO: Julie Holmes
Randy Parker

FROM: Deby Hamm, Graduate School

SUBJECT: HUMAN USE COMMITTEE REVIEW

DATE: October 8, 2002

In order to facilitate you project, an **EXPEDITED REVIEW** has been done for your proposed study entitled:

"Museum-based learning: informal learning settings and their role in student motivation and achievement in science"
Proposal # 1-ZY

The proposed student procedures were found to provide reasonable and adequate safeguards against possible risks involving human subjects. The information to be collected may be personal in nature or implication. Therefore, diligent care needs to be taken to protect the privacy of the participants and to assure that the data are kept confidential. Further, the subjects must be informed that their participation is voluntary.

Since your reviewed project appears to do no damage to the participants, the Human Use Committee Grants approval of the involvement of human subjects as outlined.

You are requested to maintain written records of your procedures, data collected, and subjects involved. These records will need to be available upon request during the conduct of the study and retained by the university for three years after the conclusion of the study.

If you have any questions, please give me a call at 257-2924.

A MEMBER OF THE UNIVERSITY OF LOUISIANA SYSTEM

P.O. BOX 7923 RUSTON, LA 71272-0029 TELEPHONE (318) 257-2924 FAX (318) 257-4487 email: research@LaTech.edu
AN EQUAL OPPORTUNITY UNIVERSITY

APPENDIX C

Letters of Support from the Assistant Superintendent of Schools
and the Principal of the School

School Board

President Superintendent

August 12, 2002

Major Professor and Committee Members:

I am writing this letter of support for Ms. Julie Holmes, an elementary teacher in the Parish School System. She recently met with me and explained her procedure and rationale for a study entitled "***Museum-based Learning: Informal Learning Settings and Their Role in Student Motivation and Achievement in Science***". The study is to be conducted at Elementary School, sixth grade science classes, and in conjunction with field trips to the IDEA Place at Louisiana Tech University.

This is to verify that the study has been fully explained to me and that I and the Parish School Board Administration fully support Ms. Holmes' project.

If you need further information or if I can assist in this project in any other way, please feel free to contact me at the Parish School Board.

Sincerely,

Assistant Superintendent

cc. Ms. Julie Holmes

July 16, 2002

To Whom It May Concern,

I am writing this letter in support for Ms. Julie Holmes. Ms. Holmes visited with me last month concerning her research measuring students' motivation and achievement in science. I fully support her efforts and hope that we can be of service to her as she completes her dissertation.

Ms. Holmes and I have agreed upon as the date for her to meet with the science teachers here at . At that meeting, a schedule for field trips to the IDEA Place Experiment Gallery will be set up so that pre-testing can be done.

I am looking forward to working with Ms. Holmes and am very interested in the data that she will acquire through her work with our sixth graders.

If I can be of any further assistance, please do not hesitate to call me.

Sincerely,

Principal

APPENDIX D

Human Use Informed Consent Form

STUDY/PROJECT INFORMATION FOR HUMAN SUBJECTS COMMITTEE

TITLE: Museum-based Learning: Informal Learning Settings and Their Role in Student Motivation and Achievement in Science

PROJECT DIRECTOR(S): Julie A. Holmes
Dr. Randy Parker

DEPARTMENT(S): Curriculum, Instruction and Leadership

PURPOSE OF STUDY/PROJECT:
To examine whether there are changes in student motivation toward science and achievement in science in relationship to informal learning settings, namely a science museum.

SUBJECTS:
Approximately 300 sixth grade students from the Parish Schools.

PROCEDURE:
The participants will be given a pretest on science knowledge and an intrinsic motivation scale. Approximately one month later, the participants will come tour the Experiment Gallery at the IDEA Place at Louisiana Tech University and be placed into one of four groups: a)control, b)lesson, c) exhibit, and d)lesson/exhibit. Each group will be posttested on science knowledge and given the intrinsic motivation scale immediately after the treatment. A delayed posttest, approximately four weeks after treatment is also planned.

INSTRUMENTS AND MEASURES TO INSURE PROTECTION OF CONFIDENTIALITY, ANONYMITY:
1. Researcher-designed science achievement test, directly correlated with the exhibits at the IDEA Place.
2. The Children's Academic Intrinsic Motivation Inventory by Gottfried (1986).

All students will participate in the museum activities and testing. However, only data from students who have signed parental consent forms returned will be used in the analysis. The participants' names will not be used in the presentation of the results of the study.

RISKS/ALTERNATIVE TREATMENTS:
There are no risks associated with participation in this study. It requires the participants to take a pretest, come to the museum, take a posttest, and a delayed posttest.

BENEFITS/COMPENSATION: The field trip to the museum will be funded by the researchers.

SAFEGUARDS OF PHYSICAL AND EMOTIONAL WELL-BEING:
Data will not be collected until permission is secured from the Human Use Committee of Louisiana Tech University. Individuals will be given the opportunity to ask questions of the research administrator and to call the project director or the Human Use Review Committee if they have further questions or concerns. The participants may withdraw from the investigation at any time without penalty. The data collected will be kept under lock and key for five years and then be destroyed.

Informed Consent Form for Museum-based Learning Study

I, ______________________________ attest with my signature that I have read and understood the following descriptions of this study and its purpose and methodologies.
I understand that my child's participation in this research is strictly voluntary. Further I understand that I may withdraw my child at any time without penalty. I confirm I have received a copy of this consent from. Upon completion of the study, I understand that the results will be freely available upon request. I understand, that my child's name will not be used in the reporting of the findings in this study.

Description of the Study
PURPOSE OF STUDY:
To examine whether there are changes in student motivation toward science and achievement in science in relationship to informal learning settings, namely a science museum.

PROCEDURE:
The participants will be given a pretest on science knowledge and an intrinsic motivation test. Approximately one month later, the participants will tour the Experiment Gallery at the IDEA Place at Louisiana Tech University and be placed into one of four groups: a) control, b)lesson, c) exhibit, and d)lesson/exhibit. Each group will be posttested on science knowledge and given the intrinsic motivation scale immediately after the treatment. A delayed posttest, approximately four weeks after treatment is also planned.

RISKS/ALTERNATIVE TREATMENTS:
There are no risks associated with participation in this study. It requires the participants to take a pretest, come to the museum, take a posttest, and a delayed posttest. All students will participate in the museum activities and testing. However, only data from students who have signed parental consent forms returned will be used in the analysis.

BENEFITS/COMPENSATION: The field trip to the museum will be funded by the researchers.

Confidentiality: The participants' names will not be used in the presentation of the results of the study. Only grouped data will be presented. Data will only be available to the principal experimenter(s), participants, or their legal representatives.

CONTACT INFORMATION: The principal experimenter(s) listed below may be reached to answer questions about the research, subjects' rights, or related matters.

Julie A. Holmes	257-2866 (work)
	255-8615 (home)
Dr. Randy Parker	257-2834

Members of the Human Use Committee of Louisiana Tech University may also be contacted if a problem cannot be discussed with the experimenters:
Dr. Terry McConathy (257-2924)
Dr. Mary Livingston (257-4315)
Mrs. Deby Hamm (257-2924)

I have not been requested to waive, and I do not waive any of my rights, or my child's rights related to participating in this study.

Parental Consent
I understand the above explanations and instructions and hereby give my

consent for my child, ________________________to voluntarily participate in this study. (first and last name)

______________________________ ______________
Parent/Guardian's Signature Date

Student Consent

I agree to participate in the museum learning study. I understand that I will receive a field trip and will be asked to take tests as part of this study. These tests will not count toward any grades in any subjects at school.

______________________________ ______________
Student's Signature Date

Bus Permission Slip

I give permission for my child, ________________________ to ride a Parish School bus to the IDEA Place for a field trip on

____
Parent/Guardian's Signature

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VITA

Julie A. Holmes is currently the Director of Educational Programs for the IDEA Place Children's Math and Science Museum at Louisiana Tech University. She is on sabbatical from her public school teaching position with Lincoln Parish Schools. She has taught self-contained classes in her twelve years of teaching experience, as well as piloting inclusion classes and teaching math, science, and social studies in a departmentalized setting. She has also served on various textbook adoption committees and has represented her school on the Superintendents Advisory Council. In 2001, she was appointed as Teacher of the Year for her school and was runner-up for Parish School of the Year. Ms. Holmes holds a Bachelors of Arts from Michigan State University and a Masters of Science from Louisiana Tech University. She is a member of many professional associations, such as Mid-South Educational Research Association, Southeastern Regional Association of Teacher Educators, and Southwest Educational Research Association. She is also a member of the Louisiana Education Research Association and has served as Local School Agency Representative and Program Chair, and is currently President of the organization. Upon completion of her Education Doctorate, Ms. Holmes would like to teach at the collegiate level and work with pre-service teachers.