12-1989

Comparisons of Learnings from Structured and Nonstructured Visits to a Science Exhibit

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COMPARISONS OF LEARNINGS FROM STRUCTURED AND NONSTRUCTURED VISITS TO A SCIENCE EXHIBIT

by

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A Dissertation
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Doctor of Philosophy
Division of Science Education

Western Michigan University
Kalamazoo, Michigan
December 1989

COMPARISONS OF LEARNINGS FROM STRUCTURED AND NONSTRUCTURED VISITS TO A SCIENCE EXHIBIT

Rosario Cañizales de Andrade, Ph.D.

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The primary purpose of this study was to determine whether the use of an activity worksheet during a museum visit to a science exhibit might help students achieve the objectives proposed for the visit. Two types of museum visits were identified: structured and nonstructured. During the structured visit students used the activity worksheet that focused their attention on concepts, displays, and activities presented in the exhibit. During the nonstructured visit, students did not use any attention-focusing device; instead, they interacted with the exhibit according to their own interests and preferences.

Secondary goals of the study were to determine if gender-related differences in achievement existed between the students that experienced the visits and if there was an interaction effect between the type of visit and gender on achievement.

A sample of 246 second- and third-grade students from five school districts of southwestern Michigan was selected for this study. Classes were randomly assigned to either structured or nonstructured visits. After the visit, a test was administered to assess achievement of the objectives students were expected to accomplish as a result of their experiences.

The analysis of variance of the data showed that students who experienced structured visits scored significantly higher ($p < .05$) on the achievement test than those students who experienced nonstructured visits. However, significant gender differences in achievement were not found. Further, significant interaction effect was not detected between the type of visit and gender on achievement.

The findings of this study provide evidence that the use of a worksheet to structure visits to museum exhibits can be a valid method to help ensure the achievement of the objectives proposed for museum visits.

Order Number 9015611

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Western Michigan University, 1989

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ACKNOWLEDGMENTS

I want to express my sincere appreciation to Dr. George G. Mallinson, chairman of my doctoral committee, for the time, expertise, and support provided throughout all the phases of this dissertation. I also want to thank the other members of my doctoral committee, Dr. Mary Anne Bunda and Dr. Patrick Norris, for their time and valuable ideas in the development of this investigation.

My gratitude goes to Dr. Robert H. Poel for all the support provided throughout my studies at Western Michigan University. My appreciation also goes to Mrs. Jacqueline Mallinson for her time and encouragement in the preparation of this dissertation.

I am also grateful to the Fundacion "Gran Mariscal de Ayacucho" (Venezuela) for its financial support.

My deep appreciation goes to Mama Trina; my sister, Nena; Macusa; and Dianita; and the other members of my family for their loving encouragement and inspiration.

My deepest gratitude to my husband, Tony, and my sons Gabriel and Javier, for their love, help, patience, and the three years they have given to make this dream come true.

Finally, I am grateful to all my friends for caring so much and always being there for me.

Rosario Cañizales de Andrade

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CHAPTER I

INTRODUCTION

Background and Statement of the Problem

When one refers to science education, it is commonly viewed in terms of formal situations such as those related to school and established curricular activities. However, research on this subject has demonstrated that science learning takes place not only in formal settings but also in nonformal situations, such as field trips, zoos, nature centers, and museums (Falk, Koran, & Dierking, 1986; Falk, Martin, & Balling, 1978; Tressel, 1980; Watson & Shattuck, 1978). Among these nonformal settings, museums have recently captured a great amount of interest. Through their exhibits and programs, museums offer students and visitors in general encounters with reality, with the past, and with the future (Bierbaum, 1988; J. N. Bloom, Powell, Hicks, & Munley, 1984; Pittman-Gelles, 1985).

Traditionally, museums have been seen as institutions where visitors observed collections of objects of some cultural and historical value (Bonner, 1985). These institutions earned their reputation of being keepers of our culture's most prized objects (Green, 1975). This perception changed when technological advances and new appreciation for the daily life of common people became challenges for museums. As a result, the museum universe expanded to reflect the entire range of human experience (J. N. Bloom et al., 1984).

Changes in museums' experiences not only dealt with content. For example, during the 1930s, a new approach to the design of the exhibits developed. Museums changed from exclusively object-oriented to experience-oriented institutions (Green, 1975). Visitors were allowed and even encouraged to interact with the exhibits. Such interactions could take the form of touching artifacts or live animals, trying out experiments, going on fossil digs, or working with a computer. In other words, the new approach to museums became a hands-on rather than a hands-off, just-look approach (J. N. Bloom et al., 1984; Danilov, 1986, Green, 1975).

A principle basic to the hands-on approach is that the visitor can learn more from an experience in which he or she is an active participant in the learning process (Gennaro, 1981; Linn, 1980; Piaget, 1970; Wright, 1980). Organizations such as the National Science Board's Commission of Precollege Education in Mathematics, Science and Technology; the American Association for the Advancement of Science; and the National Society for the Study of Education have long recognized the role of science exhibits and museums in nonformal science education (American Association for the Advancement of Science [AAAS], 1983, 1988; Bierbaum, 1988; Fantini & Sinclair, 1985).

Exhibits using the hands-on, or interactive, approach have usually been related to natural phenomena, particular scientific concepts, or technological applications. Consequently, an increasing number of science exhibits and museums have been established in the United States and other countries (Danilov, 1986; Green, 1975).

According to Koran, Longino, and Shafer (1983), the United States, alone, has 6,000 museums that account for a total of more than 300 million admissions each year.

Along with the enthusiasm to develop hands-on exhibits, the interest in investigating their effectiveness in teaching and learning science has also increased. According to J. N. Bloom et al. (1984), many research studies have been conducted in museums during recent years. These range from studies of visitor behavior to studies of the effects of visit preparation on learning from an exhibit (Falk, et al., 1978; Gennaro, 1981; Koran, Morrison, Lehman, Koran, & Gandara, 1984; Linn, 1980; Sneider, Eason, & Friedman, 1979).

One group of researchers has tried to assess how the characteristics of free-choice environments, such as hands-on museums, influence learning (Falk et al., 1978; Linn, 1980; Rice & Linn, 1978). According to Piaget (1970), learning is more likely to occur from actions, experiences, and interactions with the environment. These experiences are important for the cognitive growth of the child. Hands-on museum exhibits are designed to provide these experiences (Wright, 1980).

Another group of studies showed that children visiting museums might find many attractive experiences that they want to try simultaneously (Dierking, Koran, Lehman, Koran, & Munyer, 1984; Koran et al., 1984; Koran, Koran, & Foster, 1988). Koran and Baker (1979) pointed out that multiple stimuli cause visitors of different backgrounds, interests, and motivations to react in a wide variety of ways to the same exhibits. As a consequence, some may concentrate on

the primary concepts, whereas others may ignore the most important ideas and explore extraneous details.

These researchers proposed an approach to the random behavior exhibited by the children during museum visits (Koran & Baker, 1979). They suggested to structure the visit by following a series of steps. The steps proposed were the statement of objectives for the experience; the consideration of instructional strategies to focus the student attention on certain activities in order to achieve the objectives; the preparation of questions to be raised during the visit; and the evaluation of the outcomes of this educational experience. Some studies have supported the adequacy of structuring museum visits (Koran, Lehman, Shafer, & Koran, 1983; McManus, 1985; Watson & Shattuck, 1978).

McManus (1985) demonstrated that some practices to focus attention may improve learning outcomes as a result of a museum visit. Koran, Lehman, Shafer, and Koran (1983) and Watson and Shattuck (1978) arrived at similar conclusions. These studies suggest that directed-attention to the objectives of the museum experience is an important factor to be considered during museum visits.

Another area of research in science education that has gained considerable attention is the gender-related differences in science learning (Becker, 1989; Burrus-Bammel & Bammel, 1986; Dart & Clarke, 1988; Erickson & Erickson, 1984; Harlen, 1985; Jones & Wheatley, 1988; Kelly, 1978; Powell & Garcia, 1988; Reyes & Padilla, 1985; Steinkamp & Maehr, 1983; Tobin & Garnett, 1987). Most studies have reported differences in science achievement, in which boys appear to

score higher in science related tests than girls (Kelly, 1978; Steinkamp & Maehr, 1983; Tobin & Garnett, 1987).

Babikian (1971) and Kelly (1978) discussed that gender differences in learning styles may be important in science achievement. The authors reported that boys work better in free-choice situations than do girls. However, conclusive sex-related differences in learning from free-choice or discovery situations have not been established (Kelly, 1978).

Furthermore, some researchers have suggested that gender differences are greater at the middle/junior high school level than at the elementary level (Becker, 1989; Burrus-Bammel & Bammel, 1986; Erickson & Erickson, 1984). Nevertheless, researchers have concluded that the validity of these findings have been limited by factors related to the sampling procedure and the research methods used (Erickson & Erickson, 1984; Harlen, 1985; Kelly, 1978; Reyes & Padilla, 1985).

The Research Problem

The problem of this research study can be stated as follows: What is the extent of the relationships among learning from a science exhibit; the type of museum visit, structured or nonstructured; and the gender of the students who experience the visit?

The following questions can be raised from the research problem:

1. Is there a difference in learnings from a hands-on exhibit between students who experience structured museum visits and those who experience nonstructured visits?

2. Is there a difference in learnings from a hands-on exhibit between male and female students who experience a museum visit?

3. Does the gender of the student moderate learnings from a hands-on exhibit depending upon the type of visit he or she experiences?

Definition of Terms

Since educational terms can be ambiguous and are often used in a variety of contexts where meanings depend upon the situation, definitions of specific terms are presented to ensure a common understanding. The operational definitions of those variables used in the design of this study are discussed in Chapter III.

Learning: This term has different definitions in the literature. In Piaget's work, learning has been defined as the building of knowledge from actions, experiences, and interactions with the world (Fischer, 1970). In the context of this research project, learning is defined as the acquisition of knowledge or achievement of stated objectives as a result of the interaction with a museum exhibit.

Formal setting: The term usually refers to the school environment. A formal setting is associated with classroom lessons and other activities carried out at the school building with the purpose of learning (Fantini & Sinclair, 1985; Loomis, 1987).

Nonformal setting: The term ordinarily refers to the nonschool environment. A nonformal setting ordinarily offers learning experiences different from those associated with classroom lessons and books (Fantini & Sinclair, 1985; Loomis, 1987). According to this

definition, nature centers, museums, and factories are examples of nonformal settings for learning.

Free-choice environment: Linn (1980) referred to free-choice environment as a learning environment that offers a series of activities that respond to previously stated objectives. In a free-choice environment, the students can choose from several alternative activities that one can perform in order to achieve the stated objective. In this research, a museum exhibit with a series of hands-on activities is considered a free-choice environment.

Museum exhibit: The term refers to a set of objects or displays exposed to public inspection in a museum (J. N. Bloom et al., 1984; Loomis, 1987).

Hands-on or participatory exhibit: For the purpose of this study, Danilov's (1986) definition will be accepted. Danilov defined a hands-on exhibit as one that provides practical experiences in the operation or functioning of the objects or displays exposed to public inspection.

Structured or programmed visit: A museum visit is considered to be structured when visitors use the help of an interpreter, guide, map, instructions, or any other printed material to explore an exhibit in a specific sequence. The purpose of the guide, map, or printed material is to sequence the interaction with the displays and to focus the attention on specific activities, concepts, or objects with the aim of achieving previously stated objectives (J. N. Bloom et al., 1984; Loomis, 1987).

Nonstructured or nonprogrammed visit: A visit is considered nonstructured when the visitors explore the exhibit according to their individual needs and interests without any established orientation, such as interpreters, guides, maps, or any printed materials. Visitors adapt the exhibit to their own interests, learning style, and time limitations (J. N. Bloom et al., 1984; Loomis, 1987).

Purpose of the Study

As it was reported in the section related to the background of the problem, research on learning in free-choice environments, specifically in museums, has pointed out that attention-focusing on specific tasks is an important factor to be considered during museum visits. Practices have been proposed to focus attention as a method to improve learning based on the interaction with museum exhibits. One of the objectives of the present study was to compare the outcomes that resulted when students experienced two distinct types of visits to a museum exhibit. These visits were called structured and nonstructured. During the structured visit students used an activity worksheet to focus their attention to specific displays, concepts, and principles that fairly represented the objectives proposed for the exhibit.

Research on learning in free-choice situations has also reported gender-differences in science achievement. Since studies have suggested that males perform better than females in discovery or free-choice situations, another objective of this study was to investigate the differences in achievement between males and females according to

the type of visit experienced.

Consequently, the main purpose of this study was to investigate the relationship among the type of visit to a museum, gender of the students, and learning from a hands-on science exhibit.

The development of this research project is considered to be important because its results may:

1. Motivate teachers to use museums as nonformal learning resources.

2. Describe and explain differences in students' achievement according to the type of visit they experienced. These findings may be used by teachers when planning a museum visit as a nonformal learning activity. In addition, museum staff may consider what type of visit to recommend according to the purpose of the museum experience.

3. Contribute to the body of research on museum education.

4. Show if gender-differences according to the type of learning activity exist, namely, structured or nonstructured activities. These findings may, in turn, be used by teachers when planning a museum visit according to the students' gender.

5. Contribute to the existing body of research on science learning and gender.

CHAPTER II

REVIEW OF THE LITERATURE

The review of the literature relevant to this study has been divided into five main topics. The first topic refers to the contributions of Piaget's (1970) theory to the understanding of science learning. Second, studies on science learning in nonformal settings are presented. The third topic emphasizes the characteristics of science achievement in museums. In addition, the problem of holding the attention of the children during museum visits is reviewed. The fourth topic deals with possible explanations for gender-related differences in science achievement. Finally, some principles of the measurement of science achievement are discussed in the fifth topic.

Piaget's Theory and Science Learning

Piaget, his collaborators, and adherents have had a significant influence on the curriculum and teaching of elementary and secondary science (Driver, 1982; Fischer, 1970). His work has been the theoretical basis for the development of several science programs, such as the Science Curriculum Improvement Study (SCIS) in America, Science 5/13 in England, and the Australian Science Education Project (ASEP) (Driver, 1982).

Most of the research undertaken by Piaget and his proponents has dealt with the performance of children on different tasks. Most of

these involved the manipulation of physical materials that yields information on the way children form their ideas about their environments. The results of this research have provided science educators with insights into the ideas children bring to school and what to expect as their learning develops (Driver, 1982).

Piaget's theory is considered by many a developmental theory because its central interest focused on how cognition evolves from infancy to later stages in adolescence (Bringuier, 1980; Bybee & Sund, 1982; Fischer, 1970). In order to understand this theory, a set of key concepts must be understood.

According to Piaget (cited in Fischer, 1970), intelligence refers to the adaptation between the individual and the environment. Intelligence allows the individual to interact effectively with the environment at a psychological level. All individuals experience a cognitive growth, starting with the infant's inborn reflexes, followed by identifiable fixed stages, to the eventual capacities of abstraction and logical reasoning (Piaget, 1970). In other words, cognitive growth refers to the development that follows identifiable patterns of physical or mental action that account for specific acts of intelligence (Bybee & Sund, 1982).

Piaget proposed four distinct stages of development: sensorimotor, preoperational, concrete operational, and formal operational. Each developmental stage has certain characteristics that typify the behavior of the child in that stage. Piaget also stated that human development follows a sequential order, such that each developmental stage is the basis for the construction of the next (Bringuier, 1980;

Bybee & Sund, 1982; Fischer, 1970; Piaget, 1970).

Development results from the individual's continuous adaptation to their environment (Fischer, 1970). Adaptation is accomplished by two processes: assimilation and accommodation. Assimilation allows the individual to interpret new situations in terms of existing cognitive structures that are specific at his or her stage of development. Accommodation allows the individual to change his or her cognitive structures in order to fit the incoming information. In other words, the individual modifies an existing explanation to fit a newly perceived reality. As a consequence, cognitive structures are expanded or generalized to incorporate larger aspects of the world. In summary, development is the movement from intellectual stage to stage resulting in changes in both what the individual can understand and how the individual understands it (Bybee & Sund, 1982).

Piaget (1970) stated that the sequence of development is related to four factors: biological maturation, experience, socialization, and equilibrium or self-regulation. Maturation refers to the physical development and specialization of the functions of the brain. Experience refers to the relationships with the physical world and experiences in reasoning. Socialization can accelerate or retard the stages of development given that cognitive growth occurs in a social context. The fourth factor is equilibrium. This is the most critical factor of the four. It is the organizing factor that balances maturation, experience, and socialization (Piaget, 1970).

Another important point of Piaget's theory, relevant to science learning, is the assertion that the child must act on objects and new

situations in order to get information and accommodate the new information from these objects and situations. Knowledge, then, is built from actions, experiences, and interactions with the world (Elkind, 1981; Fischer, 1970; Piaget, 1970). Piaget further suggested that the primary role of educators is to provide children with rich educational experiences at their stages of development and beyond in order to activate the process of equilibrium. Therefore, educators should act as facilitators in helping children make discoveries (Bybee & Sund, 1982; Elkind, 1981).

Science Learning in Nonformal Settings

Historically, the growth of formal education has led to the perception that schooling and education are virtually synonymous. As a result, the only learning that is often recognized as legitimate is that obtained in schools (Fantini, 1985). This attitude prevails even though research has demonstrated that learning does take place in many settings and in many ways other than in formal settings such as schools (Falk & Balling, 1980; Kimche, 1978; Koran & Longino, 1983; Rice & Linn, 1978).

In science, nonformal settings offer a wide range of activities that cannot often be replicated easily in the classroom (Watson & Shattuck, 1978). Learners in nonformal settings are generally in an exploratory learning mode and are able to explore their environments at their own pace (Koran & Baker, 1979). In addition, they have the opportunity to interact with models, machines, objects, and their environment in ways that encourage learning of scientific principles

and facts (Gallagher, 1987; Kimche, 1978).

Learning psychologists have emphasized that experiences are the basis of learning (Piaget, 1970; Watson & Shattuck, 1978). According to Koran and Longino (1983), settings outside the classroom provide experiences in which curiosity can flourish. As a result, the attention of the learner is held for long periods of time which, in turn, increases the probability of learning (Linn, 1980; Piaget, 1970).

However, the time used in achieving the objectives proposed for the field trip depends on the familiarity the learner has of the environment. When a learner encounters a familiar setting during a field trip, the time to assimilate and accommodate the information about the setting is shorter than that in a novel environment. Subsequently, the individual is ready to process new information, such as scientific concepts involved in the field trip (Koran & Baker, 1979; Piaget, 1970).

On the other hand, if the setting is too unusual, the learner has less time to learn the concepts involved in the field trip, since most of the time will be devoted to accommodating information about the environment (Falk et al., 1978; Piaget, 1970).

Several researchers have investigated the effect of the novelty of free-choice environments on learning during free-choice situations (Falk et al., 1978; Linn, 1980; Rice & Linn, 1978).

Falk et al. (1978) conducted a study to determine what effect, if any, the degree of familiarity with a setting would have on learning during a field trip. A sample of 31 children was drawn from participants in an educational activity at the Smithsonian Institution's

Chesapeake Bay Center for Environmental Studies. The sample was divided into two groups: students familiar with the region and those unfamiliar with the same region. A pretest was given to measure knowledge of the concepts that would be studied. They found that the familiar group scored significantly higher ($p < .05$) on the posttest than the unfamiliar group. They concluded that, in the case of the unfamiliar group, only exploration and setting-oriented learning took place. On the other hand, the familiar group was able to do both, setting and task-conceptual learning simultaneously.

During the same year, Rice and Linn (1978) investigated students' behavior in free-choice environments. Fifty-eight volunteer students were randomly assigned to three groups (1, 2, and 3). All groups received an intervention program (IP) that consisted of lessons and a free-choice program (FCP), in which the student had the opportunity to select the activity they wished to develop. The groups, however, experienced the programs in different order, FCP-IP (1) and IP-FCP (3), and simultaneously, FCP and IP (2). They reported that students in Group 3 were the most task oriented, sought the most leader help, and engaged in the most peer sharing of the results during free-choice activities. In addition, this group was more motivated to perform more challenging tasks. The authors concluded that free-choice activities could be used beneficially if sessions of intervention are planned. They suggested that both programs were beneficial since intervention helped assure success in activities previous to free-choice sessions. Further, the latter encouraged students to be independent and inventive.

In 1980, Linn designed a study to compare three educational programs that included free-choice and lecture-demonstration activities for teaching certain scientific reasoning skills. Sixty seventh-grade students, 21 girls and 39 boys, were randomly assigned to three groups: lecture-demonstration (L-D), free-choice/lecture-demonstration (FC-LD), and lecture-demonstration/free-choice (LD-FC). Each group experienced a different instructional program. The objectives of the programs were the same, namely, to be able to criticize experiments and to design controlled experiments.

The results of this study showed that students from the LD group performed significantly higher ($p < .05$) on criticizing experiments than did students from the FC-LD group. On designing controlled experiments, students from the LD-FC group, who received the same treatment, but in reverse order, scored significantly higher than LD and FC-LD groups. The researcher suggested that, in this case, the ability to criticize experiments was a necessary condition for acquiring the ability to design experiments. Linn (1980) concluded that instruction combined with exposure to materials were more effective than exposure alone for the achievement of the objectives proposed for the programs.

As noted, few studies were found that investigated the learning of scientific concepts and principles in free-choice environments and the results of these are controversial. Since free-choice settings increase the interest and curiosity of children, one could expect that learning would increase. This hypothesis was supported by the studies discussed. However, one could also argue that if the setting

is too novel, learning would be less likely to occur because of the need to explore the unfamiliar environment.

Museums and Science Education

Among nonformal settings, science museums and science exhibits have become an integral part of education in many communities, capturing a great amount of interest as active sources of science education for people of all ages (Bierbaum, 1988). According to the American Association for the Advancement of Science (1988), museums and science centers serve 10 million students annually (Ames, 1988).

The hands-on approach in the design of exhibits has allowed visitors to interact in various ways with exhibits (J. N. Bloom et al., 1984; Danilov, 1986). Research in this area has indicated that interactive learning is more effective than passive learning because interactive situations focus attention and require a continuous and sustained response (Flexer & Borun, 1984; Koran & Baker, 1979; Sneider et al., 1979; Van der Lee, 1986).

Among the museums that have pioneered hands-on exhibits related to scientific principles are the Museum of Science and Industry of Chicago, the Exploratorium of San Francisco, the Lawrence Hall of Science at the University of California at Berkeley, the Natural History Museum in London, and the Ontario Science Center in Ontario, Canada (J. N. Bloom et al., 1984; Green, 1975; Oppenheimer, 1972).

In addition to offering hands-on activities, many museums have also become highly involved with school systems. They have developed school science programs, such as the Outdoor Biology-Instructional

Strategies (OBIS), from the Lawrence Hall of Science, or education centers that provide services, resources, and ideas to science teachers (J. N. Bloom et al., 1984).

As discussed previously, learning is more likely to occur when actions, experiences, and direct interactions with the student's environment are involved (Piaget, 1970). In times when computers are so readily available, the traditional classroom may not look stimulating, and teachers face the challenge of producing motivating activities to reinforce achievement (Dunitz, 1985). Museums are one way to do this with concrete examples and applications of scientific principles and concepts of varying complexity (Watson & Shattuck, 1978; Wright, 1980). Some studies have also sought to demonstrate the effect of museum experiences on the psychomotor and affective domains (Flexer & Borun, 1984; Sneider et al., 1979; Wright, 1980).

Sneider et al. (1979) evaluated a participatory science exhibit at the Lawrence Hall of Science (University of California at Berkeley) using a "posttest only" design. They measured cognitive learning, psychomotor skills, and attitudes toward astronomy materials. The researchers randomly assigned a sample of 138 high school students to two groups. One group visited the exhibit "Star Games" and the other group visited exhibits other than "Star Games." The posttest was designed to measure the achievement of objectives established for the development of the exhibit. They found significant differences ($p < .05$) between the experimental groups on the cognitive and psychomotor domains. The group that visited the exhibit scored higher than the group that did not. However, they failed to

find any significant difference between the groups on their attitudes toward astronomy materials.

In 1980 Wright studied "the effect" (p. 99) of a museum visit to the Kansas Health Institute on the achievement of sixth graders. A sample of 13 sixth-grade classes was randomly assigned to two groups. The design was controlled for differences between groups after assignment. The control group received classroom instruction and a review lesson at the school. The experimental group received the same instruction but the review lesson was a visit to a museum exhibit related to the content of the lesson. The researcher found that the experimental group scored significantly higher ($p < .05$) in the posttest than the control group. Wright concluded that multisensory, hands-on experiences were superior because they provided students the opportunity to assimilate and apply concepts discussed in class.

Flexer and Borun (1984) investigated the impact of a class visit to the Franklin Institute Science Museum on the cognitive and affective domain. Four hundred and sixteen fifth and sixth graders were randomly assigned to four groups. Each group completed the same activities but in a different order. These activities were a lesson, a visit to an exhibit, and a test. The groups were identified as follows: control (test-exhibit-lesson), exhibit only (exhibit-test-lesson), lesson only (lesson-test-exhibit), and exhibit followed by a lesson (exhibit-lesson-test). The results indicated that students in the exhibit group scored significantly higher ($p < .001$) than the students in the control group. However, the researcher failed to find significant differences ($p < .05$) between students in the lesson

only group and those in the exhibit followed by a lesson group. With respect to the affective domain, students in the exhibit only group appeared more interested in further learning than those in the lesson only or the exhibit followed by the lesson group. They concluded that probably certain science concepts require some kind of structured instruction in order to be mastered.

Koran et al. (1984) were interested in determining whether Florida State Museum visitors were attracted equally by hands-on and by nonparticipatory exhibits having identical objects. A total of 234 visitors were observed using nonobtrusive methods. Visitors were exposed to two conditions. The control group had the objects available for close inspection but could not manipulate them. The treatment group was allowed to manipulate the objects. The results showed a significant increase ($p < .05$) in the number of visitors to where manipulative objects were available. For the sample of children, the authors also found that children were significantly ($p < .05$) more attracted to the hands-on area than were adults. In a similar study conducted by Koran, Koran, and Longino (1986), similar findings were reported.

The studies discussed in this section support the hypothesis that hands-on exhibits offer improved opportunities for personal experience. However, the exploration of some exhibits, without certain directions, may not progress beyond merely "messing around" without paying any attention to the displays and objects. As a consequence, the educational objectives may not be achieved.

Researchers have suggested the further study of those factors that may affect learning in museums.

The Problem of Attention in Museums

One of the most important characteristics of museums is their design. Ostensibly, they are designed to capture the attention of the public, either by their use of colors, architecture, or written instructions. In addition, they represent a new setting to explore (Dunitz, 1985; Falk et al., 1986).

Watson and Shattuck (1978) suggested that the casual nature and brief time devoted to museum visits accentuate the importance of gaining and holding the attention of the visitors. Museum researchers (Koran & Baker, 1979; Koran & Koran, 1983, Koran & Longino, 1983) have pointed out that different types of stimuli, such as those found in hands-on museums, may cause students of varied backgrounds, interests, and motivations to react in a wide variety of ways. As a consequence, some may learn the primary concepts of an exhibit, whereas others may ignore the most important cues and explore extraneous details. The authors agreed that exhibit designers and educators need to direct their efforts on ways that focus attention.

Falk and Balling (1980) studied the effects of novelty and attention on learning. The authors determined that most children need to explore; but if they do not have the appropriate strategies for doing so, learning cannot occur. This fact can be explained, according to Piaget (1970), by the concept of development. Since experiences, maturation, and socialization affect development, it is

reasonable to think that students in an advanced stage of development will have the skills to explore a novel environment in a more efficient way than students in a lower stage. One of these skills is the ability to focus the attention on a specific task (Bybee & Sund, 1982).

Several researchers have studied the problem of attention in museums and proposed practices that may improve learning in nonformal settings (Dierking et al., 1984; Gennaro, 1981; Koran, Lehman, Shafer, & Koran, 1983; Koran et al., 1984, 1986; McManus, 1985; Stronck, 1983).

A study conducted by Gennaro (1981) investigated the effectiveness of using instructional materials previous to a visit to an exhibit at the Science Museum of Minnesota. One hundred and five students were randomly assigned to two groups. The control group was administered a pretest, a series of lessons not associated with the exhibit, a visit to the exhibit, and a posttest. The experimental group followed a similar sequence but the lessons were associated with the exhibit. The results of the descriptive statistics showed that the experimental group scored higher in the posttest than did the control group. Gennaro suggested that subjects in the experimental group were able to obtain higher scores in the posttest than those in the control group because of the pre-visit instructional materials. He warned about overgeneralizing from this study, on the basis of descriptive statistics, and recommended the development of further research.

Koran, Lehman, Shafer, and Koran (1983) conducted a study to determine the effects of pre- and post-attention-directing devices on learning from an exhibit at the Florida State Museum. A group of 29 seventh and eighth graders were randomly assigned to three groups. Students in Group 1 examined an explanatory panel. They then interacted with the exhibit; finally, they took a posttest related to the exhibit's objectives. Students in Group 2 examined the panel and the exhibit in reverse order, and then they took the same test. Students in Group 3 interacted only with the exhibit and they took the test.

The results from an analysis of variance showed significant differences among the three groups ($p < .05$). Post hoc analysis showed that students in Groups 1 and 2 scored significantly higher ($p < .05$) than students in Group 3. However, significant differences were not found between Groups 1 and 2. The researchers suggested that either cueing or review of devices (panels) directed the attention of students toward objectives they were expected to achieve. Furthermore, they recommended teachers and museum designers consider the use of these strategies to help students or visitors achieve the most from a visit to a museum.

The same year Stronck (1983) compared the "effects of different museum tours on children's attitudes and learning" (p. 283). A total of 816 students of intermediate grades were the subjects of this study. The subjects were randomly assigned to two groups: guided tour and unguided tour. The guided tour group was led by a museum teacher following the goals and procedures established in a teacher's guide prepared by the museum. The unguided tour group did not

receive any guidance from the museum staff although the visit was organized by the classroom teacher. In addition to an achievement test, two questionnaires on attitudes were administered before and after the tour.

Stronck (1983) reported that students on the guided tour scored significantly higher ($p < .001$) in the achievement test than students in the unguided tour. On the other hand, the author found that students in the unguided tour had significantly ($p < .05$) more positive attitudes toward the museum experience than students in the guided tour. Stronck concluded that teachers could plan museum visits either to reinforce learning (guided) or to improve attitudes toward science (unguided), but not for both purposes simultaneously.

In 1984, Dierking et al. investigated the effectiveness of attention focusing devices on learning in museums. They tried to determine whether placing biological specimens in display niches emphasized their attributes and aided the students in discriminating between specimens of different biological families. A sample of 99 seventh- and eighth-grade students was randomly assigned to three treatments: exhibit in a display niche or recessed exhibit (1), nonrecessed exhibit (2), and no exhibit (3). All treatments had the same objectives.

The researchers (Dierking et al., 1984) found significant differences ($p < .05$) on the achievement posttest among students in different treatments. Post hoc analysis showed that students in Treatment 2 performed significantly better than those in Treatment 1. They also found that students exposed to Treatments 1 and 2 performed

better in the posttest than those in Treatment 3. The authors of this study concluded that participatory activities enhance learning. However, the effectiveness of recessing the exhibit, as a focusing attention device, was not supported by this study.

Koran et al. (1984) studied the relationship among attention, age, sex, and holding power and three types of science exhibits at the Object Gallery located at the Florida State Museum (FSM). One hundred and thirty-one visitors were unobtrusively observed under three different conditions: no object access (1), touching permitted (2), and instruments and instructions available for manipulation (3).

The authors (Koran et al., 1984) recognized the limitations this design placed on using either parametric or nonparametric techniques for analysis. Therefore, the results only described the characteristics of the subjects in the study. They reported that attention was higher when the visitors were allowed to touch. In other words, the quality of the time spent in the exhibit was positively related to the opportunity for manipulation. In 1986, Koran et al. conducted another study and obtained similar results.

McManus (1985) conducted a survey in England on the use of worksheets in structuring museum experiences. The author reported that the worksheet-induced behavior of children changed according to the age. For children up to 10 years old, the worksheet acted as an instructor that introduced them to the exhibit; then, they could explore it on their own. For children over 10 years of age, the worksheet was more likely to be used as a school assignment. Therefore, these children were accustomed to finding their ways around the

worksheet without a real involvement with the activity.

The researcher (McManus, 1985) suggested considering these results in light of the design of the worksheets. For example, children up to 10 years of age could use a worksheet with dot-to-dot drawing, filling missing letters, and crosswords. In children over 10 years of age, worksheets should be used as an introduction to ensure the review and understanding of basic concepts, but also allowing the children more time to enjoy following their own interests as well.

The review of the research reported on museums suggests that the following conclusions are defensible:

1. Museum exhibits, particularly hands-on exhibits, can be used for a variety of purposes, such as learning science principles and concepts from experience and improving motivation, attitudes, and skills.

2. Museum participatory activities can increase the interest and curiosity of children.

3. Since typical students spend a relatively brief time in a museum visit, emphasis should be placed on gaining and holding their attention.

4. Some practices, such as the use of interpreters, guides, worksheets, and maps, may focus the attention of museum visitors. As a result, learning is more likely to occur. Studies showing the superiority of any method over the other have not been reported.

5. The selection of any practice or method to focus attention must be related to the objectives stated for the visit.

6. Among the practices suggested, one can mention: (a) the use of museum visits as review activities to apply concepts discussed in the classroom; (b) the use of museum visits as the main learning activity with previous preparation to focus attention; (c) the use of more structured or less structured visits depending upon the stage of intellectual development of the children; and (d) the use of questions to focus attention allowing the students to obtain the most relevant information and further process it for later applications.

Gender-Related Differences and Science Learning

In the early 1900s, some educators suggested that girls should not be taught physical science except at the most elementary level. The reason given was that the amount of nervous energy involved in the achievement of physical concepts there might have deleterious effects on girls' health (Kelly, 1981). In the past decade, several studies have addressed questions of gender differences in science and science-related outcomes (Becker, 1989). The typical findings of these studies have been that boys perform better than girls in science-related activities. The differences do not seem to be substantial early in life, but they tend to increase with age (Erickson & Erickson, 1984). Many theories have been proposed to explain these differences in learning style. None, however, are well established. Differences in intellectual abilities, personality traits, attitudes, and early experiences and activities have been suggested as possible explanations for gender differences in science achievement (Erickson & Erickson, 1984; Harding, Hildebrand, & Klainin, 1988; Harlen, 1985;

Jones & Wheatley, 1988; Levine & Ornstein, 1983; Reyes & Padilla, 1985; Tracy, 1987).

Maccoby and Jacklin (1974) summarized research on sex differences related to intellect and achievement, social behavior, and the etiology of psychological sex differences. The authors tried to distinguish those gender differences that had some factual basis from those that were purely myth. They concluded that many supposed differences were mythical and the product of selective reporting and observing. In addition, the authors found that differences in social behavior, such as competitiveness, timidity, activity level, and others, have little support in fact or that ambiguous findings have been reported as conclusive. Nonetheless, the authors found that, on the average, girls have greater verbal ability and less spatial and numerical ability than boys.

Kelly (1978), in England, examined sex differences in science achievement using data from the surveys conducted by the International Association for the Evaluation of Educational Achievement (IEA). The survey was conducted in 19 countries, 14 were considered developed and the rest developing countries. The principal target populations were 10-year-olds, 14-year-olds, and preuniversity students in secondary education. Stratified random samples were selected from those populations. The researcher found that differences in science achievement between boys and girls were similar in all countries. However, differences were consistently larger in physics, intermediate in chemistry, and smaller in biology. In addition, mean gender differences in science achievement seemed to increase with

age. In 1984, Erickson and Erickson arrived to similar conclusions.

Levine and Ornstein (1983) reported similar findings for the U.S.A. Data from surveys conducted in 1971, 1975, and 1980, on school achievement by gender from the National Assessment of Educational Progress (NAEP), indicated that male achievement was slightly higher at ages 9 and 13, but increased significantly by age 17. The authors also discussed the findings of the study conducted by the Commission of the States in 1980. The commission found that 13-year-old females started their high school mathematics with essentially the same achievement scores as males. However, by the end of high school, tests showed that males had higher scores in problem solving and females had lost their advantage in computation and spatial visualization.

Steinkamp and Maehr (1983) conducted a comprehensive review of the literature reporting correlation coefficients among affect, ability, achievement in science, and between each of these variables and gender. The data consisted of 255 correlation coefficients retrieved from 66 articles and reports. The researchers found that there was a weak positive correlation between boys' and girls' achievement and affect ($r = .03$). In addition, science achievement was strongly related to cognitive abilities ($r = .47$; $p < .001$; $t = 4.0$; $df = 67$; Fisher's Z transformations).

Correlation coefficients between pairs of variables and gender showed that the mean correlations between achievement and cognitive ability are significantly positive for boys ($r = .36$; $p < .001$; $t = 10.00$; $df = 29$; Fisher's Z transformations) and for girls ($r = .32$;

$p < .001$; $t = 7.95$; $df = 29$; Fisher's Z transformations). According to the authors, these results suggested that higher levels of cognitive ability are associated with higher levels of achievement (Steinkamp & Maehr, 1983).

Tobin and Garnett (1987) conducted a study designed to examine gender-related differences in participation in science activities. Fifteen teachers and 86 students from private and public schools participated in the study. Two trained observers gathered data from observations of 200 science lessons using field notes and standard protocols. The observations included written self-reports of student engagement, questionnaires from teachers, and interviews with teachers and students.

The authors (Tobin & Garnett, 1987) reported that students perceived that discussion, laboratory work, and note-taking were activities that contributed most to science learning. In Grades 8 to 10, girls tended to be more task oriented than boys. However, differences in amount of laboratory participation were observed in favor of boys. Girls preferred to work in mixed laboratory groups because of their perception that boys were more able in science allowing the work to be completed more satisfactorily. Teachers indicated that males tended to be more involved than females in public interactions in whole class settings.

In 1989, Becker presented the results of a reanalysis of two meta-analysis studies on gender and achievement. The researcher found evidence, supporting earlier studies, that gender differences in achievement varied according to the subject matter under study.

However, significant differences in favor of males in biology were reported. In earlier studies, gender differences were not significant in this subject matter. The author also found significant differences in the achievement of students in general science and physics that are consistent with earlier studies. Significant differences were not found for studies of mixed science content, geology, earth sciences, and chemistry. Other possible predictors of the magnitude of gender differences, such as grade level and test length, did not account for significant amounts of variation.

Becker (1989) pointed out the limitation caused by incomplete reports of data. In addition, the magnitude of the differences reported was inconsistent among the studies analyzed.

The findings related to gender differences in the achievement area of science and mathematics can be summarized as follows:

1. Males seem to achieve higher than females in subject matter related to science.

2. The size of the difference in achievement seems to be related to the subject matter. For example, differences are larger in physics, moderate in chemistry, and smaller in biology.

3. Gender differences seem to increase with age.

4. Males seem to have higher spatial ability than females.

5. Females below the high school level seem to have higher computational abilities than males, but this difference tends to decrease by the end of high school.

6. Females perceive that males are more able in science related subjects.

7. Males seem to be more likely to engage in science activities than are females.

Gender Differences and the Type of Learning Environment

Researchers have investigated the relationships between gender differences and learning in free-choice environments (Babikian, 1971; Burrus-Bammel & Bammel, 1986; Kelly, 1978; Koran & Koran, 1983; Koran et al., 1984, 1986; Rice & Linn, 1978; Sneider et al., 1979; Tobin & Garnett, 1987).

Kelly (1978) summarized research on gender differences and learning situations (environment). The author reported that there was a general feeling that boys were more likely to operate successfully in open-ended or unstructured learning situations than were girls. Sex-typed behavior was given as the explanation for these differences. Girls seemed to be more dependent and passive when exposed to discovery situations than were boys. Kelly's (1978) research and Burrus-Bammel and Bammel (1986) studies did not support this hypothesis.

Babikian (1971) gave empirical support to the hypothesis of gender differences in discovery situations. The researcher compared three methods of teaching science concepts: discovery, laboratory, and expository. Twenty-two junior high school classes were randomly assigned to the three treatments. All classes were taught the same objectives and a worksheet was used during the class. The worksheets were collected at the end of each session to prevent studying at home. The students were tested three times: pretest, posttest, and

retest 4 weeks after the end of the treatments.

The author (Babikian, 1971) reported that both the expository and the laboratory methods were significantly ($p < .01$) "more effective than the expository method" (p. 208) in the achievement of students. In addition, he found that boys achieved significantly ($p < .01$) better than girls without regard for the treatment. Furthermore, the differences in achievement between boys and girls were larger among students in the discovery situation.

Tobin and Garnett (1987) and Maccoby and Jacklin (1974) have suggested that girls tend to be less involved in manipulating equipment than are boys. The study by Koran et al. (1986) supported this hypothesis. Another observation is that, when structure is given, girls tend to keep more in task than boys. This hypothesis was also supported in other studies (Koran & Koran, 1984; Koran et al., 1984; Rice & Linn, 1978; Sneider et al., 1979).

In summary, the evidence for a relationship between gender differences and learning environment is not substantial and is controversial. Therefore, additional research on this topic is necessary if valid conclusions are to be drawn. Specifically, since museums are being used as learning environments for science concepts and these institutions can be best classified as being free-choice environments, research to investigate the relationship between gender-related differences and free-choice science learning in museums promises to be fruitful.

Possible Explanations for Gender-Related Differences in Science

Maccoby and Jacklin (1974) and Kelly (1978) discussed three kinds of factors that could account for the development of sex differences: biological factors, socializing agents, and learning of sex-related behavior. The authors indicated that biological factors were related to spatial ability and aggression. There has been evidence of a recessive sex-linked gene, in addition to other types of genes, related to spatial ability that have been found in 50% of males and only 25% of females. Tracy (1987) pointed out that spatial ability and science achievement were positively related. These conclusions were supported by Jones and Wheatley (1988), Levine and Ornstein (1983), and Tracy (1987).

According to Maccoby and Jacklin (1974) and Kelly (1978), two learning processes have been suggested to account for the development of socially defined appropriate behavior: parental reinforcement and the child's imitation of the same sex parent. However, the authors emphasized that the evidence was too weak to be considered conclusive. Jones and Wheatley (1988) arrived at a similar conclusion. With respect to the third process, the authors suggested that reinforcement and simple imitation were involved in sex-typed behavior, but these factors were not sufficient alone to account for the developmental changes in gender typing (Maccoby & Jacklin, 1974; Kelly, 1978).

However, Kelly (1978) reported that females see science as a masculine subject and will try to reject everything scientific,

whereas males will adopt scientific attitudes in their play and hobbies. Therefore, boys could have an advantage in improving science achievement. Based on the results of their investigations, Erickson and Erickson (1984) and Tracy (1987) disagreed with Kelly's (1978) conclusion that boys' activities and play give them an advantage over girls to perform better in science.

Levine and Ornstein (1983) suggested additional biological evidences to account for ability differences between males and females. This evidence is based on research on hormones associated with brain-related differences in ability. The authors concluded that biological differences that affect brain organization were not well understood; and as a consequence, these conclusions were not well established.

Another biological explanation that has been proposed is that sex-related differences in spatial abilities are the result of differences in the degree of brain lateralization depending upon gender (Erickson & Erickson, 1984). However, the researchers again concluded that the evidence is too weak to suggest that differences in brain lateralization are biologically determined.

Measurement of Science Learning

This section is devoted to the discussion of the measurement of science learning in general. Since this study involved the measurement of students' learning after experiencing a visit to a museum exhibit, it is important to discuss background information relevant to this subject. First, general principles of measurement are

presented. Second, the application of these principles to measurement of learning in free-choice environments is discussed. Finally, a review of studies that have attempted to measure achievement in museums is presented.

Behavioral scientists, educators, and psychologists, among others, use tests to measure abilities, achievement, personality traits, interests, attitudes, and aptitudes (Brown, 1983). These measurements are used for many purposes, such as planning and evaluation of instruction, personnel selection, students' placement and counseling, and the study of differences between groups, including their nature and extent (B. S. Bloom, Hastings, & Madaus, 1971; Brown, 1983).

Tests are important since many critical decisions are made based on the information they provide. If tests are well constructed, fairly accurate information about certain characteristics of individuals can be obtained. Brown (1983) suggested that achievement tests can be used to measure learning that occurs as a result of experiences in specific learning situations. Science learning is not an exception.

In the development of an instrument to measure achievement, the designer must take into account a set of procedures to ensure that the test will be as much reliable and valid as possible (B. S. Bloom et al., 1971; Brown, 1983; Doran, 1980; Ebel, 1972; Gronlund, 1988).

Reliability refers to the consistency of test scores; in other words, how consistent the test scores are from one measurement to another. The consistency of the test scores can be affected by

measurement errors, such as time, testing conditions, or the sample of items. An important goal of testing is to keep these errors to a minimum so that the test results will be as reliable as possible. The reliability of a test is usually measured by a reliability coefficient and the standard error of measurement that is derived from it (Brown, 1983; Gronlund, 1988).

Validity is the degree to which a test measures the characteristic that it was designed to measure. In the case of achievement tests, the scores should describe the extent to which students have achieved the stated learning outcomes (Brown, 1983; Gronlund, 1988). The validity of achievement tests can be established by content validation that is a judgmental evaluation rather than a numerical index. The usual process involves expert judges who systematically compare the test items to the domain of content to be measured and determine the degree of correspondence between them. Thus, the most important task for the experts is to determine whether the items do, in fact, represent the domain of content (Brown, 1983; Gronlund, 1988).

In order to plan and design an achievement test, a clear statement of the outcomes to be tested is necessary. A practical way of organizing the outcomes of students' experiences is the preparation of a specification table. In this table the specific outcomes or objectives to be tested and the items designed to measure them are presented. This layout is useful in the design of a balanced, fair, and relevant test. Once the instrument has been designed, a plan to establish the reliability and validity of the test can be prepared

(B. S. Bloom et al., 1971; Brown, 1983; Ebel, 1972; Doran, 1980; Gronlund, 1988).

Measuring Learning From Museum Experiences

According to Loomis (1987), visitors simultaneously learn about orientation in museum environments and also achieve educational objectives during their interactions with either participatory or nonparticipatory exhibits. This fact makes the measuring of learning in informal free-choice settings, such as museums, a difficult task. Even though, a considerable body of research on learning assessment exists, most of this research has been concentrated on formal learning situations.

Systematic measure of what people learn during a museum visit is difficult to obtain since many variables cannot be controlled (Loomis, 1987). Kimche (1978) also pointed out that equal attention must be given to the cognitive, affective, and psychomotor domains when evaluating learning from hands-on exhibits. Therefore, he concluded that there was an urgent need to validate instruments used to measure visitor's knowledge, attitudes, and skills in nonformal settings. In addition, he advised that the new instruments should be designed and validated to measure learning during the visitors' interactions with the exhibits (Loomis, 1987).

Examples of measuring each of the three educational domains exist (Loomis, 1987). In the cognitive domain, that is the domain relevant to this study, the author suggested that learning can be assessed by interviews, questionnaires, and tests. The author

pointed out the importance of structuring museum visits to avoid situations of random behavior among the children when interacting with exhibits. This author agreed with the importance of stating clear outcomes in order to effectively evaluate learning from museum exhibits.

The review of literature on measuring science learning, and specifically science learning in museums, allows one to arrive at the following conclusions:

1. The body of research on learning assessment in museums is not extensive. However, several attempts to measure achievement resulting from museum visits exist.

2. Many variables are difficult to control when measuring learning as a result of a museum visit. The control of these extraneous variables is unique and important in these assessment situations.

3. The following conclusions seem to be particularly relevant to the assessment of achievement after a museum visit: (a) Clear learning outcomes must be stated in order to effectively measure achievement; (b) a table of specifications should be prepared in order to design balanced, reliable, and valid tests; and (c) plans must be prepared to establish the reliability and validity of the test used to assess learning outcomes as a result of museum experiences.

The studies discussed in the review of the literature allowed to connect the variables that were selected for this research study. Therefore, the research problem was stated as follows: What is the

extent of the relationships among learning from a science exhibit; the type of museum visit, structured or nonstructured; and the gender of the students who experience the visit?

CHAPTER III

METHODOLOGY

In the previous chapter some of the literature relevant to science learning in museums, gender differences in science achievement, and the measurement of science learning was reviewed. In this chapter a detailed description of the study that was undertaken and the methodology used to test its hypotheses are discussed. The discussion falls under six main topics: (a) overview of the study, (b) the sample, (c) the independent variable, (d) the dependent variable, (e) procedures used, and (f) data analysis.

Overview of the Study

The purpose of this section is to discuss the extent of the relationships among the topics discussed in Chapter II and the facets of this study. In addition, the description of the research setting, research hypotheses, and the design of the study are presented. The discussion is organized under four major sections: the problem, the research setting, the research hypotheses, and the design of the study.

The Problem

Research on learning in museums has indicated that attention focusing of visitors on exhibits is an important factor to be

considered during museum visits. Some practices, such as structuring the visit, have been proposed to help visitors focus their attention on specific tasks. In this way, learning can be improved by sequenced and meaningful interactions with museum exhibits. In addition, the research on science learning has reported gender-related differences in achievement in free-choice environments such as museums.

A research study was designed with the purpose of investigating the relationships among the type of museum visits, the gender of the students, and learning from a science exhibit. The research problem of this study was stated as follows: What is the extent of the relationships among learning from a science exhibit; the type of museum visit, structured or nonstructured; and the gender of the students who experience the visit?

The Research Setting

The study was conducted at the Kalamazoo Public Museum (KPM) located in Kalamazoo, Michigan; and the exhibit selected was "Expedition: Dinosaurs" (see Appendix A). The exhibit emphasizes theories about prehistoric life and paleontological techniques. "Expedition: Dinosaurs" gives visitors the opportunity to see models of moving, roaring dinosaurs and replicas of prehistoric mammals, in addition to other displays and activities related to paleontology. Most of the activities require hands-on interaction, involving the direct manipulation of the displays by the visitors. The exhibit is divided into three different areas: (a) Fossil Finders, (b) Prehistoric Sites,

and (c) Digging for Answers (Kalamazoo Public Museum, 1988).

At the Fossil Finders area, visitors receive an introduction to the exhibition's subject. This area presents hands-on activities dealing with facts supporting theories related to prehistoric life. The Prehistoric Life area contains six robotic models of dinosaurs and prehistoric mammals. The third area, Digging for Answers, is mainly a hands-on activity area involving games, puzzles, and other interactive devices to further explore various concepts about dinosaurs and paleontology (Kalamazoo Public Museum, 1988).

The museum scheduled approximately 60 students in the exhibit during each hourly time slot. Students spent approximately 20 minutes in each of the activity areas described above. In addition, interpreters are trained to give a verbal introduction and instructions to the students during the visit (Lyon-Jenness, 1988).

The Research Hypotheses

Three research hypotheses were investigated in this study. They are as follows:

1. Students who experienced a structured visit to the exhibit "Expedition: Dinosaurs" score higher in the achievement test than students who experienced a nonstructured visit.

2. Male students score higher on the achievement test than female students after the visit to the museum exhibit.

3. There is an interaction between the type of museum visit, structured versus nonstructured, to a science exhibit and gender of

the students on learning from the exhibit as measured by the achievement test.

Research Design

An experimental study was conducted to test the hypotheses of this study. Specifically, the study involved a posttest-only control group design (Campbell & Stanley, 1963).

Experimental research makes it possible to test hypotheses related to cause-and-effect relationships. An important characteristic of such research is that at least one independent or experimental variable is manipulated. In this study the type of visit that has two categories, structured and nonstructured, was the independent variable manipulated. Another characteristic of this type of research is that the sample has to be randomly assigned to the treatments (Borg & Gall, 1983). In this study, classes were randomly assigned to the two types of visits: nonstructured and structured.

The other independent variable in this study, gender, was an assigned or attribute variable, since subjects possessed this characteristic before the study began (Ary, Jacobs, & Razavieh, 1985). It was used to compare the achievement of males with that of females. The dependent variable was the outcome of the treatments; in this case, learning from the exhibit. For the purpose of this study, learning or achievement that took place as a result of the visit was measured by an achievement test entitled: What Do You Remember About "Expedition: Dinosaurs"? This test was designed by the researcher using the objectives stated for the exhibit (see Appendix D).

In addition to the instrument used to measure the dependent variable, a questionnaire was designed to assess the role of the teachers during the study as well as to gather data related to possible sources of contamination that could jeopardize the validity of the study (see Appendix F).

The Sample

Sample Size

The minimal sample size required for this study was determined using the procedure proposed by Cohen (1977). For this purpose, the values of alpha, beta, the power (1 - beta), and the effect size were determined. The alpha value was set at .05. Then, the value of beta should be set at .20 (4 x alpha) and the power at .80 (1 - .20). The size of the difference between treatment groups was set at .50, medium size. With the values calculated, the minimal number of students needed for the study could be found by using either a formula or the appropriate table.

This procedure showed that at least 126 students were needed. The sample in this study included 246 students from 11 classes. This was larger than the minimum required to find a medium size difference between treatments (Cohen, 1977) and was judged adequate for the purpose of this study.

Characteristics of the Sample

The population of this study was defined as the second- and third-grade classes that planned to visit the exhibit "Expedition: Dinosaurs" during the season it was presented at the Kalamazoo Public Museum. These grade levels were selected since the objectives stated for the exhibit were based on, and for, this reference group. In addition, museum records showed that students in these grade levels were more likely to visit the exhibit than students at other grade levels.

For administrative reasons, such as time required to make the contacts with the schools and the preparation of the material for the study, the sample was not selected at random. The researcher decided to select the sample from those months in which the majority of second- and third-grade classes attended the exhibit. It was found that most second- and third-grade classes made reservations to visit "Expedition: Dinosaurs" during March and April 1989 (Lyon-Jenness, 1988).

As noted in Table 1, the sample of classes was from five different school districts. Furthermore, the science curricula varied, as indicated by the elementary-science textbooks in use in these schools. The researcher was aware of the potential contamination of the study due to these differences in science curricula. Therefore, data were collected to determine if there was a difference in the background information students had before the visit to the exhibit.

Table 1

Characteristics of the Classes in the Sample

School	District	County	School enrollment	Science series
Arcadia	Kalamazoo	Kalamazoo	450	Holt (1983)
Bangor	Bangor	Van Buren	450	Holt (1983)
Bloomingdale	Bloomingdale	Allegan	390	Holt (1983)
Climax-Scotts	Climax-Scotts	Kalamazoo	223	Silver-Burdett (1987)
Sunset Lake	Vicksburg	Kalamazoo	635	Harcourt, Brace & World (1969)

For this purpose, two sources of data were identified. They were the curriculum content (textbooks) and the information package (see Appendix A) sent by the museum previous to the visit. The information package was prepared by the Department of Interpretation of the KPM. Its purpose was to familiarize the students with the vocabulary and concepts used frequently to explain other concepts, facts, and principles presented in the exhibit. In other words, the use of the information package was strongly advised as a background for preparing the students for the visit.

Next a comparison of the relevant content in the school-science curricula and the museum information package was made. The results of this comparison are presented in Table 2. Note that the museum package covered more background information concerning dinosaurs and prehistoric life than any of the science used by the five school

districts Based on the results of the analysis of content described, the researcher could justify that any variance due to difference in science curricula was minimal compared with the background available in the museum information package. Therefore, the sample was considered homogeneous before the museum visit since all the students had been exposed, or at least had the opportunity to be exposed, to similar background information and preparation prior to their museum experience.

Table 2

Comparison of the Content of the Elementary Science Textbooks and the Museum's Information Package

Content	Elementary science textbooks: Holt (1983)	Silver-Burdett (1987)	Harcourt, Brace & World (1969)	Information package
Fossils	X	X		X
Paleontology				X
Reptiles and mammals	X	X	X	X
Extinction	X	X		X
Climate and environment	X	X	X	X
Geologic time			X	X
Facts about dinosaurs	X	X	X	X

Random Assignment to Treatments

The 11 second- and third-grade classes in the sample were randomly assigned to the two treatments, structured visit and nonstructured visit. The procedure used follows that of Borg and Gall (1983) and is summarized as follows:

1. A list of classes was arranged according to the date of the visit beginning with the first in March and finishing with the last in April. Generally, classes from the same school were scheduled to visit the exhibit the same day. As noted in Table 3, six different classes or group of classes were identified that required to be randomly assigned.

Table 3

School, Number of Classes and Students, Date of Visit, and Type of Visit

No.	School	No. of classes	No. of students	Date of visit	Type of visit
01	Climax-Scotts	2	58	03-17-89	Structured
02	Arcadia	1	20	04-06-89	Structured
03	Climax-Scotts	1	20	04-07-89	Nonstructured
04	Sunset Lake	3	61	04-12-89	Nonstructured
05	Bangor	2	44	04-18-89	Structured
06	Bloomingdale	2	43	04-21-89	Nonstructured
	Total	11	246		

2. Next, an arbitrary starting point was identified in a table of random numbers (Borg & Gall, 1983, Appendix C).

3. The starting point was located at the top of a column. In order to choose a random number it had to contain two digits and be from 01 to 06.

4. The first three random numbers found down the column from the starting point were selected. They were 01, 02 and 05. These numbers identified the class or group of classes that were assigned to the structured visit. The other class or group of classes (03, 04, and 06) were then assigned to the nonstructured visit.

Table 3 shows that a total of 246 students were randomly assigned to either structured or nonstructured visits. One hundred and twenty-two students experienced structured visits and 124 students experienced nonstructured visits.

The Independent Variable

Type of Museum Visits

Two types of museum visits have been identified in the literature, according to the way visitors explore the exhibits (Stronck, 1983). These are labeled structured or programmed visits and nonstructured or nonprogrammed visits. Both visits have common statements of educational objectives, developed by the museum designers, that hopefully visitors will achieve.

Visitors in the first category, structured, usually explore the exhibits with the aid of printed material, namely, an activity

worksheet or a map. In other cases, a trained person functions as a guide or interpreter. In either case, however, the purpose of the printed material or the interpreter is to capture and direct the attention of the visitor and help him or her follow a logical sequence of activities and develop specific concepts during the visit. On the other hand, during a nonstructured visit, the participants do not use any attention-focusing materials or the services of an interpreter. The sequence of activities and interactions respond instead to the general plan of the designer, the preferences of the visitor, the attractiveness of the display, or a combination of these.

For the purpose of this study, both structured and nonstructured visits to the exhibit "Expedition: Dinosaurs" were organized. The initial phase was the same for both types of visits. It consisted of a brief introduction to the exhibit and a review of background information. An interpreter was trained for this purpose by the Department of Interpretation of the museum. The duration of the introduction was approximately 20 minutes. Visitors examined some of the hands-on displays in the Fossil Finders area during this phase of the visit.

Once the introduction was completed, the second phase of the visit was initiated. From this point on, the students experienced either a structured or a nonstructured visit. The nature of the two types of visits are described as follows.

The museum visit, designed by the Department of Interpretation of the Kalamazoo Public Museum, was labeled as the nonstructured visit. The main difference between the structured and the

nonstructured visit was that during the structured visit, students used an activity worksheet. The activity worksheet had directions to find specific displays and items to complete when exploring the exhibit (see Appendix H). The purpose of the worksheet was to focus the students' attention on specific concepts and help them to follow a logical sequence through the different activities presented in the exhibit.

Only in the case of a structured visit, once the introduction was completed, did the interpreter distribute the worksheets with the clipboards and the pencils to work with them. Then, standard instructions on how to use the worksheet were given (see Appendix G).

Following either type of visit, if more than one class was scheduled to visit the exhibit at the same time, students were assigned to one of two subgroups of approximately 30 students. If only one class was scheduled, the separation was not necessary. According to the Department of Interpretation, by limiting the number of students in each area to approximately 30, every student would have a better opportunity to interact with all the hands-on activities during the time scheduled.

Next, the class or the subgroup was instructed that it had 20 minutes to explore the rest of the Fossil Finders area and the Prehistoric Sites. If more than one class was scheduled at the same time, the other group was directed to the Digging for Answers area in which students also spent 20 minutes interacting with the hands-on activities. Students in structured situations used the directions and items presented in the worksheet during the exploration of the

exhibit. On the other hand, students in nonstructured visits followed their own interests and preferences during their exploration.

After the 20 minutes had expired, the class or subgroup was then directed to the areas they had not visited previously and asked to follow the same instructions. The visit terminated when the 60 minutes scheduled for it were over.

One further important point is that, for both types of visits, teachers and helpers were instructed not to direct students' attention to any particular activity (see Appendix I). Their roles were to assist students in reading, help them with large pieces of puzzles, and control their behavior.

Development of the Activity Worksheet

For the structured visit, an activity worksheet with a series of items was designed to focus the attention of the children on specific concepts, activities, and displays. This technique would help assure that students would interact with specific displays and/or activities in order to complete the items presented in the worksheet (Falk et al., 1978; Koran et al., 1988; McManus, 1985; Stronck, 1983). As a consequence, students would be more likely to achieve the objectives proposed for the exhibit (Falk et al., 1978; Koran, Lehman, Shafer, & Koran, 1983; Piaget, 1970).

The first step in the development of the worksheet was to match the specific objectives of the exhibit with the displays and activities presented in its three areas (see Appendices J and K). Thus, the researcher could identify what objective(s) could be achieved as

a result of the interaction with a specific display or activity. Once the matching with the objectives was completed, a sample of displays and activities was selected to be included in the worksheet.

The criteria for the selection of the activities and/or displays were that (a) two displays and/or activities should be chosen for each objective, to insure its achievement; and (b) the total time required to interact with the displays and/or activities selected, in order to complete the items of the worksheet, should not exceed 10 minutes per area. Thus, students had sufficient time to complete the worksheet and explore the rest of the displays and activities that were not mentioned in the worksheet, following their own choices and interests.

A draft of a worksheet was then prepared. Most items were constructed so that students were required to interact with specific displays and/or activities to complete each item. Sections of the worksheet presented concepts to introduce the students to some displays and/or activities. Additional instructions also directed the students' attention to concepts and other displays and activities without requiring the completion of an item.

The type of items designed for the worksheet required completing words, matching, ordering pictures, and drawing circles to indicate the right answer. These types were selected because a review of second- and third-grade science books indicated that students were familiar with this style of exercises (Abruscato, Hassard, Fossaceca, & Peck, 1984; Brandwein et al., 1980; Guy, Miller, Roscoe, Snell, & Thomas, 1989; Mallinson, Mallinson, Smallwood, & Valentino, 1987;

Sund, Adams, Hackett, & Moyer, 1985).

The draft of the worksheet was reviewed by a panel consisting of a science educator, a second-grade teacher, a reading specialist, and a museum curator. The members of the panel compared the content of the worksheet with the objectives of the exhibit. The purpose of the comparison was to judge how adequately the sample of items of the worksheet represented the objectives of the exhibit. In addition, corrections were suggested for reading level, letter size, and sentence structure. A checklist was prepared to aid in this task. All the members of the panel agreed that the exhibit's objectives were represented fairly in the worksheet. However, some stylistic corrections, as well as wording and letter size corrections, were suggested to improve the quality of the worksheet.

Once corrections were made, the worksheet was field tested with a group of seven children from different grade levels (first to sixth) to check the time required for its completion and to identify any additional changes that might enhance the quality of the worksheet. Next, the final version of the activity worksheet was prepared for the structured visit (see Appendix H).

The Dependent Variable

For the purpose of this study, science learning was the dependent variable. It was defined as the acquisition of knowledge or achievement of stated objectives measured by the test What Do You Remember About "Expedition: Dinosaurs"? (See Appendix D). The test was administered after the visit to the museum exhibit "Expedition:

Dinosaurs."

The instrument to measure the dependent variable was designed by the researcher. A series of steps were followed in order to design an instrument that would produce consistent results and clearly described the domain being measured as accuratly as possible (Brown, 1983). These steps are described in the following sections.

Development of the Instrument

First, a specification table was prepared to develop the test: What Do You Remember About "Expedition: Dinosaurs"? The specification table served as an outline to describe the achievement domain being measured and provided guidelines for obtaining a representative sample of test tasks. It was a two-way chart that had the outcomes or objectives to be tested on the horizontal axis and the content on the vertical axis (Gronlund, 1988). Thus, the specification table for the instrument used in this study included the type of outcome or objective measured by each item (B. S. Bloom, 1964), the topics about dinosaurs and paleontology covered in the exhibit, and the number of items per topic and objective (Appendix C).

Initially, a 22-item first-draft of the test was prepared. This is the usual length of tests for these grade levels (Abruscato et al., 1984; Brandwein et al., 1980; Mallinson et al., 1987). Each item was classified according to B. S. Bloom (1964) as belonging in one of three categories, namely, knowledge, comprehension, and application. These categories of objectives are those typically used in second- and third-grade curricula (Abruscato et al., 1984; Brandwein

et al., 1980; Guy et al., 1989; Mallinson et al., 1987; Sund et al., 1985).

Items were of three types: multiple-choice, ordering pictures, and matching. These types of items were selected after the review of five science programs and tests used by children at these grade levels (Abruscato et al., 1984; Brandwein et al., 1969; Guy et al., 1989; Mallinson et al., 1987; Scholastic Testing Service, 1984; Sund et al., 1985). The advantages of these types of items are that they can be administered in a relatively short time, broad sampling of the content domain is possible, and reliability and validity are increased (Brown, 1983; Ebel, 1972; Gronlund, 1988). A manual of standard instructions was prepared for the administration of the instrument. In addition, a key for scoring was constructed.

Content Validation

The content validity of the test was assessed by a panel of experts consisting of a science educator, two third-grade teachers, and a reading specialist. The panel compared the specification table with the test to assure that the items were an adequate sampling of the domain. In addition, corrections were made for sentence structure, reading level, letter size, diagrams, and wording. Further, the panel members reviewed the instruction manual for the administration of the test. The purpose of the manual was to minimize the effects of irrelevant variables and increase the reliability of the test results (Brown, 1983). A checklist was provided to the panel members to help insure that comments were made on each of the aspects

described.

The results of the analysis of the checklist showed that all the panel members agreed that the instrument represented fairly the objectives and content of the exhibit. In addition, the reading level, the length, and directions of the manual were found to be adequate. They pointed out the importance of reading the questions and the alternative answers to the students to avoid variance due to differences in reading levels.

However, some suggestions were made on the letter size, sentence structure of some questions, and time limits to answer the items of the test. The letter size was changed from the exclusive use of capital letters to the conventional use given to capital and lower case letters in textbooks designed for second- and third-graders. In addition, the sentence structure of some questions seemed confusing. Therefore, it was changed to avoid misunderstandings. Also, the time limits to answer the questions were reduced since the panel members agreed that most students at these levels would not need more than 45 seconds to answer a question.

Pilot Testing

After the corrections in the first draft of the instrument were made, a second draft of the test was prepared for the pilot testing session.

A second-grade class of 24 students was selected for the pilot testing. This class had used the museum's information package and visited the exhibit the day before the draft of the instrument was

tested. The selection of a second-grade class permitted the author the opportunity to change the wording and content of the test based upon the responses of a comparable group of subjects. The teacher also was asked to keep a log of the questions or comments relevant to the pilot test.

The classroom teacher conducted the assessment session following the directions of the manual. The testing time suggested was 30 minutes. At the end of the 30 minutes, the teacher handed the completed tests to the researcher. The following day, a summary of comments about the testing session was sent by the teacher to the researcher. The comments included the teacher's impressions about the difficulty and quality of the test, length of the testing session, and the quantity and quality of the instructions included in the manual.

The teacher concluded that the difficulty level, quality, and length of the test were adequate. She also found that the manual of instructions was helpful and adequate for the administration of the test. However, some suggestions were made for modifying the diagrams. Some students found two diagrams confusing and not clear. They required the help of the teacher to identify the figure the diagram was intended to represent.

The researcher then scored the tests using the key prepared for this purpose. The results of the pilot test were used to determine the item difficulty level (DL), discrimination index (DI), standard error of measurement (SEM), analysis of distracters, and reliability of the test (KR-20). The procedures suggested by Gronlund (1988)

were followed and the computer program "Statistical Package for the Social Sciences" (SPSS-X, Norusis, 1988) was used for these calculations. Testing specialists and evaluators have emphasized the importance of these indicators to ensure the reliability and validity of the test (Brown, 1983; Ebel, 1972; Gronlund, 1988).

The item analysis showed that the difficulty level (DL) of the items ranged from 0.21 to 1.00. The discrimination index (DI) ranged from 0.00 to 0.58. Finally, the KR-20, or coefficient of reliability, obtained for the instrument was 0.57 and the standard error of measurement (SEM) was 1.58.

A final version of the assessment instrument was then prepared based on the items analysis and using the following criteria (Brown, 1983; Ebel, 1972; Gronlund, 1988):

1. Items with a difficulty level greater than zero were used in the final version. All the items of the test met this criterion. However, three items with a difficulty level greater than 0.1 and lower than 0.5 were reviewed for improvement.

2. Items with a discrimination index greater than zero were considered appropriate for the final version. Twelve out of 22 items met this criterion. However, items with discrimination indexes between zero and 0.15 were reviewed and improved if possible. Therefore, nine additional items were reviewed for improvement. Items with negative discrimination indexes were eliminated. Only one item was eliminated.

3. The standard error of measurement was expected to be less than 2. The test had a SEM of 1.58. Since this was a 22-item test,

it had the appropriate SEM value (Ebel, 1972; Gronlund, 1988).

4. The reliability coefficient (KR-20) for the test should be greater than 0.40 for the first version. The test showed a KR-20 of 0.57.

5. Distracters chosen by less than 2% of the students were reviewed and changed or improved if possible. Distracters from 18 items needed to be improved.

As a result of the item analysis and the pilot testing of the test and manual, new versions of both were prepared for the study. In addition, the pilot indicated that the time allowed to complete each item could be reduced to 30 seconds. As a consequence, the total time for the assessment session was reduced to 20 minutes. The final versions of the test and the manual of instructions were then reviewed by two science educators (see Appendices D and E). They agreed that the test was an adequate sample of the content domain and that the manual was also appropriate for its administration.

The Final Version of the Instrument

The final version of the instrument designed to measure learning from the exhibit "Expedition: Dinosaurs" had 22 items classified under three categories (B. S. Bloom, 1964): knowledge (10), comprehension (8), and application (4) (see Appendix D).

The first 10 items were multiple choice. Items 11 through 14 required the students to order a series of pictures. Finally, Items 15 through 22 asked the students to match pictures with labels, names, or characteristics.

The item analysis of the final version showed that the difficulty level of the items ranged from 0.30 to 0.93. The discrimination index (DI) ranged from 0.07 to 0.54.

Finally, the KR-20 was 0.67 and the standard error of measurement was 2. According to Ebel (1972) and Gronlund (1988), these values are adequate for an achievement test as the one designed for this study.

Documentation of Contamination

When conducting research studies, the researcher must be aware of some factors that can jeopardize the validity of the experimental design selected (Campbell & Stanley, 1963). In this study, a questionnaire was prepared which included items with the intention of detecting the presence of these factors. As a result, the researcher could explain if the results were either a consequence of the independent variables or the effect of extraneous variables.

Among the factors that could jeopardize the study, one has the events that could occur during the structured or the nonstructured visit and between it and the time of the assessment session. Specific sets of instructions were given to the teachers for the visit, the assessment session, and the follow-up activities to control for contamination.

During the visit, the role of the teachers and their helpers was to assist the students in reading and manipulating displays and puzzles. They were cautioned to avoid directing the attention of the students to concepts or any display or give additional explanations

other than those presented in the exhibit. In addition, teachers should wait until the assessment session had been completed to work in any follow-up activity, including lectures or discussions. During the assessment session, the use of the manual of instructions was required. They should follow the directions exactly as they appeared in the manual.

Items in the questionnaire provided information to determine if the teachers followed the standard instructions given for the visit, the assessment session, and the follow-up activities. Therefore, the results of the study could be explained as a consequence of either the independent variable or any variable other than the independent.

Procedures

Formal and standardized procedures were used to contact the schools and insure uniformity in treatments and prevent contamination of the data. These procedures are described under two sections: (a) contacts with the schools and (b) the data collection.

Contacts With the Schools

First, all second- and third-grade classes, listed in the museum's reservation book for March and April 1989, were selected as the sample for this study. The 11 classes were from five different school districts. Information about the districts and the schools was obtained from the Michigan Education Directory (1988). Once this information was collected, contacts first by telephone and later personally were made with superintendents of the five school districts.

Superintendents were informed about the purpose and design of the study and they were asked if their schools would be interested in participating. Each of the five superintendents agreed to participate and suggested that the researcher contact the school principals and the teachers. These initial contacts were completed during the months of January and February 1989.

Next, each school principal and the classroom teachers were contacted by telephone to arrange a meeting to explain the research proposal and the type of cooperation that was needed if they agreed to participate in the study. A follow-up note was sent to acknowledge the telephone conversation and confirm the date of the meeting.

During the meeting scheduled at each school, packets of written information were given to the principal and the teachers. Each packet included the research proposal, the description and the objectives of the exhibit, the worksheet, and the assessment instrument with the specification table. The researcher discussed the proposed study; answered any questions; and at the end, asked for their cooperation and participation. Each principal and teacher contacted agreed to participate.

The researcher also proposed to send a summary of the results of the test for each class, to their respective teacher, so that they would know how their students performed. The teachers were interested in receiving the summary. In addition, teachers were informed that they did not need to do anything additional, except use the museum's information package to prepare the students for the visit. On the day of the visit, they would receive instructions and would be

informed of the type of treatment their students would experience.

Follow-up letters were sent to the principals and teachers after the meeting. These letters requested a schedule for the assessment session that was required the school day following the visit.

Once the treatment and the assessment sessions were completed, questionnaires were administered to the teachers. As explained before, the purpose of the questionnaire was to assess the role of the teachers during the study as well as to gather other information, related to possible sources of contamination, necessary for the discussion of the results. Enclosed with each questionnaire was a self-stamped envelope to insure the prompt feedback from the teachers.

Two days later, a letter of appreciation for their participation in the study was sent to each principal and the teachers. Finally, when the information related to the assessment session was summarized, a report was sent to each teacher with a summary of the results for their classes.

Data Collection

The test was administered at the school the day following the visit to the museum exhibit. Three reasons determined the place and time scheduled for the assessment session: (a) the museum did not have an appropriate room for the test administration; (b) most of the schools were located outside the city of Kalamazoo, and the distance from the schools to the museum required at least a 30-minute trip, one way; and (c) teachers suggested that the school day following the visit would be better for the administration of the test because

students would be too excited immediately after the visit and the trip to be ready for an assessment session.

Although this limitation existed, the researcher tried to avoid contamination of the study by instructing the teachers to limit any lecture or follow-up activity before the assessment session was completed.

The researcher traveled to the school and located the classroom(s). An envelope with the copies of the test, What Do You Remember About "Expedition: Dinosaurs"? was handed to the teacher. The researcher waited outside the classroom during the assessment session. If more than one class went to the exhibit the same date, they had the assessment session at the same time.

The teachers were asked to follow the manual of standard instructions for the administration of the test. As soon as the assessment session was completed, the teachers returned the tests to the researcher. They returned the completed questionnaires, by mail, the day following the assessment session.

The researcher scored the tests using the answer key prepared for this purpose. The data were included in an SPSS-X file for later analyses.

Data Analysis

The student scores obtained on the achievement test that measured the dependent variable were used as the unit of analysis. For each of the 11 classes in the sample, the frequency distribution of the scores and measures of central tendency and variability were

computed. Specifically, mean, median, mode, range, standard deviation, and variance were obtained for each class. A class summary of the results was sent to each teacher, once the data collection process was completed.

Three research hypotheses were postulated for this study. The statistical or null forms of these hypotheses are as follows:

1. The difference between the mean test scores of students that experienced structured visits to the exhibit "Expedition: Dinosaurs" and those who experienced nonstructured visits is zero.

2. The difference between the mean test scores of male and female students that visited the exhibit "Expedition: Dinosaurs" is zero.

3. The difference between the test scores of males and females that experienced structured visits and that of those that experienced nonstructured visits is zero.

A two-way analysis of variance for independent means was used to test the hypotheses. This statistical test was selected because the following criteria were met:

1. Two independent variables were identified: type of visit and gender. Both variables had two levels, structured and nonstructured visits and males and females.

2. A normal distribution of scores could be assumed since groups were randomly assigned to the treatments. In addition, the size of each group was greater than 20 individuals.

3. The dependent variable, learning from the museum exhibit, was measured in an interval scale.

4. Homogeneity of variance could also be assumed since each experimental group had approximately the same number of students.

The two-way analysis of variance and all the calculations were computed using the statistical package SPSS-X (Norusis, 1988). The Computer Center facilities located at Western Michigan University were used for this purpose.

CHAPTER IV

RESULTS

The purpose of this study was to address the following problem: What is the extent of the relationships among learning from a science exhibit; the type of museum visit, structured or nonstructured; and the gender of the students who experience the visit?

The design of the study involved the participation of second- and third-grade students in two types of visits to the exhibit "Expedition: Dinosaurs," presented at the Kalamazoo Public Museum. Classes were randomly assigned to two types of visits: structured and nonstructured. Students in structured visits explored the exhibit with the help of an activity worksheet. The main purpose of the items presented in the worksheet was to focus the attention of the students on specific concepts, activities, and displays within the exhibit. On the other hand, students in nonstructured visits explored the exhibit without any attention-focusing device or specific directions other than their personal choices and interests. In both types of visits, teachers and helpers were instructed to avoid either giving explanations or focusing the attention of the students on specific displays or activities. Their roles were to help children handle big pieces of puzzles, read labels, and monitor the students' behavior.

Once the visits were completed, an achievement test was administered to the students, on the following school day, by the classroom teacher. Standard conditions for administration and scoring were used.

In addition, a questionnaire was completed by the teachers after the assessment session. Although this questionnaire did not measure any of the main variables of this study, the results were considered to be important. The primary purpose of the questionnaire was to gather information about the teacher's and helpers' roles during the three phases of the study, namely, preparation for the visit, the visit, and the assessment session.

Items in the questionnaire provided information to document if the teachers and their helpers followed the standard instructions given for the three phases of the study. This information was used to determine if extraneous factors may have contaminated the results.

Data from the results of the assessment session were analyzed by using two-way analysis of variance (ANOVA). The assumptions related to interval scale, normal distribution of scores, and homogeneity of variance for the use of ANOVA were met. According to Klugh (1986), this statistical test allows one to investigate "the effects of each of several independent variables, and the joint effect of these variables acting together" (p. 301). These independent variables are sometimes called factors (Hopkins, Glass, & Hopkins, 1987).

In this study, the independent variables, or factors, were type of visit, structured versus nonstructured, and gender. The dependent variable was learning as measured by the achievement test, What Do

You Remember About "Expedition: Dinosaurs"?

When two independent variables, or factors, are considered, three different hypotheses can be tested. Two of the hypotheses deal with the main effects of the independent variables. In this case, the main effects of the type of visit and gender were tested independently from one another. The third hypothesis was tested to determine whether or not there was an interaction between the type of visit and gender that had an effect on learning from a museum exhibit (Hopkins et al., 1987). The three research hypotheses were stated as follows:

1. Students who experienced a structured visit to the exhibit "Expedition: Dinosaurs" score higher in the achievement test than those students that experienced a nonstructured visit.

2. Male students score higher in the achievement test than females after the visit to the museum exhibit.

3. There is an interaction between the type of visit to a museum exhibit and gender of the students on learning from the exhibit as measured by the achievement test.

The discussion of the results for each of the research hypotheses follows. In the case of the teacher's questionnaire, the frequencies of the responses were recorded and are reported in the last section of this chapter.

The Main Effects

Hypothesis 1: Type of Visit and Achievement

The null form of Hypothesis 1 tested in this study is: The difference between the mean test scores of students who experienced structured visits to the exhibit "Expedition: Dinosaurs" and those who experienced nonstructured visits is zero.

In order to test this hypothesis, a sample of students was randomly assigned to two types of visits to the exhibit "Expedition: Dinosaurs." The visits were classified as structured and nonstructured. On the school day following the visit, an achievement test, called, What Do You Remember About "Expedition: Dinosaurs," was administered to the students. A score key was used to grade the tests. The descriptive statistics and the analysis of variance were computed using the computer package SPSS-X (Norusis, 1988).

The distribution of the test scores of students who experienced structured and nonstructured visits ranged from 3 to 21 points. The maximum possible score in the assessment instrument was 22 points. The test scores ranged from 4 to 21 points in the group that experienced the structured visit. On the other hand, students who experienced the nonstructured visit scored between 3 and 19 points. The results of the analysis of variance of these data are presented in Tables 4 and 5.

As noted in the row totals of Table 5, the mean score obtained for the structured group (13.74) is higher than the obtained by the nonstructured group (12.91). As shown in Table 4, the observed

Table 4

Results of the Analysis of Variance for the Type of Visit and Student Gender

Source of variance	df	MS	F	p
Main effects				
Type of visit	1	42.52	4.160	.042*
Student gender	1	2.17	0.217	.641
Interaction	1	14.19	1.421	.234
Residual	242	9.98		

*$p < .05$.

Table 5

Mean, Standard Deviation, and Sample Size by the Two Categories of the Independent Variables: Type of Visit and Gender

	Student gender		
Type of visit	Male (M)	Female (F)	Row totals
Structured (S)	X_{SM} = 13.41	X_{SF} = 14.09	X_S = 13.74
	N_{SM} = 63	N_{SF} = 59	N_S = 122
Nonstructured (NS)	X_{NSM} = 13.05	X_{NSF} = 12.75	X_{NS} = 12.91
	N_{NSF} = 67	N_{NSF} = 57	N_{NS} = 124
Column totals (T)	X_M = 13.22	X_F = 13.43	
	N_M = 130	N_F = 116	

difference was statistically significant ($p < .05$). This difference is considered to be greater than one that would have occurred by chance alone. Consequently, the null hypothesis of no differences in achievement between the two groups after experiencing different museum visits was rejected.

Hypothesis 2: Gender and Achievement

The null form of Hypothesis 2 tested in this study is: The difference between the mean test scores obtained by male and female students who visited the exhibit "Expedition: Dinosaurs" is zero.

In order to test this hypothesis, test scores from males and females who experienced both structured and nonstructured visits were examined. The distribution of the test scores of male and female students that visited the exhibit "Expedition: Dinosaurs" ranged from 3 to 21 points. Males scored between 3 and 21 points. Female test scores ranged from 4 to 19 points.

The results of the analysis of variance of these data are presented in Table 4. The observed difference between mean test scores of males and females was not statistically significant ($p < .05$). As a consequence, the null hypothesis of no differences in achievement between males and females was not rejected. In other words, there was not enough evidence to conclude that a significant difference in achievement existed between males and females. Examination of the column totals of Table 5 shows that the mean scores for females exceeded that of males. Although the mean test score of females

(13.43) is higher than that of males (13.22), this difference could be due to chance.

Interaction Effect

Hypothesis 3: Interaction Between Type of Visit and Gender

The null form of Hypothesis 3 tested in this study is: The difference between the mean test scores of males and females who experienced a structured visit minus that difference of those that experienced a nonstructured visit is equal to zero.

In order to test the third hypothesis the results related to interaction were examined. As noted in Table 4, the interaction was not statistically significant ($p < .05$). Therefore, the null hypothesis of no interaction was not rejected.

Figure 1 illustrates the interaction between the treatment or type of visit and gender. Note that an interaction is shown graphically between the two variables or factors. It seems that the mean differences between the categories of the type of visit, structured and nonstructured, are not constant across the categories of gender. However, according to the ANOVA results, the interaction is not statistically significant ($p < .05$). In other words, the possible interaction shown in Figure 1 could have occurred by chance. As a consequence, the researcher failed to reject the null hypothesis of no interaction between the type of visit to a museum exhibit and gender of the students.

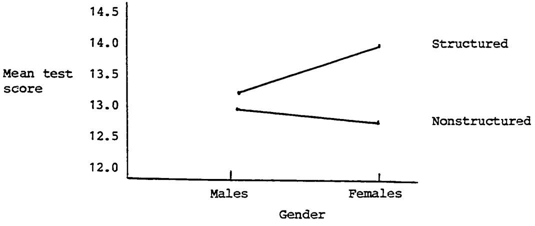


Figure 1. Illustration of the Interaction Between Type of Visit and Gender.

Results of the Teacher's Questionnaire

A questionnaire was filled out by the 11 teachers who participated in the study. The questionnaire was designed to elicit information related to the three main phases of the study, (a) preparation for the visit, (b) the visit, and (c) the assessment session. Additional data were collected with respect to the type of follow-up activities developed after the assessment session.

The purpose of this instrument was to elicit specific information to document possible sources of contamination that could jeopardize the validity of the experimental design of this study. Therefore, the researcher could explain if the findings were either a result of the type of visit or the effect of extraneous variables. Ten of 11 teachers returned the questionnaire. The answers were tallied and the results are presented in Tables 6, 7, 8, and 9.

Table 6 summarizes the information related to Phase 1:

preparation for the visit. The results show that 10 out of 10 teachers who answered the questionnaire received the information package sent by the Kalamazoo Public Museum. Furthermore, all teachers (10) familiarized the students with the terms suggested by the package. Eight out of 10 teachers used the information package related to the characteristics of prehistoric animals and suggested activities. However, 2 teachers reported that they did not use the museum package but prepared similar materials designed for the same purpose as those sent by the Kalamazoo Public Museum.

Table 7 presents the summary of the teachers' opinions of their roles, as well as the instructional support provided during the visit. Nine out of 10 teachers considered that the instructional support was either good or very good in quality. In addition, 9 teachers also considered it was adequate in quantity. In the case of the teacher's role during the visit, 9 of the teachers interacted with the students to help them in reading the labels, 2 provided guidance, and another 2 assisted students in operating the displays.

The summary of the results for the assessment session are presented in Table 8. With respect to the assessment instrument, 6 out of 10 teachers found the instrument to be of adequate difficulty, whereas 4 teachers considered it to be difficult. In addition, 8 of the teachers said its length was adequate. However, 1 teacher thought it was too long, while another believed it was short. The quality of the assessment instrument was found to be between adequate to good by 9 out of the 10 teachers that responded to the questionnaire.

Table 6

Summary of Results of the Teacher's Questionnaire.
Phase 1: Preparation for the Visit

Question (variable)	Answer(s) (number of teachers' responses)				
	Own decision	Principal's decision	Students' suggestion	To reinforce objectives	Introd. topic
1. Reason for the visit	6	1	1	2	6
		Yes	No		
2. Received information package		10			
3. Familiarized students with terms		10			
4. Familiarized students with prehistoric animals		8	2 (used other sources)		
5. Worked with the activities suggested		8	2 (developed similar activities)		
		Invent your dinosaur	Dig for words	Color the ticket	Find the fossils
6. Activities done		3	6	4	6

Table 7

Summary of Results of the Teacher's Questionnaire.
Phase 2: Visit to the Exhibit

Question (variable)	Answer(s) (number of teachers' responses)				
	Poor	Could be improved	Adequate	Good	Very good
7. Instructional support					
Quality			1	4	5
	Very few	Few	Adequate	Much	Too much
Quantity		1	9		
	Guidance		Readings	Operating displays	
8. Type of interaction with students	2		9	2	

Teachers also gave their opinions about the manual of directions. Nine out of 10 teachers considered that the quantity of directions was adequate. On the other hand, 6 of them said that the quality was adequate; while an additional 3 teachers found it either good or very good.

Table 8

Summary of Results of the Teacher's Questionnaire.
Phase 3: Assessment Session

Question (variable)	Answer(s) (number of teachers' responses)				
	Too difficult	Difficult	Adequate	Easy	Too easy
9. Assessment instrument					
Difficulty		4	6		
	Too long	Long	Adequate	Short	Too short
Length	1		8	1	
	Poor	Could be improved	Adequate	Good	Very good
Quality		1	4	5	
	Too many	Many	Adequate	Few	Very few
10. Directions (manual)					
Quantity	1		9		
	Poor	Could be improved	Adequate	Good	Very good
Quality		1	6	2	1

Finally, Table 9 presents the summary of the activities planned after the assessment session. This table reveals that 9 out of the 10 teachers planned to have follow-up activities. These follow-up activities included dioramas, readings, and other projects related to dinosaurs.

Table 9

Summary of Results of the Teacher's Questionnaire:
Follow-up Activities

Question (variable)	Answer(s) (number of teachers' responses)		
	Yes	No	
11. Follow-up activities			
Plan any	9	1	
	Dioramas	Readings	Projects
Type of activity	1	6	3

Summary

The results of the ANOVA test allowed the rejection of the Null Hypothesis 1 stated for this study: The difference between the mean test scores of students who experienced structured visits to the exhibit "Expedition: Dinosaurs" and those who experienced nonstructured visits is zero.

This hypothesis was rejected because statistically significant differences ($p < .05$) were found between the mean test sores of students that experienced the two types of visits: structured and nonstructured.

However, the ANOVA results did not allow the rejection of Hypothesis 2: The difference between the mean test scores obtained by male and female students who visited the exhibit "Expedition: Dinosaurs" is zero.

The Null Hypothesis 2 was not rejected since statistically significant differences ($p < .05$) were not found between the mean test scores of male and female students. The differences observed could be a result of chance.

Finally, the Null Hypothesis 3, the interaction effect, was not rejected. This hypothesis was stated as follows: The difference between the mean test scores of males and females who experienced a structured visit minus that difference of those that experienced a nonstructured visit is equal to zero.

This hypothesis was not rejected because the interaction effect was not found to be statistically significant ($p < .05$). Although an interaction was observed, it could have been a result of chance.

CHAPTER V

DISCUSSION AND CONCLUSIONS

The discussion and conclusions that follow are based on the analysis of the data and observations conducted to investigate the relationships among learning from a science exhibit; the type of museum visit, structured or nonstructured; and the gender of students who experienced the visit. For convenience, the chapter has been divided into five major sections: (a) interpretation of the results, (b) limitations of the study, (c) implications of the findings, (d) recommendations for future research, and (e) final comments.

Interpretation of the Results

Three null hypotheses were tested in this study:

1. The difference between the mean test scores of students who experienced structured visits to the exhibit "Expedition: Dinosaurs" and those who experienced nonstructured visits is zero.

2. The difference between the mean test scores obtained by male and female students who visited the exhibit "Expedition: Dinosaurs" is zero.

3. The difference between the mean test scores of male and female students who experienced a structured visit minus that difference of those who experienced a nonstructured visit is equal to zero.

The results of the ANOVA analysis indicated the rejection of only one of the three null hypotheses stated for this study. The null hypothesis rejected was Number 1. The rejection was based on a statistically significant difference, with a probability level of .042, between the mean test scores of students who experienced two distinct types of visits: structured and nonstructured. Therefore, this difference could not be interpreted as a result of chance (alpha = .05) and was attributed to the treatment.

Consequently, the evidence supports the Research Hypothesis 1 since students who experienced a structured museum visit to the exhibit "Expedition: Dinosaurs" scored higher on the achievement test than those who experienced a nonstructured visit to the same exhibit.

This finding is consistent with those reported in similar studies relating achievement to the use of attention-focusing devices or practices during museum visits (Koran, Lehman, Shafer, & Koran, 1983; McManus, 1985; Stronck, 1983). McManus (1985) also used worksheets in structuring museum visits. Koran, Lehman, Shafer, & Koran (1983) used an explanatory panel as a pre- and post-attention-focusing device during a museum visit. Stronck (1983) used a guided, or structured, tour as a practice to focus the attention of the students to specific concepts and activities during the museum experience. The purpose of these devices and practice was, as with this study, to focus the attention of the students on essential objects or events that represented desired outcomes of the experience to reinforce learning of specific exhibit objectives.

The evidences of this study, as well as those from similar studies, suggest that structured visits may help ensure the achievement of the cognitive objectives of the visit. These results can be explained and understood in the light of Piagetian research by the processes labeled assimilation and accommodation (Piaget, 1970). According to Piaget (1970), cognitive development results from the individual's continuous adaptation to the environment through assimilation and accommodation of new information. Falk et al. (1978) suggested that if the individual encounters a familiar setting during a field trip, the time to assimilate and accommodate to the new environment is shorter than in a novel setting. Once the individual has adapted to the setting, he or she is more likely to achieve the objectives planned for that experience in a shorter period of time.

If one relates it to museums, the exhibits represent new settings to explore in which visitors find many attractive displays and experiences that they want to explore at the same time (Koran & Baker, 1979). The exhibit selected for this study, "Expedition: Dinosaurs," met these characteristics. As a consequence, it could cause students to react to the same exhibit in a variety of ways (Koran & Koran, 1983). Some may in fact focus on primary concepts of the exhibit, whereas others could explore details irrelevant to the primary objectives stated for the visit (Koran & Baker, 1979).

The age of the visitor is another important factor when reacting to novel situations. Similar to this study, one of the McManus (1985) samples was formed by elementary school children up to 10 years of age. On the other hand, Koran, Lehman, Shafer, and Koran

(1983) selected a sample of seventh- and eighth-grade students, and Stronck (1983) used a sample of fifth-, sixth-, and seventh-grade students. The individuals forming the sample of this study were from second and third grades with ages ranging from 7 to 9 years. These children were younger than most of those participating in similar studies. However, the results suggest that also at this age level the use of an attention-focusing device, namely, a worksheet, helped them to achieve the objectives proposed for the visits.

Falk and Balling (1980) suggested that young children, similar to those who participated in this study, are at early stages of cognitive development and do not have yet the skills needed to explore novel settings efficiently. These children interact with their environment based on their previous experience. This stage of mental development is labeled the "concrete" period. Children's thoughts are primarily conditioned by what they encounter through direct experience. Therefore, sometimes they need structured experiences during exploration because they are still developing reasoning strategies and mental operations to confront new situations (Bybee & Sund, 1982).

A characteristic of this study, that differs from the other literature reviewed, is that the sample was established to be homogeneous before the students experienced the visits to the museum exhibit. Although students came from different school districts, the homogeneity of the sample was documented by the review of the curricula represented by the science book series used by the different school districts. Therefore, the difference in the mean test scores

between students who experienced structured visits and those who experienced nonstructured visits can be interpreted as a result of the use of the worksheet. The use of the worksheet was the main difference between the two types of visits. Other extraneous variables that could affect the results were controlled as much as it was possible, as documented by the results of the questionnaire filled out by the teachers.

The short period of time scheduled for field trips accentuates the importance of gaining and holding the attention of the students. In this study, one might suggest that students in structured visits needed a shorter period of time to assimilate and accommodate to the exhibit's environment than those in nonstructured visits. The worksheet was designed to help students explore the new setting and, at the same time, focus on the main concepts and principles presented in the exhibit. On the other hand, students who experienced nonstructured visits would need more time to explore and accommodate to the new exhibit's environment before being able to focus on these concepts and principles. Given the time slot scheduled for visits, students in nonstructured visits might actually have less time for concept formation than those in structured visits.

The results confirm that, when the main purpose of a museum visit is the reinforcement and/or the achievement of instructional objectives, the use of attention-focusing devices, namely a worksheet, may improve the achievement of students similar to those who participated in this study.

The statistical analysis of the data failed to allow the rejection of the Null Hypothesis 2. In this research study, gender-related differences were found. Girls scored higher (13.43) than did boys (13.22) in the achievement test. However, this difference was too small to be statistically significant (p = .641); alpha = .05). Therefore, it is not justified, based on these results, to claim gender-related differences in science achievement as a result of a museum visit to a science exhibit. Subsequently, the results of this study failed to support the Research Hypothesis 2, which stated differences in achievement between males and females after a museum visit.

These results are also consistent with those reported by several researchers but disagree with others (Becker, 1989; Erickson & Erickson, 1984; Steinkamp & Maehr, 1983). In these studies, some researchers have found significant differences between science achievement in males and females and others have not found these differences. In addition, all of them disagree in the magnitude of the difference, if any, and some have hypothesized a positive correlation between grade level and the magnitude of the difference.

Steinkamp and Maehr (1983) conducted a comprehensive review of the literature reporting correlations, among other variables, between gender and science achievement. They found that gender differences in science achievement were small in studies with young children. However, gender differences related to achievement increased in studies with older students.

Erickson and Erickson (1983) arrived to similar conclusions in a study conducted in British Columbia. They found that, in fourth grade, the difference in achievement was small. However, this difference increased with age according to the subject matter under study. In the case of earth science, the difference, reported in $\underline{p}$ values, increased from 3.7 at 4th grade to 12.5 at 12th grade.

The results of Becker's (1989) work disagree to some extent with the findings reported by Erickson and Erickson (1983). The author did not find significant differences in achievement in earth science at any grade level. He concluded that none of the variation in the outcomes was accounted for by grade-level differences.

Comparing these findings with the results of the "Expedition: Dinosaurs" project, one finds that they are similar. The researcher found differences in achievement but they were too small to be considered statistically significant. Since the sample of this study was formed by young children (7-9 years old), it might be expected that gender-related differences in achievement would be either too small to be detected or nonexistent.

Finally, the Null Hypothesis 3, the hypothesis of no interaction between the type of visit and the gender of the students, was also not rejected. The exact probability in this case was .234. As noted, the probability of this event to occur by chance is far from .05 (alpha level). Therefore, the evidence in this study did not support the Research Hypothesis 3, which claimed an interaction between the two independent variables, type of visit and student gender, on the students' achievement after a museum visit to a

science exhibit.

However, as noted in Figure 1 that illustrates the interaction effect, it appears that some interaction may exist. A difference was found between the mean test scores of girls in structured and nonstructured visits (1.34) that was larger than that difference between boys (0.34). Although the results failed to reach an acceptable level of significance and the researcher was not justified in rejecting chance as a possible explanation, it is possible that the failure to reject the null hypothesis was a Type II error caused by sample variation. The Type II error is the failure to reject the null hypothesis of no difference when there is, in fact, a difference (Borg & Gall, 1983). The graphic representation of the interaction showed that the mean differences in achievement between the categories of the type of visit, structured and nonstructured, were not constant across the categories of gender. Perhaps the interaction of the independent variables did exert an effect on the students' achievement and the design of the study was not sensitive to the difference.

Research in this area has suggested that girls seem to be more dependent and passive than boys when exposed to discovery situations. As a result, Maccoby and Jacklin (1974) and Tobin and Garnett (1987) have suggested that girls tend to keep more in task when structure is given. Gender-typed behavior, that appears to increase with age, has been suggested as an explanation. Given the age of the students in the sample of this study, second- and third-graders, the differences might not be large enough to be detected by the sensitivity of the instrument used.

Limitations of the Study

Three limitations in the study design need to be considered. First, the sample was not randomly selected from the population. The population of this study was defined as the second- and third-grade classes from public schools who made reservations to visit the exhibit "Expedition: Dinosaurs" presented at the Kalamazoo Public Museum. The researcher selected only those second- and third-grade classes that planned their visits for March and April 1989. This criterion was used because most of the classes at those grade levels made reservations for these months.

This fact may question the representativeness of the sample. A more suitable condition should be to select the sample randomly from all the second- and third-grade classes that planned to visit the exhibit during the entire season it was presented at the Kalamazoo Public Museum. This limitation is an issue of external validity only; it did not affect the internal validity of the study, since the classes selected were randomly assigned to the types of visits.

The second limitation was the way the random assignment to the treatments was conducted. The researcher randomly assigned whole classes to the two conditions: structured and nonstructured visits. Random assignment suggests that each student be assigned, by chance, to the treatments or conditions. However, the researcher had to deal with students, not as individuals, but as members of an intact group. Thus, the researcher opted to give one treatment condition per classroom, either a structured or a nonstructured visit, in order to

preserve the intact nature of the group. Random assignment of classes to the types of visits implies that the class has to be the unit of analysis. However, with gender as a design variable the analysis of the results has to be done using the student as the unit of the analysis.

The third limitation was the place and time scheduled for the assessment session. The assessment session was conducted at the school the day following the visit to the museum exhibit. A more controlled situation would be to have the testing immediately after the visit and before the students left the museum. However, this was impossible given to the lack of a room at the museum for this purpose. In addition, teachers pointed out that students should not take the test the same day, even at their home school, because of the degree of excitement and the long trip most students have to make in order to visit the exhibit. As a result, these conditions may contaminate the results.

However, one could argue that contamination might occur during the period of time between the visit and the testing session. To prevent this, the researcher explained the situation to the teachers and they agreed to cooperate on this matter. As shown in the results of the teachers's questionnaire, all the teachers reported that they conducted the discussion and the development of other follow-up activities after the assessment session was completed.

Implications of the Findings

This research can provide useful information related to learning in free-choice environments such as museums. Among the people that can use this information are teachers, school administrators, and staff involved with the educational aspect of museums.

Usually teachers arrange field trips mainly for educational purposes; in other words, with specific educational objectives in mind. Field trips give the students the opportunity to interact directly with the environment, machines, or models. These experiences permit the expansion of the classroom to the entire world of the student. Unfortunately, teachers have limited time available to devote to these activities. This is a common limitation that enhances the importance of planning field trips to obtain the most benefits from these educational experiences.

The findings of this research suggest that an activity worksheet might be a useful instructional device that can be included in the planning and development of field trips. The activity worksheet, used during the structured visits, served as an attention-focusing device. It helped the students follow a logical sequence during their interaction with the displays. In addition, the worksheet gave instructions to focus the student's attention to key science concepts and principles presented in the exhibit. Therefore, teachers, school administrators, and museum staff should consider the design of this type of instructional device for field trips to museums. Even more, teachers and school administrators could consider their use for field

trips in general.

Particularly museums could offer worksheets to the public as a more structured alternative to explore their exhibits. This would reinforce the educational function that museums have, mainly in the case of young visitors. They need more structure than do the older children in order to explore successfully new environments and achieve the objectives proposed for this educational experience.

Recommendations for Future Research

The researcher recommends some changes in the design of the study. First, the sample should be randomly selected from the population. This process will ensure that the sample is representative of the population (Borg & Gall, 1983). As a result, the research findings can be generalized beyond the sample used in the study.

Second, a different alternative would be to design a study that would include the age of the students as the third independent variable. This design would allow the testing of differences in achievement according to the age, gender, and type of visit the students experience. As reported in the literature, it seems that older students have already acquired the skills to adapt to new environments in a shorter period of time than younger children. In addition, older children seem to explore new environments, without any structure, in a more effective way than younger children. It would be interesting to select samples of students from the last two of the four different developmental stages defined by Piaget (1970) and compare the extent of the differences in achievement among these

samples as a result of experiencing the two types of visit: structured versus nonstructured. One hypothesis could be that older children in nonstructured visits would score higher in a posttest of similar content than younger children, in the same type of visits, after their interaction with a science exhibit.

Another recommendation is to use a larger number of classes for the sample. Unfortunately, it is difficult to assign students to the treatments. Once the school year starts, students become part of a whole class as an intact unit. Random assignment will be more effective in equating groups when a larger pool of classes is available.

Although gender-related differences in science achievement were not found, the researcher suggests to retain gender as a design variable. Research on this subject is needed given the controversy that exists and the educational implications this could have. In addition, there is the possibility of an interaction effect that was not detected for the lack of enough evidence. It was mentioned previously that the failure to reject the hypothesis of no interaction between gender and the type of visit could be a consequence of committing a Type II error.

A final suggestion would be to conduct the assessment session immediately after the visit has finished. Thus, additional sources of contamination could be controlled.

Final Comments

The results of the research presented here and the review of the literature on museum education (Koran & Baker, 1979) suggest that,

when planning a museum visit, the following generalizations might be considered:

1. Teachers and school administrators should state specific objectives for the visit. Thus, the teacher and the students can know what they are expected to achieve as a result of the visit.

2. Students should be prepared for the visit. It is recommended that the characteristics of the museum exhibit and the background information that might be required be discussed. Museum personnel could help in the accomplishment of this task.

3. Young children need to focus their attention on the objectives of the visit. Structured visits that use guides or interpreters, maps, and activity worksheets are useful. In addition, to focus the attention on the objectives, they structure the sequence of the visit in a logical way. As a result, the achievement of the stated objectives is more likely to occur.

4. Teachers should pay special attention to the evaluation of the visit's outcomes. The analysis of the results will give information related to: (a) the instructional impact the visit has had on the children and (b) the quality of the plan designed for the visit.

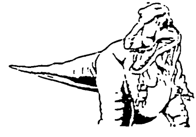
Research on museum education is needed. The findings reported are not consistent across the studies. In addition, some aspects of learning in museums have yet not been explored. These facts offer new avenues for future research on museum education. The growth of the body of research on this area may contribute in the future planning, execution, and evaluation of museum visits and exhibits.

Furthermore, it would reinforce the importance of museums as learning resources for the community.

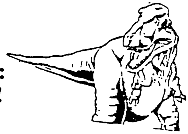
APPENDICES

Appendix A

Information Package



EXPEDITION: DINOSAURS!



Expedition: Dinosaurs! is a traveling exhibition produced by a consortium of four Michigan and Indiana museums including the Kalamazoo Public Museum. The exhibition includes six full and partial scale Dinamation models of dinosaurs and prehistoric mammals that move, roar and appear to be very life-like. The exhibition emphasizes the techniques, tools and theories of paleontologists, the scientists who study fossils. It is from the work of paleontologists that our concepts of prehistoric life have developed. The exhibit is divided into three areas. The **Fossil Finders** provides hands-on opportunities to learn about fossils and how they form. It also emphasizes the kinds of information that paleontologists can learn about prehistoric animals through the study of fossils, how paleontologists work and some of the human history involved in the search for fossils. **Prehistoric Sights** shows how information derived from fossil study can be used to help us imagine what prehistoric animals looked like. Students will see very life-like replicas of prehistoric animals with realistic habitats as the backdrop. In **Digging for Answers**, students will explore, through hands-on experiences, facts that paleontologists have uncovered about prehistoric life.

A. OBJECTIVES OF THE EXHIBIT

1. To understand that our concepts of dinosaurs and prehistoric mammals have been developed from the careful scientific study of fossil evidence.
2. To learn about what a fossil is, how it is formed, and the kinds of information we can learn from the fossil record.
3. To see a very life-like view of what some dinosaurs and prehistoric animals may have looked like.
4. To learn about the steps that paleontologists go through in uncovering and using fossil evidence.
5. To learn about the natural history of some specific prehistoric animals.
6. To explore facts and theories about dinosaurs and prehistoric mammals through many hands-on experiences.

B. ABOUT THE EXHIBIT

1. **Expedition: Dinosaurs!** has been divided into three activity areas to provide a variety of learning experiences, and to give all students an opportunity to make use of every part of the exhibit.
2. Students will enter and receive an introduction to the program in an area called the **Fossil Finders.** This area contains many participatory activities that emphasize the factual basis for our theories about dinosaurs and other prehistoric animals. Exhibits cover what fossils are and how they form, what scientists can learn about animals from the study of fossils, the techniques that a paleontologist uses when he goes about his study, "famous fossils" that have changed our ideas about prehistoric life, and information about the early history of exploration for dinosaur fossils. The kinds of fossils that can be found in the midwest along with a geologic time perspective will also be included. These exhibits will be used to introduce the whole experience at the museum, and can also be used for individual interaction.
3. The **Prehistoric Sights** area contains six Dinamation models of dinosaurs and prehistoric mammals. These models are designed using modern theories based on fossil study. The replicas fill in details that may never known, such as the color of dinosaurs or

KALAMAZOO PUBLIC MUSEUM

how they sounded, to give a very realistic impression of what these prehistoric animals may have been like. The models included in this area are: Apatosaurus (Brontosaurus) and baby, a Pachycephalosaurus, Tyrannosaurus, Dimetrodon (robotic model), Saber-toothed Cat, and Woolly Mammoth. The Dimetrodon robotic model shows how the prehistoric replicas actually work.

4. **Digging for Answers** is a hands-on area that includes games, puzzles and activities to help the student explore what is known about prehistoric animals. Students will assemble skeletons, learn the names of dinosaurs, compare fossil footprints, learn about the adaptations of teeth for various types of food, use computers and try other activities.

C. ACTIVITIES AT THE MUSEUM

1. A maximum of two classes (or approximately 60 students) will be scheduled for each hourly time slot. The program takes one hour.

2. Upon arrival at the museum, classes will receive a brief introduction from museum staff about what a fossil is, how it forms, and the kinds of information that the fossil record can reveal about prehistoric life. A short review of the kinds of information that fossils have revealed about dinosaurs will also be included. The introduction will use artifacts and the exhibits in a hands-on area called the **Fossil Finders.**

3. One group of students will then be directed to a hands-on area called **Digging for Answers.** This area is filled with games, quizzes and puzzles that explore the many facets of dinosaurs and other prehistoric animals. Students will spend approximately 20 minutes in this area using the hands-on, self-explanatory activities.

4. The second group of students will visit the **Prehistoric Sights** area of the exhibit and may use the hands-on exhibits in the **Fossil Finders** area. After approximately 20 minutes, the groups will be directed to the area that they have not yet visited. By limiting the number of students in each area to approximately 30, it is hoped that every student will have the opportunity to use all of the participatory activities in the time allotted.

D. TO PREPARE YOUR STUDENTS

1. Although many students have a good working knowledge of dinosaur names and terms, a clear understanding of the following words will familiarize them with terms used in the exhibit and introduction.

fossil--a trace of a once living plant or animal. Fossils may be actual remains, footprints or impressions.

paleontologist--scientist who studies ancient life as it is revealed in fossils

reptile--a class of air breathing, egg laying animals with backbones. Modern reptiles are cold-blooded, have a scaly skin and lay eggs with leathery shells.

mammal--a class of air breathing warm-blooded animals with fur. Most modern mammals bear live young.

extinction--the dying out or complete disappearance of a group of animals

climate--conditions including temperature, rainfall, and wind that typify a particular region

environment--the circumstances, both living and non-living, surrounding an organism

Mesozoic Era--geologic period often called the Age of Reptiles. The Mesozoic began about 225 million years ago and ended about 65 million years ago. The Mesozoic is divided into three periods, the Triassic, Jurassic and Cretaceous.

Cretaceous Period--covers a time span from 136-65 million years ago. It is the most recent period of the Mesozoic Era. Most dinosaur fossils have been dated to this period, and it is at the end of this period that the dinosaurs became extinct.

Jurassic Period--covers a time span from 193-136 million years ago. It is a part of the Mesozoic Era. The largest of the dinosaurs lived during this period.

Triassic Period--covers a time span from 225-193 million years ago. It is a part of the Mesozoic Era. Dinosaurs appeared in the middle of this period.
Pleistocene Epoch--the Pleistocene or Ice Age is a part of the Cenozoic Era, the most modern period in geologic time. Much of the midwest was glaciated during the Ice Age, and many large mammals including the woolly mammoth and mastodon lived during this time.
Permian Period--covers a time span from 280-225 million years ago. It is the most recent period of the Palezoic (ancient life) Era.
geology--the study of the origin, history, and structure of the earth
decomposition--the breaking down of an organism into basic chemical elements. The decomposition of soft body parts is usually a part of the process of fossil formation.
sediment--material suspended in water and air. This material settles out and is deposited on the bottom of a lake or ocean; the deposition process may be a part of fossil formation.
minerals--a naturally occurring inorganic substance having a definite chemical composition and crystalline structure
prehistoric--refers to events that took place and organisms that lived before recorded time (written history)
carnivore--an animal that eats mainly meat. Most carnivores have adaptations for meat-eating like large, sharp teeth and powerful jaws.
herbivore--an animal that eats mainly plants. Most herbivores have adaptations such as grinding teeth and a long digestive tract which aid in digesting plants.
omnivore--an animal that eats both plants and animals

2. Make sure that students are familiar with the characteristics of these dinosaurs and prehistoric animals

Apatosaurus--The name Apatosaurus means "deceptive lizard"; it received that name because it was easily confused with other sauropods. The Apatosaurus had previously been called Brontosaurus, a name which meant "Thunder Lizard". Apatosaurus probably lived in the plains and forest habitats of western North America, feeding on twigs and the needles of conifers. Its neck was almost 20 feet long, and enabled it to browse on vegetation at the tops of trees. Apatosaurus probably traveled in herds, and relied for protection on its size and tough, leathery skin. This dinosaur was about 75 feet long from nose to tail, and weighed about 30 tons. Its teeth were small and peg-like, and adapted for plant eating. Its brain was small, about th_ size of a human fist.

Pachycephalosaurus--The name Pachycephalosaurus means "Thick-headed lizard", an appropriate name since the dinosaur had a plate of bone 9 inches thick covering its skull. Wart-like knobs and spikes covered this bony plate and the dinosaurs' nose. The purpose of this thick bone is unknown, but males had thicker skulls than females, and some scientists speculate that males competed for territory by butting their heads together, or used their heads in defense. Pachycephalosaurus is the largest of a related group of dinosaurs which ranged from turkey-size to 15 feet in length. The whole group walked on two legs with their bodies held horizontally like birds, and their tails extended for balance. The Pachycephalosaurs were plant eaters, and had short sharp teeth. Fossil skulls, found in Wyoming and Alberta, are the only remains of Pachycephalosaurus that have been discovered.

Tyrannosaurus--Tyrannosaurus means "Tyrant Lizard", a name chosen because of the large size and sharp teeth and claws of this dinosaur. Tyrannosaurus was one of the last and largest of the carnivorous dinosaurs. It was up to 50 feet long, over 18 feet tall and weighed about 6 tons. It ran with its tail extended for balance. The jaws of Tyrannosaurus were about 3 feet long and lined with 60 dagger-like teeth that were between 3 to 6 inches in length. Tyrannosaurus had huge feet with long talons, but its arms were very short. The

Tyrant Lizard lived in western North America during the late Cretaceous period. Because of its size Tyrannosaurus could not run swiftly, and probably preyed on animals that were easy to catch. Fossils of Tyrannosaurus have been found in Wyoming.

Dimetrodon--Dimetrodon is not a dinosaur, but a Pelycosaur, an ancestor of the mammal-like reptiles. Its name means "Two-measure teeth", and refers to the fact that it had teeth of two different sizes. Dimetrodon is best known for the 2 to 3 foot sail along its back which may have helped to regulate its body temperature. Dimetrodon was about 10 feet long, was carnivorous, and moved on all four legs. It lived during the Permian period, before many dinosaurs had appeared and became extinct by the beginning of the Mesozoic Era. Dimetrodon fossils have been found in Texas.

Woolly Mammoth--The woolly mammoth was one of a number of large elephant-like mammals that lived during the Ice Age. There were several types of mammoths including the Woolly mammoth, the Columbian mammoth, and the Jefferson mammoth as well as a forest browser called the American Mastodon. Mammoths were generally grassland grazers and probably lived along the southern edge of the glacier. The woolly mammoth was very common in the artic regions of the northern hemisphere. Fossil finds of mammoths indicate that they fed almost exclusively on grasses, and had teeth that were 8 to 9 inches long with thin ridges on the chewing surface. The coat of the woolly mammoth was composed of reddish-brown fur interspersed with long black hairs. Mammoths and mastodons were probably hunted by the Paleo-Indians.

Saber-toothed Cat--The Saber-toothed Cat or Tiger lived during the Ice Age or Pleistocene. The cat was about 4 feet tall at the shoulder and about 10 feet long, stalked its slower moving prey, and used its strong leg muscles and claws to spring upon its victims. It is thought that saber-toothed cats probably preyed on mastodons; the extinction of the cats closely follows the extinction of mastodons in both Europe and North America. The lower jaw was hinged in a way that allowed it to swing open and hang straight down so that its saber-like teeth could be cleared for action.

E. ACTIVITIES AT SCHOOL

The activities that follow may give you ideas for other dinosaur activities with your students. Several are included on separate pages so that they may be duplicated if needed.

1. **Invent your own Dinosaur.** A dinosaur's name often tells us something about the animal. The words listed below with their meaning, are often used by scientists to name dinosaurs. Have students put their own name together, and then draw a dinosaur that meets the description.

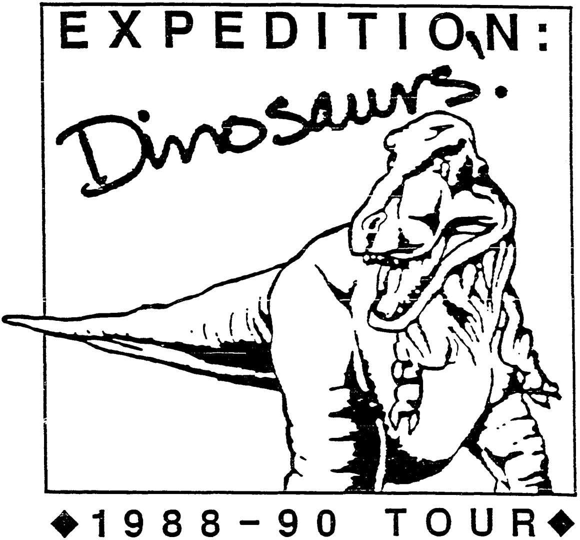
Archaeo--ancient	**Mono**--single
Brachius--arm	**Onychus**--claw
Bronto--thunder	**Ops**--face
Cephalus--head	**Ornitho**--bird
Cerato--horned	**Pod**--foot
Cheirus--hand	**Pteryx**--wing
Dino--terrible	**Rex**--king
Don--tooth	**Saurus**--lizard
Gnathus--jaw	**Spino**--thorny
Ichthy--fish	**Stego**--plated
Lestes--stealer	**Styraco**--spiked
Lophus--crest	**Tri**--three
Mimus--imitator	**Tyranno**--tyrant

2. **Dig for Words.** The words that follow with their definitions are hidden in this word box. Some words read from left to right or from top to bottom. Circle the words when you dig them out.

Cope--a scientist who found many dinosaur fossils in the 19th century
Cretaceous--the last of 3 time periods that make up the Age of Dinosaurs
Dig--a scientific examination of fossil sites
Dinosaur--extinct reptile that dominated the earth for millions of years
Diplodocus--the longest dinosaur
Fossil--a trace of a plant or animal that was once alive
Jurassic--the middle of 3 time periods that make up the Age of Dinosaurs
Marsh--a scientist who found many dinosaur fossils in the 19th century
Mesozoic--name for the Age of Dinosaurs
Pangaea--huge continent that contained all the land on earth at the beginning of the Mesozoic Era
Pterosaur--flying reptiles related to dinosaurs
Reptile--class of animal with a backbone and scaly skin
Triassic--first time period in the age of dinosaurs

C	T	A	R	Z	I	C	F	S	C
O	R	A	E	O	O	I	O	P	I
P	I	E	P	T	I	O	S	T	S
E	A	A	T	M	G	Z	S	E	S
S	S	G	I	A	E	O	I	R	A
O	S	N	L	R	C	S	L	O	R
Z	I	A	E	S	N	E	M	S	U
I	C	P	T	H	I	M	O	A	J
O	I	P	L	O	D	O	C	U	S
A	D	I	N	O	S	A	U	R	S

3. Color this ticket to Expedition: Dinosaurs!



Appendix B

General and Specific Objectives of the Exhibit
"Expedition: Dinosaurs"

GENERAL OBJECTIVES OF THE EXHIBIT

As a result of the participation of those visiting the museum exhibit in the different activities presented, he (she) will be able to:

1. Understand that the body of knowledge about dinosaurs and other prehistoric animals has been developed based on the study of fossil evidence.
2. Understand that a fossil is, how it is formed, and assess the kind of information that can be obtained from the fossil record.
3. Experience a life-like view of what some dinosaurs and other prehistoric animals may have looked like.
4. Recognize the steps that paleontologists follow to find and use fossil evidence.
5. Understand the behaviors of some specific prehistoric animals as being part of the natural history.
6. Explore the facts and theories about prehistoric life through hands-on experiences.

SPECIFIC OBJECTIVES OF THE EXHIBIT

As a result of the participation of those visiting the museum in the different activities presented, he (she) will be able to:

1. Define the term fossil.
2. Identify fossils presented in the exhibit.

3. Order the steps required for the formation of fossils.
4. Relate the samples of fossils presented in the exhibit with the information that can be obtained from them.
5. Describe the work of paleontologists with the help of the displays and activities.
6. Distinguish between the prehistoric environment and today environment with help of the exhibit.
7. Recognize that explorations for fossils started about 150 years ago.
8. Identify examples of fossils found in mid-west Michigan.
9. Name and identify some animals of long ago with help of the models.
10. List few characteristics of some animals of long ago, such as diet, footprints, life period, and reproduction.
11. Distinguish between dinosaurs and other animals of long ago.

Appendix C

Table of Specifications of the Assessment Instrument:
What Do You Remember About "Expedition: Dinosaurs"

TABLE OF SPECIFICATIONS FOR THE INSTRUMENT

What do you remember about "Expedition: Dinosaurs"

Outcome / Content	knowledge	comprehension	application	Total No. of items
Fossil concept				0
Fossil samples	2			2
Fossil formation			4	4
Information obtained from fossils		4		4
Paleontologist's work	1			1
Prehistoric environment		1		1
Fossil exploration		1		1
Michigan fossils	1			1
Prehistoric animals	4			4
Characteristics of prehistoric animals	2	1		3
Differences between dinosaurs and other animals		1		1
Total No. items	10	8	4	22

Appendix D

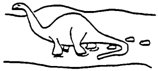
The Assessment Instrument: What Do You Remember About "Expedition: Dinosaurs"

1

Are you a boy or a girl. Draw a circle around your answer

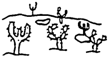
 

What do you remember about "Expedition: Dinosaurs"?



Draw a circle around the right answer. Only one answer is right.

1. Where did this animal  live?

2. Which animal of long ago was found in Kalamazoo?

3. Which animal is not a dinosaur?

Draw a circle around the right answers. Only two answers are right.

4. Which are fossils?

5. Which of these animals were carnivores?

2

Draw a circle around the missing words. Only one answer is right.

6. Paleontologists know about plants and animals of long ago by studying ______

ferns teeth bones fossils

7. Dinosaurs' diet can be discovered by studying their ______

toes jaws horns back legs

8. Explorations to look for fossils started about ______ ago

10 years 50 years 150 years 300 years

Write numbers under the pictures to show the right order.

9. How does a fossil form?

( ) ( ) ( ) ( )

The pictures show fossils. The sentences tell what we can learn from fossils. Draw lines to connect the fossils with what we can learn from them.

10. which animals lived at the same time

11. how the animal moved

12. how the plant looked

13. how the animal reproduced

Draw a line from the animal to its right name.

14. Apatosaurus 15. Pachycephalosaurus 16. Dimetrodon 17. Mastodon

Appendix E

Manual of Instructions to Administer the Assessment Instrument: What Do You Remember About "Expedition: Dinosaurs"

DIRECTIONS FOR THE ADMINISTRATION OF THE ASSESSMENT INSTRUMENT:

What do you remember about "Expedition: Dinosaurs"?

This manual contains the directions to administer the instrument to assess learning that takes place as a result of the visit to the exhibit "Expedition: Dinosaurs". Because the reliability of the instrument is very important, directions should be followed carefully. Your cooperation in this matter is highly appreciated.

A. Materials

_____ instruments. One for each student and one for the teacher

_____ pencils

_____ watch

B. Time limits

The assessment session will take a maximum of 20 minutes. Test questions are read individually, therefore, working time may vary.

The time limit per question represents a maximum working time. If all the students finish before a given time limit is up, you may continue on with the next question.

C. How to give the directions

Read through all the directions before administering this instrument. Follow along in the instrument as you read the directions.

The directions to be read aloud to the students are <u>underlined</u>. The directions to the teacher are printed in regular type.

Read the directions to the students <u>exactly</u> as you see them in this manual. Do not speak too slowly nor too quickly. Read them in a steady speaking voice, avoiding a great deal of expression.

D. Introduction to the Assessment Session

The first day following the visit to the exhibit and at the scheduled time for the assessment session, make the following announcement to the students:

Who can remember where did we go yesterday (or last Friday?). Wait for answers. That's right, we went to the Kalamazoo Public Museum to see the Dinosaurs!.

Well, the people from the museum are interested in knowing what you remember about the things that you saw and did there. They want to know this because it will help them to make other exhibits even better in the future. This way, you can get the best from them.

E. Assessment Session

The assessment session starts when you explain how the museum is going to know what the students remember. Say to the students:

To know what you remember, the people from the museum gave me this sheet called "What do you remember about Expedition: Dinosaurs?". This sheet has questions about things that you saw and did at the museum.

I am going to give each of you a copy of the sheet and I am going to tell you how to work with it. One important thing to remember is that you have to work by yourself. Your answers are what you remember about the visit.

Another thing....., they do not want to know your name, they just need to know if you are a boy or a girl. Do not write your name on the sheet.

Now, I am going to pass the sheet. Distribute the sheets among the students. Make sure everybody has one.

We are going to start on the page that has a dinosaur walking at the top, on the right side. Did everybody find it?. Wait for answers.

Okay, let's answer the first question: "Are you a boy or a girl?. Draw a circle around your answer"

What are you going to do?. Wait for answers. That's right, if you are a boy, draw a circle around the picture of the boy. If you are a girl, draw a circle around the picture of the girl. The next questions also ask you to draw circles or lines to show the right answer.

From now on, I will read the instructions, the questions and those answers that are words or sentences. Then, I will give you time to choose the answer.

Follow along with me as I read to you. Let's start:

Read the title, instructions, and questions for items 1 to 5. Allow 20 seconds to answer each question.

go to page 2

Now, turn the page. For the next three questions (6 ,7 & 8), you need to draw a circle around the missing words.

Read each question and the four alternatives. Allow 30 seconds to answer each question.

For the next question (9), you need to write numbers under the pictures to show the right order.

Read the question. Allow 45 seconds to write the numbers.

In the next questions (10-13), the pictures show fossils. The sentences tell what we can learn from fossils. I will read each sentence and you are going to draw lines to connect the fossils with what we can learn from them.

Read the number and the sentence one at a time allowing 15 seconds to make the connection for each one.

Now the last part (14-17). You need to draw a line from the animal to its right name. The names are:

Read the number and the names one at a time allowing 15 seconds to draw the line for each one.

You did a great job!!. Congratulations!!.

Leave everything on your desk. Now, I am going to collect the sheets (and pencils, if necessary).

As you collect the material say:

The people from the museum really appreciate all your help. I am sure they will be very happy for what you did.

END OF THE ASSESSMENT SESSION

Once again, I highly appreciate all your cooperation for the implementation of this assessment session.

Rosario Canizales de Andrade.

Appendix F

The Teacher's Questionnaire

"EXPEDITION: DINOSAURS" PROJECT
TEACHERS' QUESTIONNAIRE

Please check the answer which most closely describes your position.

PREPARATION FOR THE VISIT

1. You chose to visit "Expedition: Dinosaurs" for the following reason(s):

   ( ) my own decision
   ( ) Principal's suggestion
   ( ) students' suggestion
   ( ) to reinforce objectives covered in class
   ( ) to introduce the topic to the students
   ( ) other(s) ______________________

   ____

2. Did you receive the visit's information material prepared by the Department of Interpretation from the Kalamazoo Public Museum?

   ( ) Yes ( ) No

   If your answer is NO, please go to item No. 7.

3. Did you familiarize the students with the terms suggested in the information material?

   ( ) Yes ( ) No

4. Did you familiarize the students with the characteristics of the prehistoric animals presented in the information material?

   ( ) Yes ( ) No

5. Did you work with the activities proposed in the information material?

   ( ) Yes ( ) No

   If your answer is NO, please go to item No. 7.

6. Check the activities you did:

   ( ) Invent your own dinosaur
   ( ) Dig for words
   ( ) Color the ticket to "Expedition: Dinosaurs"
   ( ) Find the fossils in the picture

(over)

VISIT TO THE EXHIBIT

7. What is your opinion about the instructional support provided during the visit?

Quality	Quantity
( ) very good	( ) too much
( ) good	( ) much
( ) adequate	( ) adequate
( ) could be improved	( ) few
( ) poor	( ) very few

8. Describe briefly your interaction with the students during the visit:

____

____

____

ASSESSMENT SESSION

9. What is your opinion about the instrument used to assess learning from the exhibit?

Difficulty level	Length	Quality
( ) too difficult	( ) too long	( ) very good
( ) difficult	( ) long	( ) good
( ) adequate	( ) adequate	( ) adequate
( ) easy	( ) short	( ) could be improved
( ) too easy	( ) too short	( ) poor

10. What is your opinion about the directions for the assessment session?

Quantity	Quality
( ) too much	( ) very good
( ) much	( ) good
( ) adequate	( ) adequate
( ) few	( ) could be improved
( ) very few	( ) poor

(over)

FOLLOW UP ACTIVITIES

11. Do you plan to do any activity following the visit?

( ) yes ( ) No

If so, please describe briefly:______________________________

____

____

12. Which Science Series do you use?:____________________________

____

13. If you have any additional comments, please feel free to write them:

____

____

____

____

____

____

____

____

Thank you for your help !

Appendix G

Directions for the Use of the Activity Worksheet:
Explore "Expedition: Dinosaurs"

"EXPEDITION: DINOSAURS"

DIRECTIONS FOR THE ACTIVITY WORKSHEET

Explore "Expedition: Dinosaurs"

After the usual introduction, say to the students:

"I'm going to give you a sheet like this (show the worksheet) that will help you to explore "Expedition: Dinosaurs". You will pretend to be a very young scientist trying to discover more things about dinosaurs. Do you like that? (wait for answers. I hope they will be "Yeah !!!"). It has questions about fossils, dinosaurs, paleontologists, etc. Most of the time, the worksheet will tell you where to go to find the answers. I'm going to pass the worksheet, so you can see it."

Pass the worksheets to the group, make sure everyone gets one. Now, say to the children:

"Does everybody have one? (wait and check). Great!!. The worksheet has 4 pages (show them).
On the top of the first 3 pages, you can see the name of the area, where you have to go to find the answers for that page. The name of the area is underlined in red. Can you see that? (wait and check).... Page 1 says "PREHISTORIC SIGHTS", to complete it you need to be in that area (show the area)....

Page 2 says "DIGGING FOR ANSWERS", to complete it you need to be there (show the area).... And for the last 2 pages, you need to be in the "FOSSIL FINDERS" area, that is this one we are in right now. Is there any question? (wait for answers)....

"You can work by yourself or in pairs, but remember you need to answer the questions on your own paper. Please, keep your voice level down. If you don't know where the area or the exhibit is you can ask for help."

"Okay, are you ready to explore Expedition: Dinosaurs?. (wait for answers). Great !!!

Divide the group and give the instructions on how to switch areas as you usually do.

Thanks for your help!!!

Rosario Canizales de Andrade

Appendix H

The Activity Worksheet: Explore "Expedition: Dinosaurs"

Read the sentence. Write the missing word.

The name of the scientist that studies fossils is:

____

Paleontologists study fossils to learn things about plants and animals of long ago.

Find the exhibit "FOSSIL SECRETS".
Match the fossil with the secret it can tell.

where the animal lived

how the animal moved

what the animal ate

what the babies looked like

The fossil of an animal of long ago was found in Kalamazoo.
Write the missing letters to name it.

M _ _ T _ O _ _

Congratulations !!. You did a great job.
Leave the clipboard with the sheet in the box.
Go and discover more things about dinosaurs.

Explore "Expedition: Dinosaurs"

PREHISTORIC SIGHTS

See the animals in this area.
Are all of them dinosaurs?. Draw a circle around your answer.

Yes No

The dinosaurs are those that lived during the Triassic, Jurassic, and Cretaceous times.

Draw a line from the animal to its name.

Apatosaurus
Tyrannosaurus
Pachycephalosaurus
Woolly Mammoth
Saber-Toothed cat
Dimetrodon

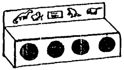
Did all these animals live at the same time?. Circle your answer.

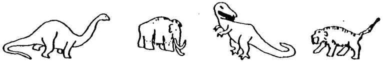
Yes No

What other things can you tell about these animals?
Think about it !!

DIGGING FOR ANSWERS

Find the exhibit "TOOTH COMPARISON"
Touch the teeth in the boxes. To which animal do they belong?
Draw a line from the box to the animal.





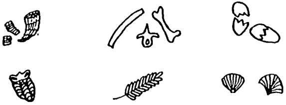
Do other activities. Play with the puzzles and computer games.

Discover other things about dinosaurs and how paleontologists work.

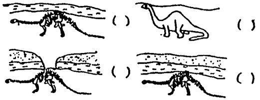
Go to the **FOSSIL FINDERS** area to find the answers for the last two pages.

FOSSIL FINDERS

Look for samples of fossils in the entire area.
Draw a circle around the fossils that you saw.



Find the exhibit "HOW FOSSILS FORM". What happened first?
Write numbers to order the pictures.



Go to the exhibit "DISCOVER A FOSSIL". Follow the instructions.
How many fossils did you discover?. Write the number.

____ fossils.

Appendix I

Directions for the Visit to the Exhibit
"Expedition: Dinosaurs"

DIRECTIONS FOR THE VISIT TO THE EXHIBIT

"Expedition: Dinosaurs"

(Teacher)

The exhibit "Expedition: Dinosaurs" has been designed to give all students the opportunity to discover the paleontological techniques, tools, and theories developed to explain prehistoric life.

Students will explore, through hands-on experiences, facts about prehistoric life. In addition, they will see very life-like replicas of prehistoric animals.

Since the purpose of this study is to assess learning that takes place as a result of this visit, it is necessary to consider some directions to meet standard conditions. In this way, all the students will experience the same treatment. The directions are as follows:

1. Try to limit, as much as possible, your interaction with the students to discipline situations.

2. Try to leave, as much as possible, to the museum interpreters the explanation about the exhibit.

3. If you find that students need help with reading, headings, instructions, labels, you can read those to them. However, avoid to explain or give more information than the one presented.

4. Some puzzles have big pieces (wood). Small children will need help to assemble them. In this case, your participation will be appreciated.

5. If you have planned to have a follow-up activity for the visit, please wait until the assessment session has been finished. We want to assess what the students remember from the visit. Any additional activity will change the conditions of other groups participating in this study.

Once again, we very much appreciate your interest and cooperation, and I look forward to seeing you tomorrow or next Monday.

Sincerely,

Rosario Canizales de Andrade

Appendix J

Specific Objectives of the Exhibit
"Expedition: Dinosaurs"

SPECIFIC OBJECTIVES OF THE EXHIBIT "EXPEDITION: DINOSAURS"

As a result of the participation of those visiting the museum in the different activities presented, he (she) will be able to:

1. Define the term fossil.
2. Identify fossils presented in the exhibit.
3. Order the steps required for the formation of fossils.
4. Relate the samples of fossils presented in the exhibit with the information that can be obtained from them.
5. Describe work of paleontologists with the help of the displays and activities.
6. Distinguish between the prehistoric and today environment with help of the exhibit.
7. Recognize that explorations for fossils started about 150 years ago.
8. Identify examples of fossils found in mid-west Michigan.
9. Name and identify animals of long ago with the help of the models.
10. List few characteristics of some animals of long ago, such as diet, footprints, life period, and reproduction.
11. Distinguish between dinosaurs and other animals of long ago.

Appendix K

Relationship Between the Objectives, Displays, and Activities of the Exhibit "Expedition: Dinosaurs"

Relationship Between the Displays, Activities and the Specific Objectives of the Exhibit

Area / Display or activity	Objective 1	2	3	4	5	6	7	8	9	10	11
<u>Fossil Finders</u>											
(*) How a fossil forms	X		X								
(*) Discover a fossil	X	X									
(*) Fossil Secrets	X			X							
When did they live									X	X	
(*) How fossil finders work					X		X				
Famous Fossils					X		X				
Paleontology Scrapbook		X			X		X		X		
(*) A mastodon in Kalamazoo							X		X		
<u>Prehistoric Sights</u>											
(*) Apatosaurus and baby						X			X	X	X
(*) Pachycephalosaurus						X			X	X	X
(*) Tyrannosaurus						X			X	X	X
(*) Saber-toothed Cat						X			X	X	X
(*) Woolly Mammoth						X			X	X	X
(*) Dimetrodon						X			X	X	X

(*) display or activity mentioned and/or included in the worksheet.

(continues)

(continues)

Area / Display or activity	Objective 1	2	3	4	5	6	7	8	9	10	11
<u>Digging for Answers</u>											
(*) Puzzles									X	X	
(*) Skeletons (puzzles)									X	X	
(*) Tooth comparison				X					X	X	
(*) Paleontologist's pictures					X		X				
(*) Footprints				X						X	
(*) Computer games	X	X		X		X	X		X	X	X

(*) display or activity mentioned and/or included in the worksheet.

Appendix L

Human Subjects Review Board Approval of Protocol

Human Subjects Institutional Review Board

Kalamazoo, Michigan 49008-3899

WESTERN MICHIGAN UNIVERSITY

TO: Rosario Canizales de Andrade

FROM: Ellen Page-Robin, Chair E.P-R.

RE: Research Protocol

DATE: March 17, 1989

This letter will serve as confirmation that your research protocol, "Comparisons of Learnings from Structured and Non-Structured Visits to a Science Exhibit," has been approved as exempt by the HSIRB.

If you have any further questions, please contact me at 387-2647.

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