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COMPARISON OF MIDDLE SCHOOL STUDENT PERFORMANCE ON PHOTOGRAPH-BASED MULTIPLE-CHOICE ITEMS AND TEXT-BASED MULTIPLE-CHOICE ITEMS ON A STATE SCIENCE ACHIEVEMENT TEST

A Dissertation

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Doctor of Philosophy

in

the Department of Educational Theory, Policy, and Practice

by

Susannah F. Craig
B.S., Louisiana State University, 1991
M.A., Louisiana State University, 1994
December 2007
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This six year process would not have been possible without the love and support of my family and friends. To my husband, Stewart, I thank you for the gifts of time, encouragement, and support. To my children, Stewart and Patrick, thank you for being the inspiration for researching methods that improve education. To my mother, Dr. Sue Weaver, thank you for your guidance and direction; you are my constant “cheerleader,” mentor, and friend.

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ABSTRACT

The purpose of this study was to investigate how photograph-based life science multiple-choice items influenced Louisiana science students’ performance on statewide standardized tests, in comparison with text-based items about the same content. This mixed methodology research study focused primarily on types of multiple-choice items, specifically five matched pairs of multiple-choice items, text-only and same-text with a photograph. For the 2007 LEAP field test, statistics from 11 multiple-choice items were utilized to characterize student performance on photograph-based multiple-choice items. Data from all Louisiana 8th grade students taking Form 3 (n=1130) and Form 4 (n=1182) were analyzed to compare student performance on each item type.

Additional case study research was conducted in two schools. Within each school, one 8th grade class was exposed to the 20-Question Model (Wandersee, 2000) (treatment group); the remaining 8th grade classes were not (control group). Questionnaires were given to all 8th grade students at each school which focused on the student’s experience when answering the field test questions with a photograph. In addition four eighth-grade students, who were contrasted on gender and on high or low academic performance, were interviewed and asked to co-construct six concept maps related to six different test items used in the study (four with photographs, two without photographs).

The analysis of the quantitative data showed a significant difference on the heron item. There was a moderate positive correlation between achievement level and mean number correct on the photograph-based items ($r_s= .1536$). The data show that students performing at low achievement levels benefited from the photograph-based item. The qualitative data analysis revealed positive student perception when working with photographs during classroom
instruction and taking assessments. The student interviews and concept maps with the four students revealed students’ conceptions and misconceptions about life science concepts.
CHAPTER ONE
INTRODUCTION

FEDERAL AND STATE MANDATED ASSESSMENTS

The primary goal of the No Child Left Behind (NCLB) federal act is to close the achievement gaps among students of diverse backgrounds and improve achievement for all students. By mandating adequate yearly progress for all students, the federal government forced states to be accountable for student achievement in English language arts, mathematics, and science (NCLB, 2001). The NCLB (2001) legislation states that each State plan shall demonstrate that the State educational agency, in consultation with local educational agencies, has implemented a set of high-quality, yearly student academic assessments that include, at a minimum, academic assessments in mathematics, reading or language arts, and science that will be used as the primary means of determining the yearly performance of the State and of each local educational agency and school in the State in enabling all children to meet the State's challenging student academic achievement standards, except that no State shall be required to meet the requirements of this part relating to science assessments until the beginning of the 2007-2008 school year. (NCLB, p. 25)

In 1994, the Improving America’s School’s Act focused on English language arts and mathematics accountability issues for any schools receiving Title I federal funds. In 2001, NCLB extended the Improving America’s Schools Act to include all schools within states that receive Title I funds (National Research Council [NRC], 2006). Instead of mandating accountability measures tied to federal funds for individual schools within districts and states, the 2001 act extends the mandate to include accountability measures for all schools within states that receive
any Title I funds (NRC). In addition, NCLB mandates science as a component of federal and state accountability issues (NCLB).

For the purposes of this study, science assessment was the primary focus. The NCLB requirements for science include challenging science standards and assessment of those standards at least three times during the educational career of a student: once in grades 3–5, once in grades 6–8, and once in grades 9–12 (NRC, 2006). The state of Louisiana met and exceeded these requirements by continuing existing testing programs: the Louisiana Educational Assessment Program (LEAP) and the Graduation Exit Exam (GEE), which are a cumulative assessments that measure content standards and benchmarks at the end of three grade clusters: K-4, 5-8, and 9-12. In addition, the Louisiana Department of Education (LDE) instituted two testing programs based on rigorous content standards and grade level expectations: the Integrated Louisiana Educational Assessment Program (iLEAP), which is the standards-based assessment measuring grade level expectations at grades 3, 5, 6, and 7, and the LEAP Alternate Assessment 2 (LAA 2), which is the standards-based assessment developed for students performing three grade levels below the enrolled grade (LDE, 1997, 2000, 2004, 2005a, 2005b, 2005c, 2005d, 2006a, 2006c, 2006e, 2006f). Currently, Louisiana administers two criterion-referenced science assessments at seven grades: Grade 3 iLEAP, Grade 4 LEAP, Grades 5, 6, and 7 iLEAP, Grade 8 LEAP, and Grade 11 GEE (LDE, 2000, 2005a, 2005b, 2005c, 2005d). The LAA 2 science test is also administered at Grades 4, 8, and 11; Grades 5, 6, and 7 will be implemented in the spring of 2009 (LDE, 2006c).

The LEAP, GEE, and LAA 2 assessments are criterion-referenced tests, which are assessments that measure student performance for a set criteria or standard. The iLEAP assessment is a combination of a norm-referenced test, which is a standardized test that measures
student performance and compares it to the typical performance of a group (norm) and a
criterion-referenced test. The English language arts and mathematics tests are a combination of
the *Iowa Test of Basic Skills* (Hoover, Dunbar, & Frisbie, 2001) and additional items that
measure the grade level expectations (GLEs). The iLEAP science test is strictly criterion
referenced.

As the federal government mandates criterion-referenced tests to measure student
achievement in science, with significant consequences for students, researchers must carefully
examine the types of items utilized to measure students’ understanding of science concepts. The
LDE’s primary focus is to develop statistically sound science assessments based on the state and
national standards, benchmarks, and grade-level expectations for each grade level. Although the
state tests have been developed to meet these requirements, work is ongoing to further develop
these technically sound instruments by refining individual items in a variety of areas. The LEAP
and GEE science tests include multiple-choice, short-answer, and extended constructed-response
items (LDE, 2000, 2006a, 2006e, 2006f). The iLEAP science tests include multiple-choice items
only (LDE, 2005a, 2005b, 2005c, 2005d). The LAA 2 science tests include multiple-choice and
short-answer items (LDE, 2006c). Five strands of science are assessed on the state tests: Science
as Inquiry, Physical Science, Life Science, Earth and Space Science, and Science and the
items are developed to supplement item banks, and each science instrument is constructed from
approved Louisiana test item banks (LDE, 2006d).

There is a need for research on better assessment practices as increased science testing at
all grades from Grades 3 through 11 is mandated by the NCLB federal act with limited funding
across four subject areas. Prior to 2006, students were assessed with a norm-referenced science
test at Grades 3, 5, 6, 7, and 9. Subsequently, Louisiana administered newly developed criterion-referenced tests at Grades 3, 5, 6, and 7 in 2006. These assessments are shorter and solely multiple-choice. To insure the validity of the tests that are developed, it is imperative to look directly and critically at curriculum as well as instructional methods, including textbooks.

**BIOLOGY CURRICULUM AND TEXTBOOKS**

According to Wandersee (2000), “perusal of history of biology serves to document that it is one of the most visual of the sciences. Research biologists have long realized that the well-chosen image can communicate what they have learned about the living world much better than words” (p. 129). Images can portray scientists’ and researchers’ thinking; even Aristotle “proposed that we cannot think without images” (Robin, 1992, p. 9). Many science classrooms use textbooks as the primary resource for curriculum materials (American Association for the Advancement of Science [AAAS], 1993; Lloyd, 1990; NRC, 1990; Nixon, 2001; Pozzer, & Roth, 2003; Roth, Bowen, & McGinn, 1999). A perusal of high school science textbooks indicates that a large number of photographs and drawings are available for students to use to better understand the material (NRC, Nixon, Pozzer, & Roth). In Nixon’s (2001) research on the use of photography in textbooks, for example, one high school science biology book was evaluated and found to be approximately one-fourth photographs, with almost every page including a photograph. Nixon spent 5 weeks with the teacher and students in a high school biology class using the 20-Question Model (Wandersee, 2000) teaching the students how to use the photographs in the textbooks to facilitate understanding of biological concepts.

Historically, biology textbooks and teachers have used visual stimuli, including photographs, to enhance the understanding of biological concepts (Pozzer-Ardenghi, & Roth, 2004; Reid & Miller, 1980; Roth, et al, 1999; Wandersee, 2000). Photographs have been used to
present biological concepts that are difficult for the human eye to see, such as chromosomes, mitosis and meiosis, and DNA molecules. Photographs have also been used to capture a moment in time of an organism (Wandersee), so that students can observe and compare characteristics of organisms, for example, phenotypes of organisms.

If biology is a visual science (Wandersee, 2000) and photographs are used as stimuli in textbooks (Pozzer-Ardenghi & Roth, 2004; Roth et al., 1999), then why has biological content historically been measured primarily in a text-only format (Sadler, 2000) or utilizing text with naturalistic drawings (Roth et al, 1999)? In order to align the biology assessment practices with curriculum and thereby provide a more accurate picture of students’ conceptual understanding, research needs to be conducted to identify more effective ways to measure student understanding of life science concepts. Specifically, new ways must be investigated to measure biological content knowledge using visual stimuli, particularly photographs.

DESCRIPTION OF THE RESEARCH PROBLEM

Because the way that students make meaning from photographs determines how science is taught and how it is assessed, this study was designed to compare student performance on photograph-based life science multiple-choice items and text-only versions of the same multiple-choice items. This mixed methodology research study utilized descriptive and inferential statistical analysis in comparing data from two types of multiple-choice items, data from interview protocols, data from student questionnaires, and data from case study research. Student responses from 11 multiple-choice items were utilized from the grade 8 LEAP science field test to compare five photograph-based multiple-choice items to five text-only multiple-choice items that measure the same concepts. Responses from an additional item which asks students to use the photograph to answer the question were evaluated. Two schools with similar demographics
were selected from the field test sample to participate in the study. The researcher introduced the 20-Question Model (Wandersee, 2000) to one class within each school. After the administration of the field test, all grade 8 students at both schools were asked to complete a questionnaire about the photograph-based items. Additional case study research was conducted with four students, two from each school, to determine if photograph-based multiple-choice items impacted overall performance on LEAP science items and if retention was sustained.

RESEARCH QUESTIONS

The Primary Research Question

How does middle school students’ performance on photograph-based multiple-choice items in a state science achievement test compare to their performance for text-only multiple-choice questions?

The Subquestions

1. Which categories of students, if any, benefit most (based on their scores) from the inclusion of photograph-based multiple-choice items?

2. How well does student performance on science-content-equivalent items, using matched pairs of the two types of multiple-choice items, correlate?

3. Are there differences in test performance between students who were introduced to and used the 20-Q Model of Photographic Inquiry during science instruction and those who did not?

4. How do four concept-map-based mini-case studies of a high and a low test-scoring male and female triangulate with their subscores on the tests’ photograph-based multiple-choice items and their subscores on the text-based multiple-choice items?
GOWIN’S VEE DIAGRAM OF PROPOSED RESEARCH

The Vee Diagram, developed by Gowin (1981), is a tool used by students to facilitate the understanding of how science knowledge is constructed (Wandersee, 1993). Students can use this diagram to plan or outline research, or to gain a better understanding of published research. Conceptual and theoretical concepts are listed on the left side of the Vee; components of methodology comprise the right side of the Vee; the research questions fill the middle of the Vee; and the vertex of the Vee points to the event on which the researcher is collecting data. By using this diagram, students can identify research questions within a study, recognize the conceptual/theoretical framework that supports the study, and identify any value or knowledge claims suggested by the study (Trowbridge and Wandersee, 1998; Wandersee, 1990).

The following Vee diagram (see Figure 1) outlines this study.

PROPOSED TIMELINE OF RESEARCH

The research was divided into several phases: ongoing review of the literature from April 2004 to completion; a pilot study of field-tested items on the grade 8 LEAP field test (April 2004), development and revision of photograph-based test items (August 2005), scheduled April 2006 field test of items postponed due to Hurricane Katrina, revision of photograph-based and text-based multiple-choice items and test form placement (June 2006), student training on 20-Question Model (March/April 2007), administration of field test (April 2007), mini-case study of four students (April 2007), student/teacher interviews (April 2007), data collection and analyses of questionnaire, case-study, and interview data (May/June 2007); statistical analyses of items (June 2007); and final analysis and evaluation of research (July 2007).
**Research Question**
How does middle school students' performance on photograph-based multiple-choice items in a state science achievement test compare to their performance for text-only multiple-choice questions?

**Subquestions**
Which categories of students, if any, benefit most (based on their scores) from the inclusion of photograph-based multiple-choice items?

**Conceptual/Theoretical**

- **World Views**
  - Humans nature is consistent.
  - Testing can be done abstractly, when the examinee is not in direct contact with the stimuli.
  - Testing, if done well, accurately reflects what a student knows.

- **Philosophy/Epistemology**
  - Learning is a lasting change in the meaning of experience (Gowin)
  - Meaningful learning can facilitate conceptual understanding

- **Theories**
  - Human Constructivism
  - Information Processing
  - Dual Coding

- **Principles**
  - Wandersee’s 20-Q Model of Image-Based Biology Test-Item Design can be used as a model to assess student understanding of science concepts.
  - Photographs assist in assessing student’s biological conceptions

- **Constructs**
  - Concept Mapping
  - Metacognition
  - Concepts

- **Biology, Skills, Content, Dispositions, Photograph-Based Item, Text-Based Item, Multiple-Choice Item, Tacit Knowledge,**

**Methodological**

- **Value Claims**
  - Wandersee’s 20-Q Model assesses student conceptual understanding of biological concepts.
  - Photographs can be used to “capture a moment in time” in the life of an organism.
  - Photographs assist in visualizing biological concepts; difficult concepts can be learned and assessed using photographs.

- **Knowledge Claims**
  - Biology is the most visual of the sciences; it is typically assessed in text-only format.
  - There is a disconnect between the way biology is presented in textbooks and assessed on tests.
  - Photographs can be used as the stimulus material for multiple-choice items.

- **Transformations**
  - Photographs can aid with conceptual understanding of biological concepts.

- **Records**
  - Students respond to a questionnaire about the photograph-based items and the 20-Q Model.
  - Photographs can aid with conceptual understanding.

- **Events**
  - Students will take the spring 2007 field test which included photograph-based multiple-choice items and respond to a questionnaire about the photograph-based multiple-choice items.
  - Statistics from approximately 1500 students per item will be analyzed to determine effectiveness of the photograph-based multiple-choice items.
  - 2 classes of students will be exposed to the 20-Q Model to facilitate the use of photographs as stimulus material. 2 classes will receive regular science instruction without the introduction of the 20-Q Model. Students performance on photograph-based items will be analyzed.
  - 4 students will create concept maps of biological concepts to determine retention of biological concepts.

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*Figure 1. Gowin’s Vee of the Proposed Research Study*
CHAPTER TWO
THEORETICAL FRAMEWORK AND LITERATURE REVIEW

To understand appropriate ways to assess students in the middle grades, the investigator examined three major issues: how students learn science, how photographs are recognized by students, and how photographs are utilized in middle school curriculum (including assessment practices). The ways students learn science were subdivided into several categories: scientific literacy, biological literacy, the constructivist learning theory, human constructivism, tools for constructing knowledge, and alternate conceptions in science. Further research on qualitative, quantitative, and mixed methodology studies in the literature was conducted.

HOW STUDENTS LEARN SCIENCE

Scientific Literacy

In 1989, AAAS set out to define scientific literacy in *Science for All Americans*. The AAAS (1989) defined a scientifically literate person as

one who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes. (p. 4)

In *Benchmarks for Scientific Literacy* (1993), the AAAS outlined three components of the nature of science which foster the development of the scientifically literate person, the scientific worldview, scientific inquiry, and the scientific enterprise. Benchmarks within these three
sections indicate that students should be actively engaged in scientific investigations to facilitate scientific literacy and understand the work of the scientist (AAAS, 1993, 2001).

The National Science Education Standards (NSE S) (NRC, 1996) further define scientific literacy as the ability to ask questions about everyday experiences, to describe or explain natural phenomena, to be able to read, comprehend, and discuss current science literature, and to use evidence to evaluate investigations. Scientific literacy has varying degrees of mastery. As students mature, scientific literacy develops based on interests and experiences of the students; some may be more literate in life science concepts as opposed to physical science concepts.

Scientific literacy is prominently placed as the first standard in the NSES; this section is called Science as Inquiry with instructions for teachers to use these skills and understandings to teach the content strands. Science as inquiry is divided into two categories in which “students should develop [the] abilities necessary to do scientific inquiry [and] understanding about scientific inquiry” (NRC, p. 105).

The NSES (1996) provides several suggestions for changing the emphasis of science instruction: on conceptual understanding rather than recall of facts, on inquiry as the vehicle for teaching conceptual understanding of science content knowledge, and on deeper conceptual understanding of fewer concepts rather than coverage of many science topics. The NSES (1996) also suggests changing the emphasis of science instruction to promote inquiry, as follows: 1) activities should include student investigation and analysis of concepts, not simply verification of previously known knowledge or demonstration lessons; 2) investigations and experiments may take more than one class period to complete and should be encouraged; and 3) the process skills should be used in investigating science concepts and solving problems. Rather than racing through the textbook from cover to cover, students should complete more investigations to
develop “understanding, ability, values of inquiry and knowledge of science content” (NRC, p.113). Students should not simply explore and experiment, but be able to explain science concepts and defend scientific arguments. Finally, the NSES state that inquiry should include student communication of ideas to peers and classmates (NRC).

Scientific inquiry also includes the work of scientists, the study of the natural world and states the explanations about natural phenomena determined by collected data (NRC, 1996). Within science as a field of study, scientists make observations about the world around them, develop hypotheses and predictions about possible outcomes, formulate questions, gather evidence using a variety of methods and techniques (e.g. mathematics, technology), explore and use prior research findings, design investigations, complete research, publish results, consider new evidence as it is revealed, make additional predictions or explanations, and inform the public (NRC, 2000).

Inquiry also refers to the actions of students in the classroom. Students should see themselves as scientists by recognizing science as a process, engaging in activities that reflect the work of a scientist, designing investigations, revising knowledge and understanding how scientists examine and make explanations about natural phenomena (NRC, 1996, 2000). Within science as a discipline, students should use prior knowledge to raise questions about the world around them, predict or formulate hypotheses about explanations and solutions to their questions, design and complete simple investigations, use observations to collect data, develop explanations based on collected data, consider alternative explanations, and communicate findings to other classmates. Students in classrooms should experience science as a process and should be actively engaged in “doing” science (Biological Sciences Curriculum Study [BSCS], 1993; Layman, 1996; NRC, 1996; NRC, 2000). Scientific inquiry not only requires that students be actively
involved in the scientific process, but that students understand that the process of inquiry is the foundation for the scientific knowledge in existence today (NRC, 2000).

Inquiry also refers to the actions of teachers and administrators. Science educators should expose students to the processes of science so they can “do” science – ask questions, formulate hypotheses, and conduct investigations (BSCS, 1993; Laymon, 1996; NRC, 1996; 2000). Teachers must plan activities that engage students, give them permission to inquire, and encourage them to learn how to learn through inquiry (NRC, 2000). Teachers who promote inquiry-based teaching methods must also recognize the integration of science, mathematics, and technology, the various learning styles of students in their classroom, and understand that science teaching and learning is a dynamic enterprise (Laymon, 1996).

Administrators who understand and value inquiry provide leadership to teachers by facilitating and supporting the changes that occur when implementing inquiry-based methods. They encourage teachers to attend professional development meetings, provide instructional materials and equipment which facilitate inquiry-based teaching methods, assist in communicating to parents about the positive changes that occur as a result of participating in inquiry-based methods, support inquiry and problem solving in other areas of the curriculum, and evaluate teachers using methods consistent with inquiry-based methods (NRC, 2000).

Scientific literacy is the method for teaching and learning science content knowledge. Using inquiry-based teaching and learning methods aids students in the conceptual understanding of science concepts. In addition to being scientifically literate, it is critical for students to also be literate in the specific science areas, including biology.
Biological Literacy

In 1993, the BSCS published a book *Developing Biological Literacy*, a guide for the biology curriculum at the secondary and collegiate levels with three components. First, the BSCS (1993) makes three recommendations for biology curriculum: 1) unify the content of biology by the theory of evolution; 2) provide opportunities for students to experience science as a process, a way of knowing; and 3) provide programs and activities that facilitate the development of biological literacy. These three recommendations became the foundation for the BSCS goals for biology education that includes a biology course which concentrates on the unifying principles of biology, presents content within contexts that are meaningful, advocates active learning environments (e.g., discussions, labs, field experiences), and improves the biological literacy of all students (BSCS).

Second, recognizing that biological literacy is more than just fact memorization, the BSCS (1993) identifies four levels of biological literacy. The first level is nominal biological literacy. At this level, although students may know biological terms, they have a very limited understanding of biological concepts – most students enter their high school biology class with this knowledge. The second level is functional biological literacy. At this level, students define terms and describe concepts correctly, but are unable to do anything with that knowledge – most students leave biology class with this knowledge. The third level is structural biological literacy. At this level, students develop a continued interest and commitment to learning biology on a more personal level. The fourth level is multidimensional biological literacy. At this level, students actively search for new knowledge to overcome personal deficiencies and use this knowledge to solve problems.
The BSCS (1993) recommendations, goals, and levels of biological literacy all point to the main purpose of the document—to focus on appropriate methods for students to actively construct their own knowledge. The BSCS supports the move away from strict lecture-based classrooms to inquiry-based classrooms where students are actively constructing their own biological knowledge. But how should the instruction facilitate this knowledge construction?

Finally, the BSCS endorses the 5 E Model of constructivism. The 5 E Model for implementing constructivism consists of five stages that students progress through in the learning cycle: Engage, Explore, Explain, Elaborate, and Evaluate. During the engagement stage, students are engaged in the learning by recognizing past experiences and relating these experiences to new knowledge. During the exploration phase, students are provided common experiences to explore the new knowledge. These experiences serve as the foundation for further concept building and knowledge construction. During the explanation phase, students explain new concepts in their own words using a variety of methods. During the elaboration phase, students apply their new knowledge to a new scenario or solve a problem—they are able to extend their knowledge. During the evaluation phase, students receive feedback, whether formally or informally, on the correctness of their explanations (BSCS, 1993).

Good science instruction is inquiry-based and asks students to observe, describe, investigate, predict, and provide evidence (BSCS, 1993; NRC, 1996). Good science instruction provides opportunities for students to construct their own knowledge (BSCS, 1993; Fensham, Gunstone, & White, 1994).

**The Constructivist Learning Theory**

The constructivist learning theory has its beginnings as far back as Socrates and Plato. Socrates used questioning techniques to help Plato use his own existing knowledge to construct
new knowledge (Hawkins, 1994). Socrates also used questioning skills to help an uneducated slave boy deduce the Pythagorean theorem. In the 1800s, Kant presented an organization of categories—a basic system of questions that inquiry must ask of nature—guides us in an ongoing process of constructing, testing, and reconstructing explanatory hypotheses” (Hawkins, 1994, p.10). Kant viewed all knowledge as a constructive process.

While the works of Socrates and Kant centered on knowledge construction, James and Dewey posit that determining the prior knowledge of a child is crucial for knowledge construction. James believed that the blueprint for effective teaching included four steps: 1) recognize the child’s interest; 2) determine prior knowledge of material to be presented; 3) present material clearly; and 4) connect new knowledge to old knowledge in a logical way (Pajares, 2003). Dewey built upon James’ thinking as he concentrated on the education of the whole child. In Dewey’s (1902) writings, the child is the focal point.

The child is the starting point, the center, and the end. His development, his growth, is the idea. It also furnishes the standards. To the growth of the child all studies are subservient; they are instruments valued as they serve the needs of growth. (p. 187)

To educate the whole child, educators must take the time to identify the needs of the child and provide opportunities for the child to experience learning in the way that he or she learns best (Dewey, 1933; Marlowe & Page, 1988). As the child interacts and manipulates materials or ideas, a discrepant event occurs that encourages the child to question his or her thinking; when resolution of the discrepant event occurs, the child can assimilate new knowledge. “Statements are made, inquiries arise, topics are discussed, and the child continually learns. He states his experiences; his misconceptions are corrected” (Dewey, 1900, p. 35). Dewey and James’ thinking was the foundation for a critical component of the constructivist learning theory which
includes assessing the student’s prior knowledge, experiencing an event, and assimilating new knowledge.

Piaget’s tenets also support the constructivist learning theory and the tenets of James and Dewey. In the theory of constructivism, Piaget felt that students “literally create their knowledge as their biological dispositions interact with their experiences” (Brainerd, 2003). Piaget explained his theory of constructivism by referencing a story told to him by a mathematician, who as a young child

believed that number was influenced by spatial arrangement. That is, he thought that the number of elements in a set of objects would be greater if they were spread out than if they were compressed. One day the mathematician was playing with a pile of pebbles, and he chanced to count them. He spread them out, expecting the number to increase, but when he counted them, the number had not changed. He clumped them together, and the number was still the same. (Brainerd, p. 271)

This anecdote exemplifies Piaget’s constructivist theory perfectly. The young child had a misconception, recognized that his initial thoughts were different, tried several times to disprove the new learning, and finally accepted a new concept. Piaget felt that for students to develop cognitively, they must experience a discrepancy and come to grips with current knowledge, wrestle with the knowledge, and ultimately assimilate new knowledge to their own understanding (Brainerd, 2003; Gruber et al, 1977; Marlowe & Page, 1988).

Piaget’s work influenced the work of Jerome Bruner, who in his early years presented Piaget to American educators (Mintzes & Wandersee, 1998). Bruner’s (1960) philosophy centered around structure and cognition.
At each stage of development the child has a characteristic way of viewing the world and explaining it to himself. The task of teaching a subject to a child at any particular age is one of representing the structure of that subject in terms of the child’s way of viewing things. (p.33)

To Bruner, Piaget’s levels of cognitive development were an internal structure; Bruner’s philosophy focused on the external structures of knowledge (Lutekehaus & Greenfield, 2003). Bruner (1960) identified three stages of cognitive learning – enactive, iconic, and symbolic. The three stages depended upon one another but were not developmental stages (Lutekehaus & Greenfield). Young children need to manipulate concrete objects and proceed to representing those concrete objects with abstract symbols (Mintzes & Wandersee; Lutekehaus & Greenfield). Bruner’s work supported the constructivist learning theory in several ways: that “discovery learning using concrete objects” (Mintzes & Wandersee; Marlowe & Page, 1988), that recognizing the structure of content knowledge allows students a scaffold to construct their own knowledge (Bruner; Mintzes & Wandersee; Lutekehaus & Greenfield), that young children can learn more advanced concepts when presented developmentally appropriately (Lutekehaus & Greenfield), and that students should be allowed to emulate the work of scientists by actively inquiring during science class (Bruner; Mintzes & Wandersee; Lutekehaus & Greenfield).

Piaget’s and Bruner’s theories of knowledge construction focused on stages of learning and knowledge construction. Vygotsky’s theory of constructivism focused on the action of the student. “Passivity of the student is the greatest sin from a scientific point of view, since it relies on the false principle that the teacher is everything and the pupil nothing (as quoted in Bozhovich and Slavin 1972, 165)” (Dixon-Krauss, 1996, p. 18). Vygosky’s emphasis is on the student as an
active participant in the learning. Vygotsky stressed the zone of proximal development as encompassing

the gap between the child’s level of actual development determined by independent problem solving and his or her level of potential development determined by problem solving supported by an adult or through collaboration with more capable peers which is the comparison of the level of problem solving that a child has between working individually or working with more capable peers. (Dixon-Krauss, 1996, p.196)

From Vygotsky’s perspective, the most important role component of constructivist teaching and learning is that the student is actively involved in constructing knowledge while the teacher is the facilitator and mediator (1996).

The work of all of these men —Socrates, Plato, James, Dewey, Piaget, Bruner, and Vygotsky —is the scaffold that the constructivist learning theory is built upon. Central to this theory is the child: identifying the prior knowledge of the child, providing opportunities for the child to discover; presenting a discrepant event so that the child can wrestle with constructing his or her own knowledge, and allowing the time to do so are all critical components of the constructivist learning theory.

The constructivist learning theory has informed teachers about how students learn and impacted how science is taught. “A constructivist framework challenges teachers to create environments in which they and their students are encouraged to think and explore. This is a formidable challenge. But to do otherwise is to perpetuate the ever-present behavioral approach to teaching and learning” (Brooks & Brooks, 1999, p. 30). According to Appleton (1997)

The main tenet of constructivist learning theories is that existing ideas which learners may hold are used to make sense of new experiences and new information. Learning
therefore occurs when there is a change in the learner’s existing ideas, either by adding some new information or by reorganizing what is already known. (p. 303)

There are many different components of the constructivist learning theory; human constructivism takes these components and builds upon them.

**Human Constructivism**

According to Mintzes, Wandersee, and Novak “knowledge is a human construction that is a natural outgrowth of the capacity of human beings for high level of meaningful learning” (2000, p. 8). Information is not necessarily knowledge; knowledge is constructed using an organizational method with varying level of concepts and can be applied to new situations. “The single most important factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly” (Ausubel & Hanesian, 1968, epigraph).

The primary tenet of human constructivism is how humans make meaning. “Meaning making is the fundamental adaptation of the human species and the driving force underlying all form of conceptual change, whether that change occurs in the mind of the experienced professional scientist or a young child confronting wonders of nature for the first time” (Mintzes, Wandersee, & Novak, 2000, p. xix). Human constructivism builds its principles upon the constructivist learning theory (Mintzes et. al., 1998, 2000). Knowledge cannot be imparted to students; students must be allowed to actively construct knowledge and subsume it into their existing cognitive structure (Mintzes et al., 1998). “The building of a unique conceptual framework is an active process that requires consciously connecting new knowledge to existing knowledge and testing it against one’s perception of real world objects and events and the knowledge constructed by others” (1998, p.52).
While there are “many faces of constructivism” (Good, Wandersee, & St. Julien, 1993), Novak proposes a more comprehensive constructivism which includes current knowledge about cognitive structure and endorses tools for teachers and students to use to structure knowledge (Mintzes et al., 1998). Within human constructivism, the learner, the teacher, the knowledge base, and society are four crucial components of education (Schwab, 1977). Novak, Mintzes, and Wandersee (2000) add a fifth component: assessment. These assessment practices include tools for measuring and assessing student cognition.

**Tools for Constructing Knowledge**

Ausubel (1965) focused most of his research on how students make meaning—how students learn new knowledge. Learning is not simply conditioned or stimulus-response. For example, learning language, words and word meanings represents how students have identified a word and connected that word with concrete images in their cognitive structure. Ausubel (1963) investigated how external organizational tools could be used to identify cognitive structure and facilitate meaningful learning and retention. He surmised that if a student’s cognitive structure is organized, new learning can be integrated meaningfully. According to Ausubel (1965), students make new meaning by integrating concepts, symbols, and propositions into their existing cognitive structures. A connection must be made between prior knowledge and new knowledge for “meaningful learning” to occur.

Ausubel (1963) explains that using advance organizers with students prior to the introduction of new material helps students organize their cognitive structures in preparation for new concepts. In one study involving undergraduate students, hierarchical organizers were presented to students prior to learning the content. As a result, the students were able to retain the new knowledge about the concept of metallurgy of carbon steel. In another study, Ausubel and
Fitzgerald (1962) researched how advance organizers facilitated the learning in undergraduate pre-service teachers. Within this study, the participants were assessed on their prior knowledge of the endocrinology of pubescence. Ausubel and Fitzgerald (1962) were testing the use of advance organizers in facilitating the learning of two sequential passages. The results indicated that participants with lower verbal ability were able to retain the new knowledge with the use of an advance organizer.

Building upon the ideas of Piaget, and primarily Ausubel, Novak (1998) began a 12-year longitudinal study on student learning of science concepts and how their conceptual understanding changes from grade 1 to grade 12. In school year 1971-72, 191 students were given science instruction every 2 weeks with audiotutorial lessons and interviewed by researchers every 4 to 6 weeks. The lessons provided students with a logical sequence of instruction. In school year 1972-73, an additional 48 students were added. These students did not receive the audiotutorial lessons. The magnitude of interview transcriptions became such a problem that Novak created the concept map to represent the ideas and thoughts of the student participants. The evidence from the concept map comparisons indicates that the students acquired new concepts and greater understanding during the 12-year period. The results of the study show that the “instructed” students demonstrated continuous improvement in science while the “uninstructed” students did not fare as well (Novak, 1998; Novak & Musunda, 1991).

The findings generated by Novak (1998) also support those of Ausubel. In Ithaca, New York, formal science instruction was not mandated until after the 2nd grade. The “instructed” students were able to construct a cognitive structure of basic science concepts to utilize when integrating new knowledge. The “uninstructed” students did not have this experience with the audiotutorial lessons or science instruction during the first grade year; the ‘uninstructed’ students
were unable to lay down a knowledge base or cognitive structure to connect new knowledge to
during subsequent years (Mintzes et al., 1998).

A critical component of the Novak (1998) study was the creation of the concept map as a
map of cognition. Concept maps continue to impact research on cognitive maps and can be used
effectively as learning and assessment tools in a variety of ways. Concept maps provide a
medium for a) organizing subject matter to facilitate meaningful learning and knowledge recall
(Novak & Gowin, 1984; Novak & Wandersee, 1990); b) assisting in curriculum development
(Starr & Krajcik, 1990; Symington & Novak, 1982); c) assessing and identifying student
conceptions and misconceptions, which is formative assessment (Wandersee, Mintzes, and
Novak, 1998); and d) summative assessment of conceptual understanding (Edmondston, 2000;
Trowbridge & Wandersee, 1996).

Another cognitive mapping tool on how humans structure and create knowledge was
developed and researched by Gowin. Gowin (1970, 1981) identified five major questions that
should be asked when trying to understand conceptual knowledge: “1) What is the telling
question of the work? 2) What are the key concepts? 3) What methods were used to answer the
telling question? 4) What are the major claims in the work? 5) What value claims are made in the
work?” (1981, p. 81). Gowin’s research supports the use of these questions when preparing for
new research or for evaluating previously conducted research (Novak, 1998).

Gowin (1977) utilized these five essential questions when creating a new cognitive map,
the Vee heuristic. *The American Heritage Dictionary of the English Language* defines a
heuristic as “helping to discover or to learn; guiding or furthering investigation; designating the
educational method in which the student is allowed or encouraged to learn independently
through his own investigation” (Morris, 1982, p. 620). This definition exemplifies how Gowin’s
Vee is used for research. Novak, Gowin, and Johanson (1983) used the Vee diagram with secondary and university students to understand the complicated Earth science concept of seasons. Novak and Iuli (1993) completed additional work with a research group at Cornell University that studies root and root functions. Gowin’s Vee diagrams and concept maps helped this research group identify epistemological issues and recognize how individual research aided the research of the whole group (Novak, 1998). The Vee diagram continues to be used in research studies to help students focus their question for study.

THEORIES OF VISUAL COGNITION

Paivio’s Dual Coding Theory

Another theory that has impacted educators’ understanding of how students learn, especially in respect to learning using photographs, is the Dual Coding Theory developed by Paivio (1991). Wandersee (2000) states that

this theory proposes that people can encode information as language-like propositions or picture-like mental representations. His research has shown that pictures contain information that is not contained in text, that information shown in pictures is easier to recall because it is encoded in both memory systems, not just text, and that verbal concepts are, so to speak, “hung on visual pegs,” providing a visual-verbal linkage that facilitates recall. (p. 133)

Simply stated, pictures and text are coded differently in the human brain. Concepts are reinforced when photographs/images support the written text. Appropriate use of photographs can impact student learning.
Solso’s INFOPRO Model of Visual Processing

Solso’s (1997, 2003) information processing model (INFOPRO) maintains that the brain processes information through stage-like process similar to a “conveyor belt.” When processing visual information, such as a photograph, reflected light energy enters the pupil in the eye and falls on the retina, permeated with photosensitive neurons that line the interior of the eyeball; here, initial optical processing occurs. These retinal receptors work with other neurons—some processes are activated and others inhibited; lines, edges, contours, contrasts, and colors are initially processed, and so on—in an intriguing amalgamation of neurochemical actions. These initial processes operate automatically, without conscious control, and are generally the same for all members of any given species. (2003, p. 88)

Solso (2003) posits that the brain processes are even more complex than the optical processes. The brain then takes the image and begins to process it into its own cognitive structure. The brain recognizes the images and then determines where to store the information and how to use the information.

Tufte’s Theory of Visual Information Design

Within Tufte’s (1990, 1997, 2001, 2006) theory of visual information design, several points are critical to the effective use of graphics. Regarding the principles of graphical excellence, graphics must be designed with clarity including substantive data with a well thought out design. The graphic itself must be clear to the reader and provide the information efficiently.

When selecting and creating graphics to show information, Tufte (2001) developed five principles to follow: clearly represent the data, maximize the most information possibly in the smallest amount of space possible, remove extraneous information; remove extraneous
decoration, and finally revise and edit the graphic until the “greatest number of ideas in the shortest time with the least ink in the smallest space” (Tufte, 2001, p.51) is present in the graphic.

Within Tufte’s four volumes, he provides many examples of graphics that do not work. In many cases the graphics include too much information or “chartjunk;” designers feel the need to fill every space instead of maximizing the empty space (Tufte, 1990); the graphics are cluttered which can mispresent and mask the data (Tufte, 1997); the misuse of color for decoration can affect the representation of the data shown (Tufte, 1997); and the placement of the data within the design of the graphic and the size of the visual representation can misrepresent the data (Tufte, 1997, 2001). Tufte (2001) maintains that graphical integrity is critical when presenting information in a graphic that does not misrepresent the data. Several principles of graphic integrity are 1) the numerical data on the graphic should match proportional to the visual representation of numerical data; 2) the graphic should have clear and correct labeling; 3) the graphic design should emphasize showing a correct representation of the data, not focusing on design elements; 4) The design should maintain the same number of variables in design as the same number of variables in the data; 5) the graphic representation of the data cannot utilize pieces of the data out of the context on the data set (2001).

Tufte (2001) maintains that advances in technology have increased the visual representation of scientific knowledge, and the density of that knowledge. Satellite photography has changed the way celestial bodies are studied (Tufte, 1990). The medical field has used photographs (x-rays, MRI, CT scans, PET scans) to represent organisms. The small multiple design display has changed how organisms are viewed over a period of time or how organisms are compared to one another (Tufte, 1990); in medicine, the small multiple display can show
changes in brain functions during a PET scan; or changes in a specific spot in nature to show the 
seasons (Tufte, 1990). By displaying several pictures of the same organism or place over a 
period of time, the viewer can see subtle changes that take place (1990).

When selecting photographs to be used in graphical design, Tufte’s principles (1990, 
1997, 2001, 2006) should be implemented. The focal point of the picture should be the object 
discussed in the text, so that the picture matches the text. When selecting a photograph, 
extraneous information in the photograph which can clutter should be removed. Color can be 
used as long as it does not take away from the focus of the picture. The placement of the object 
within the photograph (to the left or the right) can impact perception of the object. The use of a 
scale can aid the viewer in understanding the size of the object in the photograph, for example, 
placing a small object in a human hand.

The perspective of the photographer can also change how the photo is perceived. If the 
photograph is taken from the ground up, the object of the photo will appear much larger. Size 
can distort the graphic and change the perception of the viewer (2001). Also correct labeling of 
photographic elements or captions is critical to the overall design and integrity of the graphic 
(1997). Tufte’s principles must be considered when utilizing photographs in curriculum and 
assessment materials.

PHOTOGRAPHS IN THE LEARNING PROCESS

Textbooks are the most common tool used for teaching science content in the high school 
biology and middle school life science programs. The textbooks themselves cover a broad range 
of topics rather than focusing on fewer topics well (AAAS, 1989, 1999, 2000). Within these 
texts, photographs fill almost every page (Pozzer & Roth, 2003; Pozzer-Ardenghi & Roth, 2004; 
high school biology books and found an average of 0.79 photographs per page. Pozzer & Roth (2003) evaluated four Brazilian biology textbooks and found 0.55 photographs per page. Nixon (2001) evaluated one high school biology textbook on the Louisiana state adopted list and found that 0.72 of the textbook contained one or two photographs per page.

Many say that a picture is worth a thousand words. Mayer and Gallini (1990) say that a picture is worth 10,000 words when the photograph along with the text is understood by the students. Pozzer and Roth (2003) liken a picture to a word taken out of context: a picture is only as good as its caption or connecting text. The adjoining label can help students pinpoint information in the photographs that in turn will facilitate more understanding of the text. While evaluating four Brazilian texts, Pozzer and Roth (2003) identified four categories of photographs: decorative, illustrative, explanatory, and complementary. Decorative photographs did not have adjoining texts and were used usually at the beginning of a chapter. Illustrative photographs had a label naming what was in the photograph; this photo is used strictly to provide a visual image of information presented in the main text. Explanatory photographs are photographs with accompanying text that not only identifies what is in the picture but also provides additional information used to explain the photograph. Complementary photographs are photographs with captions that provide new information that is not listed in the main text. All four types of photographs were included in each textbook and classified by Pozzer and Roth (2003).

Photographs are used for a variety of purposes in textbooks as well as other sources. Wandersee (2000) adds that not only are science textbooks filled with photographs, but science as a discipline utilizes images to explain further text in journal articles as well. In many cases, the life sciences use photographs for several purposes.
Life science photographs can: (a) serve as a “shared workspace” for thinking about biological question and issues, (b) provide external memory storage that maintains an accurate view of objects or event, and stores more information than human memory alone can store, (c) capture (freeze in time) the spatial arrangement of object or events of interest, (d) provide the imagery necessary to anchor relevant concepts, principles and theory in long-term memory, (e) serve as a primary, complementary, or redundant communication channel for biological learning. (p. 132)

Photographs make up a large part of biological curriculum resources and provide an opportunity for students to enrich and enhance their understanding of biological concepts. In addition, photographs can be used to assess student understanding of life science concepts (Nixon, 2001; Wandersee, 2000).

Additional research in which photographs have been self generated by students and used to assess conceptual understanding has been conducted. Nixon (2001) found that photographs could be used to probe students’ conceptual understanding of science concepts—the more students engaged with the photographs, the better they became at communicating their understanding of scientific concepts and ideas. Their discussions about photographs with the students enabled Nixon to identify misconceptions. The students used digital cameras to self generate photographs and then utilized the 20-Question Model (Wandersee, 2000) to discuss and write about the photographs. In Shultz’s (2007) study, middle school students’ self generated still photographs and time-lapse photographs of the growth of amaryllis bulbs and the dissection of daylilies to determine conceptual understanding of plant structures and functions. Group discussion allowed students to express their understanding of plant growth.
MIDDLE SCHOOL SCIENCE CURRICULUM AND ASSESSMENT PRACTICES

Current Curriculum Practices

According to the NRC (1996),

the goals for school science that underlie the National Science Education Standards are to educate students who are able to: experience the richness and excitement of knowing about and understanding the natural world; use appropriate scientific processes and principles in making personal decisions; engage intelligently in public discourse and debate about matters of scientific and technological concern; and increase their economic productivity through the use of the knowledge and skills of the scientifically literate person in their careers. (p. 13)

In 1996, the NRC outlined what students were expected to know and be able to do in science in American schools. The standards identified were content standards, teaching standards, professional development standards, and assessment standards (NRC). In the middle school life sciences students “should develop understanding of structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems; and diversity and adaptation of organisms” (NRC, 1996, p. 155).

Much of the middle school curriculum relies on the use of textbooks in the classroom. Kesidou and Roseman (2002) evaluated nine middle school science programs to determine how well they met the national standards and to determine their strengths and weaknesses. To assess the coverage of life science concepts, Kesidou and Roseman (2002) used “the flow of matter and energy in ecosystems” (p. 525). The findings indicate that none of the programs examined met the identified criteria. The findings indicated three major problems with these nine programs:  1) “the programs’ content does not focus on the key ideas…details irrelevant to learning key
science ideas are interspersed with details distracting from key ideas;” 2) “the programs’ instructional design does not support the attainment of the key idea. Programs are particularly deficient in providing coherent explanations of real-world phenomena using key science ideas, and building on students’ existing ideas or helping them overcome their misconceptions or missing prerequisite knowledge; 3) “the programs’ support to teachers in helping students attain the key idea is minimal” (Kesidou and Roseman, 2003, p. 538).

In another evaluation of middle school textbooks, Roseman, Kesidou, Stern, and Caldwell (1999) evaluated all middle school science textbooks at that time and found the books to be large, filled with facts, but “light on learning” (p. 6). Since textbooks are often used as the primary curriculum, research needs to examine on how to select better the information and photographs in the text to facilitate conceptual understanding of science concepts.

The primary middle school curriculum for many districts focuses on the use of textbooks. These textbooks are filled with much information. How is this information assessed? A discussion on current assessment practices follows.

Current Assessment Practices

In Louisiana, the LEAP science test has been administered to eighth-grade students since March 2000. According to the LEAP Assessment Guide – Grade 8, there are eight life science multiple-choice items on every administered form (LDE, 2006f). Appropriate assessment practices for assessing life science understanding in the classroom and on standardized tests needs to be addressed.

Assessment research has focused on the efficacy of test items in measuring organized knowledge, while other research has focused on the cost effectiveness of item construction and
test administration. Stern and Ahlgren (2002) analyzed the assessment materials found in middle school curriculum materials and found them to be poor. According to Stern and Ahlgren (2002), assessment influences every level of the education system and is one of the most crucial catalysts for reform in science curriculum and instruction. Teachers, administrators, and others who choose, assemble, or develop assessments face the difficulty of judging whether tasks are truly aligned with national or state standards and whether they are effective in revealing what students actually know…If used properly, good assessment can be a powerful catalyst for improving both curriculum and instruction. (p. 889)

The findings indicate that assessment materials in the middle school life science area are poor. Stern and Ahlgren caution that high students’ scores may mislead teachers because test items do not measure for understanding (2002).

Additional research looks at the cost analysis of multiple-choice items versus constructed response items. Lawrenz, Huffman, and Welch (2000), compared the cost analysis of “four types of assessment formats: multiple-choice, open ended, laboratory station, and full investigation” (Lawrenz, Huffman, & Welch, 2000, p. 615), compared the time to develop items, the time to develop scoring rubrics for items, and the time to score items. These four types of tests were administered to ninth-grade students (n = 3,550) who were from culturally diverse background and from urban, suburban, and rural areas in California, Iowa, Montana, New York, North Carolina, Texas, and the District of Columbia. They found that multiple-choice items take the least amount of time to administer, to create the test form, to develop reliability in scoring, to score each item individually, and to take the test as a whole (Lawrenz et al.). With increased state-mandated standards-based science testing and limited funding to administer these tests, new and more appropriate ways are needed to measure student understanding using multiple-choice
items. After researching the current middle school curriculum practices and the types of assessments utilized, the investigator must take a closer look at how photographs are used in curriculum and assessment practices.

The Use of Photographs in Curriculum and Assessments

“Photographs and other graphics found in biology textbooks are a vastly underused learning resource. Teachers expect to see them there but devote little class or homework time to extracting meaning from them” (Wandersee, 2000, p. 131). This is a mistake, because “students who actively transform and practice applying their knowledge from biology text to biology graphics (and, conversely, from graphics to text) attain greater understanding” (Wandersee, 1988, 1990, 2000). Several research studies support the use of photographs in curriculum and assessment practices in the life sciences.

Deschri, Jones, and Heikkinen (1997) found that pictures and diagrams in chemistry laboratory manuals aided students in processing difficult chemistry concepts. In chemistry classes (n=83) at the University of North Colorado, two experimental groups used a laboratory manual that integrated the text with pictures and diagrams; the two control groups used a laboratory manual in which all pictures and diagrams had been replaced with text. After six weeks the students were tested on content knowledge (achievement), attitudes towards this chemistry course, and observed manipulative skills including methodical working, experimental technique, manual dexterity, and orderliness (p. 897). The researchers concluded that “visual information aids consisting of pictures and diagrams integrated with text in the design of chemistry laboratory manuals can help students perform better in the cognitive, affective, and psychomotor domains” (p. 901).
Noh and Scharmann (1997) found a positive influence on chemistry instruction for students who were presented pictures at the molecular level. In two academic classrooms in Korean high schools, male students who had declared a science major were administered the Group Assessment of Logical Thinking (GALT). The treatment group students were exposed to 31 pictorial materials while the control group received traditional instructional materials, during 21 hours of instruction per group. The students were administered the Chemistry Concepts Tests and the Chemistry Problem-Solving Test, with results indicating that “instruction with pictorial materials at the molecular level helped students construct more scientifically correct conceptions than traditional instruction” (p. 199). The students’ conceptions and problem-solving ability thus were enhanced when pictures were used in introducing concepts and solving problems in chemistry.

Glenberg and Langston (1992) reported research demonstrating the use of pictures for students in building better mental models. In experiments with two groups of students (n=48) in an Introductory Psychology course at the University of Wisconsin—Madison, the use of sequentially ordered text (only) was compared with use of pictures of the steps that correlated to the text. Thirty-two pieces of text were constructed, each with a corresponding pair of pictures. The control group read the text-only materials, while the experimental group viewed the pictures with shortened text. The study results were that the pictures “add no new information to that which is explicitly stated in the text, and yet the pictures demonstrably improve retention” (p. 130). This occurs because pictures also reinforce the text: information is processed twice and comprehension is facilitated (Glenberg and Langston). The research concluded that “subjects in the with-pictures condition responded more accurately [to post-tests] than did the subjects in the not-pictures condition” (p. 136).
Mayer and Gallini (1990) predicted that the use of pictures would better explain the complicated physics concepts of a braking system. College students (n=96) were equally assigned to four treatment groups varying on text taken from the 1997 *World Book Encyclopedia*. Group one received a booklet with no illustrations; group two received a booklet that illustrated major parts within a braking system; group three received a booklet that showed the major actions of the parts within a braking system; and group four received a booklet that showed the parts and the actions within a braking system. When administered a post-test, low-prior knowledge students improved in performance on recall and problem solving when using text with increasing explanatory illustrations (p.720).

Mayer and Sims (1994) found that using pictures with text on the human respiratory system improved performance of students with varying levels of ability. A like number of high-ability and low-ability college students (n=97) were assigned to each of three treatment groups for instruction. The concurrent group used pictures and text simultaneously; the successive group read text and then saw pictures; and the control group used text only (p. 397). The findings of the study were that “inexperienced students were better able to transfer what they had learned about a scientific system when visual and verbal explanations were presented concurrently than when visual and verbal explanations were separated” (p. 399).

Nixon (2003) predicted that students’ biological understanding would improve with use of photographic images in biology textbooks and the 20-Question Model of Image-based Biology Test-Item Design (20-Question Model) (Wandersee 1988, 1990, 2000). A 10th grade biology teacher and students (n=36) were interviewed to examine the “cognitive benefits and costs of incorporating biology-textbook and student-generated photographic images into the learning and assessment processes” (p vii). An analysis of the students’ textbook revealed that
24% of its content was devoted to photographs and diagrams, which contributed significantly to textbook cost. The study showed that “the teacher and students paid little attention to photographic images other than [as] aesthetic elements for creating biological ambiance, wasting valuable opportunities for learning” (p. vii), and wasting resources. These findings indicated, moreover, that application of the 20-Question Model to photographs in biology textbooks is useful to identify misconceptions, to assess a variety of learning styles, and to assess biological concepts effectively (p.viii).

Nixon (2003) spent 5 weeks working with a class of tenth-grade biology students and their teacher. Nixon’s research produced several major findings that can be applied to further research. First, the biology textbook used in this classroom was filled with photographic images that were untapped as a teacher resource; the teacher concentrated on the text but failed to see the photographic images as a tool to probe student understanding of difficult concepts. Second, the students were unfamiliar with how to use the photographic images in their textbook to enrich their conceptual understanding; once taught how to use the 20-Question Model in conjunction with classroom activities, the students’ retention of biology concepts was enhanced and retained. Third, the classroom instructional practices focused on traditional teaching methods focusing on rote memorization of facts without utilizing teaching practices for meaningful learning — knowledge constructed by the students. Nixon used the 20-Question Model as a tool to facilitate the students’ construction of their own knowledge. The students used the questioning techniques from the 20-Question Model to gain a better understanding of photographic images in the textbook, as well as photographic images taken by themselves with digital cameras. Fourth, these activities not only impacted classroom discussion but also impacted classroom assessment practices; the students were given the opportunity to write about the photographs. As a by-
product of this study, the students writing improved. The students were asked more meaningful questions and were able to respond in a more meaningful way.

While the results of this study focused on one classroom of students, the study has implications for further research. The 20-Question Model, when used as a tool for formative classroom assessment, can foster retention of science concepts. The 20-Question Model can also be used to write assessment items directly related to the content within a photographic image. Because the biological sciences are so visual, this model can facilitate question writing focused on conceptual understanding rather than rote memorization (Nixon, 2003; Wandersee, 2000).

Additional studies have analyzed middle school curriculum and assessment practices to identify needs and have found them to be lacking in terms of the expectations of science education reform. Curriculum in the life sciences is weak, with most of the instruction focused on a large amount of content knowledge overloaded with detail (Kesidou and Roseman, 2002). Middle school science assessments are poor because they assess factual knowledge without assessing student understanding of life science concepts (Stern and Ahlgren, 2002). There is a clear need for further research on appropriate ways to teach and assess life science concepts.

These research examples indicate that analytical use of photographs can facilitate more lasting learning in the life sciences. The use of photographs can influence student understanding of difficult life and environmental science concepts (Wandersee, 1988, 1990, 2000). Other research in the physical sciences as well as life sciences has also indicated that the use of images supporting text material can impact student understanding positively. Considering the impact of science reform efforts and the new federal legislation No Child Left Behind, educators need better and more appropriate ways of teaching and assessing life science concepts.
Case Study Research

Qualitative research is a method of inquiry that utilizes a specific tradition to explore an individual, a culture-sharing group, or a case (Creswell, 1998). According to Creswell, “good” qualitative research includes several components employing one or more of the five traditions. The researcher is the instrument of data collection and employs rigorous and multiple data collection methods such as interviews, observations, and documentation. To determine the meaning making of the participant, the researcher analyzes words and pictures. The researcher tells the story of the participants from his or her own perspective and the written report is persuasive (Creswell, 1998; Denzin and Lincoln, 1994).

Yin (2003) describes a case study as a research strategy to be used to “contribute to our knowledge of individual, group, organizational, social, political, and related phenomena” (Yin, 2003, p. 1). A case study is the study of a bounded system (Creswell, 1998). The researcher must identify a program or event that warrants further investigation. The case can be a single-site or multi-site case. There are three types of case studies: intrinsic case study, the study of a single case (Creswell, 1998); instrumental case study, the study of an issue (Stake, 1995), or collective case study, the study of the multiple cases (Stake, 1995). Case studies can be used for three reasons: exploratory, descriptive, or explanatory (Yin, 2003). Data collection techniques include interviews, direct observations, participant observations, documents, archival records, and audiovisual records (Creswell, 1998; Yin, 2003). According to Yin (2003), the researcher must use three sources of evidence: multiple sources, a database and investigator report, and the “chain of evidence” (p. 105). The researcher completes a content analysis of all these data to determine themes and extract a holistic picture of the case. As these data are analyzed, the
picture of the case emerges. The researcher must then describe the case in such a way that the reader understands the case (Creswell 1998; Yin, 2003).

Case study uses direct and participant observations, interviews, archival records, documents, and audiovisual records. Case study analyzes the text from interviews, observations, archival documents or records, or from audiovisual records of the case. In addition, case study research includes four types of triangulation during the data analysis phase: triangulation between data sources, triangulation between investigators, triangulation of various perspectives on the same data set, and triangulation of methods (Yin, 2003). Investigators may use any or all of these types when analyzing data to describe a holistic picture of the case, which includes a written description of the case (Creswell, 1998).

The challenges to case study research include the time to collect extensive amount of data, the ability to describe the case so the reader can understand the importance of the case, and the ability of the researcher to insert his or her own voice into the description of the case (Creswell, 1998).

In many disciplines case study research is paired with quantitative data and can be used to support and further define quantitative studies. These studies fall under the category of mixed methodology.

Mixed Methodology

Tashakkori and Teddlie (1998) described the major differences between the positivist (quantitative) and the constructivist (qualitative) paradigms and ultimately concluded that a mixed model approach is statistically sound. Within a mixed method approach, qualitative and quantitative methods are combined to support a strong research design (Brewer and Hunter, 1979). Quantitative and qualitative methods can be combined in three ways: equivalent status,
dominant-less dominant and multi-stage mixed. Creswell (1995) supports a 2-stage design to mixed methods in which a study may originally be quantitative in nature, yet need further exploration so a qualitative piece is added to support the quantitative data.

A further way for quantitative and qualitative methods to be mixed is to use a mixed model approval. A mixed model approach utilized both methodologies at each stage of research design: research questions, data collections, data analysis, and report writing (Tashakkori and Teddlie, 1998). There are three types of mixed model approaches: confirmatory, exploratory, and complete mixed model. For purposes of this study, the investigator will focus on an exploratory mixed model design.

Within an exploratory mixed model design, the research identifies a topic that needs further study and uses qualitative and quantitative methods to describe the topic. Tashakkori and Teddlie (1998) discuss a study completed by Tashakkori and Taylor (1997) in which they examined teacher characteristics within a reconstructed school district. Without stating an a priori hypothesis, the researchers developed a survey instrument to be administered to all teachers within this district. The survey instrument consisted of closed and open-ended questions (responses). The data analysis included statistical analysis of the closed-ended question responses and content analysis of the open-ended responses. Four categories of teachers within the district were identified and a written description of the general characteristics of each type of teacher was written. The researcher explored types of teachers, yet used both methodologies to create a stronger research design (Tashakkori and Teddlie, 1998).

The pragmatists say that a research design is stronger when the appropriate methodologies are used to answer the research question (Tashakkori and Teddlie, 1998). Brewer and Hunt (1989) insist that a research design is stronger when both methodologies are utilized.
Creswell (1998) outlines the five traditions of qualitative inquiry and Tashakkori and Teddlie (1998) provide evidence to support the mixing of qualitative and quantitative methods.

**SUMMARY**

As the NCLB federal act mandates science testing three times from Grades 3–12 and monies to develop sound assessments is spread across four content areas, more research needs to be conducted on how to write items that measure students’ conceptual understanding rather than rote memorization of facts. Because the biological sciences are so visual, assessing students using visual stimulus can provide a connection that is missing between teaching and assessment practices. Nixon’s (2001) work utilizing photographs in biology textbooks coupled with the 20-Question Model (Wandersee, 2000) to probe students’ conceptual understanding of life science concepts was utilized to guide the study of assessment items with the photographs as stimulus.

Currently, the literature base is sparse concerning the use of photographs as stimulus materials on multiple-choice test items, particularly on state-mandated tests. By using an exploratory mixed model approach, this study intends to contribute to the extant literature by focusing on student performance on photograph-based life and environmental science multiple-choice items on the grade 8 LEAP science assessment.
CHAPTER THREE
METHODS AND MATERIALS

Increased science testing at all grades from grades 3 through 11 is mandated by the No Child Left Behind federal act, and funding is spread very thinly across four subject areas. The LEAP, GEE, and iLEAP testing programs assess five strands of science: Science as Inquiry, Physical Science, Life Science, Earth and Space Science, and Science and the Environment. For purposes of this study, a focus on life science was maintained. For LEAP and GEE, life science concepts continue to be assessed at grades 4, 8 and 11. Prior to 2006, students at grades 3, 5, 6, and 7 were assessed with a norm-referenced test— the Iowa Test of Basic Skills. In the spring of 2006, based on the mandate of NCLB, students at these grades were administered newly developed criterion-referenced tests using assessments that were shorter than LEAP and solely multiple-choice. For the iLEAP testing program, life science concepts are taught and assessed at grades 3, 5, and 7. For the LEAP testing program, life science concepts continue to be assessed at grades 4, 8 and 11.

This study was proposed to explore additional effective ways to measure student understanding of life science concepts. Research was conducted to determine efficient ways to assess science concepts.

PILOT STUDY

The study’s purpose was to determine whether the use of photograph-based multiple choice items was a feasible alternative to text-based items. A pilot study was implemented in the spring of 2004 using 10 multiple-choice items on a grade 8 LEAP field test form. Of these items, eight items were photograph-based and two of the eight items were matched with a text-only version of the item. These eight photograph-based multiple-choice items were included on Field
Test Forms 3 and 4 and administered in April 2004. This procedure was facilitated because of the investigator’s professional responsibilities, including school visitation for observation of field testing of items and interviewing students about the items. The investigator subsequently interviewed three students about the photograph-based items. The three students had been selected by the school test coordinator as those who would be able and willing to discuss the items and as those who covered a range of ability levels. Two girls and one boy were selected, all of whom were African American. The investigator used an interview protocol (Appendix B). For each test item, the students were asked the same four questions: A) Which answer did you select as the correct answer?, B) Did you use the picture to help you answer the question? If yes, which part of the photograph did you use?, C) Could you have answered this question without a picture?, and D) Show the student the color version of the photograph. Would seeing the picture in color help you answer the question? If so, how? In all cases, the students explained that they used the photographs to help them answer all questions except one.

In addition, the investigator presented the students with a color version of the photograph. When asked if a color photograph would facilitate answering the question, all three students indicated that since the black and white photographs were clear, the color would not help.

To analyze the item-specific data statistics, the investigator compared the item difficulty (proportion of students who answered the item correctly) and point biserials (Pearson product-moment correlation) for each of the 10 items. Table 1 includes the statistics for each item.

For all items except the pitcher plant item, the item difficulty is high, meaning that more than 50% of the students taking the item answered the item correctly. The acceptable item difficulty range for use on LEAP, iLEAP or LAA-2 is .20 to .90. On all items except the pitcher plant item the point biserial was high. Any item with a point biserial above .15 or .20 is generally
acceptable for LEAP, iLEAP, or LAA-2. The fact that most of the items have a point biserial above .30 indicates that the item discriminates well—students who performed better on the test as a whole answered the items with photographs correctly.

Table 1

Item Difficulty and Point Biserials for Photograph-Based Multiple-Choice Items

<table>
<thead>
<tr>
<th>Item</th>
<th>Item Difficulty</th>
<th>Photograph-based Item</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Item Difficulty</td>
<td>Point biserial</td>
</tr>
<tr>
<td>Puffer fish</td>
<td>Form 3 – .89</td>
<td>Form 3 – .33</td>
</tr>
<tr>
<td></td>
<td>Form 4 – .85</td>
<td>Form 4 – .37</td>
</tr>
<tr>
<td>Spider web</td>
<td>Form 3 – .58</td>
<td>Form 3 – .36</td>
</tr>
<tr>
<td></td>
<td>Form 4 – .55</td>
<td>Form 4 – .38</td>
</tr>
<tr>
<td>Marsh ecosystem</td>
<td>Form 3 – .69</td>
<td>Form 3 – .21</td>
</tr>
<tr>
<td></td>
<td>Form 4 – .67</td>
<td>Form 4 – .32</td>
</tr>
<tr>
<td>Alligator</td>
<td>Form 3 – .61</td>
<td>Form 3 – .45</td>
</tr>
<tr>
<td></td>
<td>Form 4 – .66</td>
<td>Form 4 – .48</td>
</tr>
<tr>
<td>Pitcher Plant</td>
<td>Form 3 – .35</td>
<td>Form 3 – .08</td>
</tr>
<tr>
<td></td>
<td>Form 4 – .36</td>
<td>Form 4 – .02</td>
</tr>
<tr>
<td>Fossils</td>
<td>Form 3 – .81</td>
<td>Form 3 – .30</td>
</tr>
<tr>
<td></td>
<td>Form 4 – .80</td>
<td>Form 4 – .30</td>
</tr>
</tbody>
</table>

In addition to the six items with photographs as the stimulus, there were two matched pairs of items, one text-only version and one photograph-based item, on the field test. To analyze
the item specific statistics, the researcher compared the item difficulty and point biserials for the paired items. Table 2 includes the statistics for each paired item.

Table 2

Item Difficulty and Point Biserials for Paired Photograph-Based and Text-Only Multiple-Choice Items

<table>
<thead>
<tr>
<th>Item</th>
<th>Text-only</th>
<th>Photograph-based</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Item Difficulty</td>
<td>Point Biserial</td>
</tr>
<tr>
<td>Heron</td>
<td>Form 1 – .39</td>
<td>Form 1 – .30</td>
</tr>
<tr>
<td></td>
<td>Form 2 – .43</td>
<td>Form 2 – .33</td>
</tr>
<tr>
<td>Desert/Tundra</td>
<td>Form 1 – .44</td>
<td>Form 1 – .21</td>
</tr>
<tr>
<td></td>
<td>Form 2 – .45</td>
<td>Form 2 – .23</td>
</tr>
</tbody>
</table>

These data indicated that the items with the photographs have a better discrimination than the items with the text only. In every instance the point biserial was higher with the photograph-based item. This indicates that students who performed better on the test as a whole answered the photograph-based items correctly.

The data from the pilot study were useful and suggested additional questions for the investigator, which helped formulate the research questions for further study.

RESEARCH STUDY

The purpose of this dissertation study was to investigate how photograph-based life science multiple-choice items influence student performance on statewide standardized tests, in comparison with text-based items about the same content. This mixed methodology research study focused primarily on types of multiple-choice items, specifically five matched pairs of multiple-choice items, text only and same text with a photograph. Statistics from eleven
multiple-choice items were utilized from the grade 8 LEAP field test to identify student performance on photograph-based multiple-choice items. Additional case study research was conducted in two middle schools. Within each school, one class of eighth graders was exposed to the 20-Question Model (Wandersee, 2000); the remaining eighth-grade classes were not. After taking the field test, questionnaires were given to all eighth-grade students taking the LEAP science field test at each school. One questionnaire was utilized, and the questions focused on the student’s experience when answering the questions with a photograph.

In addition, four eighth-grade students, who were contrasted on gender and on high or low academic performance, were selected by their teacher to be interviewed and asked to co-construct six concept maps related to six different test items used in the study (four with photographs, two without photographs). Their concept maps were compared with performance on the text-only and photograph-based multiple-choice items. These mini-cases studies were conducted to compare the performance of these students on the photograph-based and text-only multiple-choice items in measuring student understanding of life science concepts.

Institutional Review Board Approval

An application for exemption from the oversight of the Louisiana State University Institutional Review Board (IRB) was submitted to the board and approved. This study met the qualifications for exemption: (a) the research was conducted in an educational setting with the approval of the district superintendent, school principal, and classroom teachers, (b) the study involved educational and assessment practices, (c) the consent of parents/guardians and students was obtained prior to beginning the study, (d) the research participants, district, school, and students remained anonymous when reporting the findings by assigning pseudonyms. The consent forms and questionnaire are in the Appendices. See Appendix C for a copy of the
approval. Appendix D is the copy of the investigator’s Human Subject Research Course Completion Certificate.

### Participant Consent

Student and parent/guardian consent forms were submitted and collected prior to the start of the research project. The consent forms for the student and parent/guardian explained: 1) the purpose for the study, 2) the potential benefits for being included in the study, 3) the potential risk associated with being in the study; 4) the opportunity for the student to opt out of the study; and 5) the assurance of confidentiality of study participants. The Student Consent Form is included (Appendix E), as is the Parent/Guardian Consent Form (Appendix F).

### Participants

The Louisiana Department of Education selected and approved the field test sample, and the investigator contacted schools on the list for Form 3 and Form 4. One school administering Form 3 was selected and one school administering Form 4 was selected. After securing permission to work within the school from the principal, the teacher at each school selected one grade 8 class to complete the study.

### Procedures

The spring 2007 science field test was administered to eighth-grade students during April 2007. Five field test forms were administered to approximately 1500 students per form. Seventy-one districts were included in the entire field test sample, excluding the Recovery School District. The following set of procedures was used to select the schools for the entire field test sample:

1. A school with eighth-grade students and instruction was selected at random from each district
2. For larger school districts, one or two additional schools were selected.

3. The sample selected was representative of schools in the state in terms of academic achievement level, percent of minorities, percent of students receiving free/reduced lunch, percent of students in special education/LEP/504, and school size.

4. The five test forms were randomly assigned to the selected schools.

5. All of the students in the eighth grade at each selected school completed the form assigned to that school.

6. All schools selected for the field test were included, no matter how few students they have enrolled in the eighth grade.

7. Special School District #1, the Louisiana School for the Visually Impaired, and the Louisiana School for the Deaf were treated as districts in the sampling, and therefore were to be assigned field test forms.

8. The sample pulled for each field test form was equated.

For the purposes of this study, the 11 items appeared on Field Test Forms 3 and 4. There were five text-only multiple-choice items and five matched items with a photograph as stimulus. There was one additional photograph-based item which appeared on both forms. Table 3 identifies the photograph-based and text-only item placement on the field test. Test Forms 3 and 4 were administered to approximately 1200 students statewide. The participants within this sample consisted of eighth-grade students that represent the Louisiana population. This sample included males and females, blacks (not Hispanic), whites (not Hispanic), Hispanics, Asians or Pacific Islanders, and Alaskan Natives or American Indians. The sample also included students with disabilities, Limited English Proficient students, and 504 students who used accommodations.
An exploratory mixed model design (Tashakkori & Teddlie, 1998) was implemented. After the randomized sample was selected by staff members at the Louisiana Department of Education, two schools were purposefully selected from the sample (one from the Form 3 list and one from the Form 4 list) in which to conduct additional qualitative research. The 20-Question Model (see Appendix A) and concept mapping were used with students (see Appendix L).

The investigator entered these two schools as a participant observer. After discussions with the principal and the school test coordinator, the teacher at each school selected one class to complete the study. The investigator provided instruction to the students in one class on how to use the 20-Question model to help them use the photographs during testing. The other classes at the school did not receive any additional instruction.

The conceptual variable being assessed was knowledge of life science concepts. The independent variable was the presentation of items with or without photographs. The dependent
variable was the student performance on those five text-based multiple-choice items as compared to the five photograph-based items on the Field Test Forms 3 and 4.

The setting of the quantitative section of this study initially took place in 27 Louisiana middle schools—13 schools were administered Form 3 and 14 schools were administered Form 4. All eighth-grade students at each of these schools took the LEAP grade 8 science field test form. Field test forms 3 and 4 were representative of the grade 8 LEAP Science Test and consisted of 3 sessions: Session 1 – 40 multiple-choice items; Session 2 – 4 short-answer items; and Session 3 – 1 comprehensive science task (3 short-answer items and 1 extended-constructed response. Student materials included a test booklet and an answer document.

The study addressed potential threats to internal validity (selection bias) and external validity (generalizability of results to students statewide). These threats were minimized by random selection of schools, by matching of schools by state demographics in the sample, and by random assignment of field test forms to schools across the state. Each eighth grader was administered the field test during the same testing window of three days, and all eighth graders in the same school took the same form on the same day. In addition, a control group (classes that did not receive the treatment) was used, thus minimizing threats resulting from the interaction of setting and treatments. To increase the validity of the statistical conclusions, item analysis was conducted to yield item difficulty, point biserials, and the percentage of students selecting each answer choice or leaving each item blank.

Qualitative Methods

Prior to the week of field testing the investigator was introduced to a grade 8 class at School A and School B. The investigator taught three lessons using the 20-Question Model (Wandersee, 2000) as a tool for analyzing photographs. Lessons one and two utilized a
PowerPoint presentation of 21 photographs. The investigator facilitated a class discussion about each photograph. Lesson three included a group activity in which the students utilized the 20-Question Model (2000) to analyze photographs from their textbook. The PowerPoint presentation is Appendix G and the class activity sheet is Appendix H.

Table 4
Description of PowerPoint Presentation and Questions, Lessons 1 and 2

<table>
<thead>
<tr>
<th>Photograph Number</th>
<th>Description of Photograph</th>
<th>Questions Asked</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>A black bear splashing in the water</td>
<td>Describe this event biologically.</td>
</tr>
<tr>
<td>1.2</td>
<td>American alligator on a log</td>
<td>On what basis do you suspect this organism is a reptile?</td>
</tr>
<tr>
<td>1.3</td>
<td>Two black, orange, and white butterflies perched on a plant</td>
<td>What do you observe in this photograph?</td>
</tr>
<tr>
<td>1.4</td>
<td>Four elephants of various sizes on the savannah</td>
<td>Describe the photograph. Make an inference about the four organisms.</td>
</tr>
<tr>
<td>1.5</td>
<td>Black ant on a flower</td>
<td>What is the biological principle operating here? Predict what may happen next in this situation.</td>
</tr>
<tr>
<td>1.6</td>
<td>A group of pelicans near water</td>
<td>Use evidence from the photograph to determine habitat and infer relationship between the pelicans.</td>
</tr>
<tr>
<td>1.7</td>
<td>A butterfly and bee on a pink flower</td>
<td>How biologically does the flower help the butterfly and bee? How does the butterfly and bee help the flower?</td>
</tr>
<tr>
<td>1.8</td>
<td>Heron standing in a watery area</td>
<td>Describe the habitat and discuss the feature of the heron that help it survive.</td>
</tr>
</tbody>
</table>
1.9. Desert Determine the limiting factor of a desert ecosystem.

1.10 Rhinoceros on the savannah Make connections between the desert and savannah ecosystem.

1.11 Rain forest, lush and green What are the limiting factors in this ecosystem?

1.12 Rain forest, deforested What evidence from the pictures shows how humans have changed this ecosystem?

1.13 Healthy wetland ecosystem Describe the components of a wetland.

1.14 Drained wetland ecosystem What evidence from the photograph suggests that humans have altered this environment?

1.15 Swamp Make connections between the swamp and river ecosystems.

1.16 River Make connections between the swamp and river ecosystems.

**Lesson Two**

2.1 Cluster of red blood cells What is the function of this structure?

2.2 Cluster of red and white blood cells Identify the white blood cells and describe how to determine the difference between a red and white blood cell.

2.3 Paramecium Describe the organism. What is the function of the cilia?

2.4 Cell division Predict what will happen next in the cell division process?

2.5 Healthy Lungs and Heart What evidence from the picture help you infer which organ is the heart?
During the week of field testing, the investigator was in the school observing the administration of the grade 8 LEAP field test. After the field test was completed, the investigator asked the students to fill out a questionnaire asking them about their experience taking items with photographs as the stimulus material. The student questionnaire asked what they thought about the photograph-based items when compared to the text-only multiple-choice items. The student questionnaire is Appendix I.

Additional case study research was conducted to determine students’ retention of science concepts. Two students from each school were selected by their teacher to work with the investigator. The students were selected from the class introduced to the 20-Question Model. The researcher interviewed each student about photographs in textbooks, photographs on the test, and their use of the 20-Question Model in class. The students were shown the photographs used on the field test, asked to explain how he or she answered each of the six study questions, and asked to co-create a concept map for each of the six topics with the investigator to assess retention of life science concepts. The investigator analyzed the concept maps to observe possible patterns or themes emerging from the data.

The procedures used were consistent across the two schools selected and with each student. Additional interview questions emerged, however, based on the discussions with each student. The materials used were each student’s test booklet and answer document, the questionnaire, and a notebook to take field notes.

The validity and credibility for qualitative component was established by triangulation between persons, space, and time. The observations and interviews of the four students were analyzed to determine themes across the two schools. The instructional strategies and textbooks used in each of the two schools were be analyzed to determine emerging themes.
Setting

Two schools from different districts were selected to participate in the study. Based on the demographics of each school and school performance on LEAP, two schools were selected from the LEAP Science field test sample. The schools were selected on several criteria. First, the school had to be randomly selected in the sample for either Form 3 or Form 4. The investigator compared the demographics and scale score statistics from schools in the field test sample to select comparable schools. For comparative purposes, the schools were selected based on eight categories for their eighth-grade class: scale score, total n-count, free and reduced lunch count and percentage, minority count and percentage, special education count and percentages (see table 5). The scale score was the primary criteria utilized to select schools.

Table 5

Demographics for School Selection in the Field Test – 8th Grade Only

<table>
<thead>
<tr>
<th>Schools</th>
<th>Scale Score</th>
<th>Total Count</th>
<th>Free and Reduced count</th>
<th>Free and Reduced Percentage</th>
<th>Minority Count</th>
<th>Minority Percentage</th>
<th>Special Education Count</th>
<th>Special Education Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>School A</td>
<td>313.75</td>
<td>150</td>
<td>86</td>
<td>57.33</td>
<td>16</td>
<td>10.67</td>
<td>25</td>
<td>16.67</td>
</tr>
<tr>
<td>School B</td>
<td>313.86</td>
<td>89</td>
<td>28</td>
<td>31.46</td>
<td>12</td>
<td>13.46</td>
<td>2</td>
<td>2.25</td>
</tr>
</tbody>
</table>

Note: School A includes grades 6-8. School B includes grades K-8.

Each district was contacted to secure permission to enter the schools and conduct the study.

DATA ANALYSIS

The Primary Research Question

How does middle school students’ performance on photograph-based multiple-choice items in a state science achievement test compare to their performance for text-only multiple-choice questions?

Item analysis was used for each item on the field test:
• Classical item difficulty—(i.e., p-value)

• Classical item discrimination statistic—(i.e., point-biserial correlation)

• For multiple-choice items, the number of examinees who left the item blank and the percentage of students answering each distracter.

Using classical statistics, the investigator compared the statistics on the photograph-based multiple-choice items and the text-only multiple-choice items to determine how the photographs impact student performance. In addition, the investigator completed six simple $t$-tests to compare the photograph-based item to text-only item for each topic using the entire field test samples for Form 3 and Form 4. The investigator also calculated effect size to compare the difference in performance of the photograph-based item to the text-only version.

The Subquestions

1. Which categories of students, if any, benefit most (based on their scores) from the inclusion of photograph-based multiple-choice items?

   Using the entire field test sample for Form 3 and Form 4, the investigator compared student performance on the photograph-based version and the text-only version of the item to the students performing at each achievement level. The investigator determined if there were any categories of students that benefited from the inclusion of photograph-based multiple-choice items.

2. How well does student performance on science-content-equivalent items, using matched pairs of those two types of multiple-choice items, correlate?

   The investigator compared student achievement level data on the grade 8 operational test (administered in March 2007) to the mean number correct on the photograph-based items and text-based items to determine if student performance correlated on each type of item. The
investigator calculated Spearman’s rho, which is used when two values are ranked from highest to lowest. Spearman’s rho was used to indicate how much agreement there was between the ranks of each variable (Shumacher and McMillan, 1993).

3. Are there differences in test performance between students who were introduced to and used the 20-Q Model of Photographic Inquiry during science instruction and those who were not?

The investigator separated the statistics from each form of the field test and divided them into two categories: students exposed to the 20-Question Model at School A and School B, and the remaining grade 8 students at School A or School B not exposed to the 20-Question Model. The investigator analyzed mean number correct on the photograph-based items and mean number correct on the text-only items between all grade 8 classes at each school to compare student performance in the class that was introduced to the 20-Question Model and the classes that were not introduced the 20-Question Model.

4. How do four concept-map-based mini-case studies of a high and a low test performing male and female triangulate with their subscores on the tests’ photograph-based multiple-choice items and their subscores on the text-based multiple-choice items?

Interviews with four different students, two from School A and two from School B, were conducted to identify how students performed on the photograph-based multiple-choice items. Student interviews about classroom instructional practices were conducted and thought processes about how each student answered the six questions on the field test were discussed. In addition, the investigator co-created concept maps with the four students to determine if retention of conceptual understanding had occurred. The technique of co-construction of concept maps allows the student to describe his or her conceptual understanding while the investigator draws
the concept map. After finishing each map, the student reviews and approves the map (Abrams, 1993; Rye & Rubba, 1998). A content analysis of interviews and concept maps was completed to determine if themes emerged. The investigator also compared individual student performance on photograph-based items and the text-only items to the concept maps co-created with the students to determine if their content retention impacts student performance.

Timeline for the Project

The research was divided into several phases: ongoing review of the literature from April 2004 to completion; pilot study of photograph-based items on the grade 8 LEAP field test (April 2004), development and revision of photograph-based test items (August 2005), review of the items by a content and a bias review committee of the Louisiana Department of Education, Division of Student Standards, Assessments, and Accountability (spring and summer 2005), scheduled April 2006 field test of items which was postponed due to Hurricane Katrina, revision of photograph- and text- based items and test form placement (June 2006), field test forms constructed over a three month period (fall 2006), field test sample constructed (November and December 2006), field test forms printed (January 2007), field test materials shipped to districts (March 2007), class instruction on 20-Question Model (April 2007), field test administration (April 2007), mini-case study of four students (April 2007), student/teacher interviews (April 2007), data collection and analyses of questionnaire, case-study, and interview data (May/June 2007); statistical analyses of items (June 2007); and final analysis and evaluation of research (July 2007).
Two schools were selected to participate in the research study. The investigator identified and selected these two schools from the field test sample drawn by the Louisiana Department of Education. Each school was randomly chosen for field test participation to create a sample that was representative of the entire state. The samples for Form 3 and Form 4 were considered equivalent by the Louisiana Department of Education. The investigator purposefully selected one school from Form 3 and one school from Form 4 to participate in the study. Pseudonyms were utilized throughout the reporting of the study to maintain confidentiality.

**School A**

School A is located in a rural community approximately 10 miles from a mid-sized city and 30 miles from a large city. There are 40 schools in this growing district, of which 13 are middle schools. School A is one of four schools in the small community. The school is a 6th, 7th, and 8th grade facility that sits upon the same compound as the lower elementary, the upper elementary, and the high school. Most of the children from this town attend all four schools. School A is approximately sixteen years old but has been maintained so well that upon entering the school, the investigator felt that it was new construction.

The school size is average with approximately 478 students and 34 faculty members. Of the students, 150 are eighth graders, with 86 students qualified for free and reduced lunch, 16 students classified as minority, and 25 students classified special education. The average scale score for the eighth-grade students at this school is 313.75. The demographics for the entire student body are in Table 6.
Table 6

School A Demographics

<table>
<thead>
<tr>
<th>Category</th>
<th>Female</th>
<th></th>
<th>Male</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Percent</td>
<td>Total</td>
<td>Percent</td>
<td>Total</td>
<td>Percent</td>
</tr>
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<td>Gender</td>
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<td>251</td>
<td>52.51</td>
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<td>6.07</td>
<td>53</td>
<td>11.09</td>
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<tr>
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<td>0.84</td>
<td>2</td>
<td>0.42</td>
<td>6</td>
<td>1.26</td>
</tr>
<tr>
<td>White</td>
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<td>41.42</td>
<td>220</td>
<td>46.03</td>
<td>418</td>
<td>87.45</td>
</tr>
<tr>
<td>At Risk</td>
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<td>28.66</td>
<td>160</td>
<td>33.47</td>
<td>297</td>
<td>62.13</td>
</tr>
</tbody>
</table>

During the initial meeting at School A, the investigator met with the principal and the grade 8 science teacher to discuss the scope of the study. The initial meeting was very positive; the principal and teacher were excited to be included and thoughtfully chose the intended class to receive the treatment. It was agreed that the investigator would facilitate three forty minute lessons over three days on the 20-Question Model (Wandersee, 2000) with Ms. Gant’s first period class. School A maintains a 7 period schedule each day.

The investigator met with Ms. Gant in her classroom to set up actual teaching times and discuss the comprehensive curriculum and textbook series being used at School A. Based on a district mandate, Ms. Gant follows the *Louisiana Comprehensive Curriculum (LCC)* in her classroom. The discussion revealed that the district adopted an integrated series for grades 6, 7, and 8, yet the *LCC* maintains that the focus of grade 8 science is primarily Earth science. To follow the *LCC* guidelines, Ms. Gant is supplementing her textbook series with an older Earth science textbook.
The investigator taught two lessons to the treatment group on Wednesday and Friday prior to field testing, and a third lesson on Monday during the week of field testing. After the final lesson, the treatment group took the field test and completed a student questionnaire. In addition, every eighth-grader taking the LEAP Science field test at School A completed the student questionnaire.

There were 22 students participating in the treatment group at School A. The investigator utilized LEAP results from March 2007 to identify the science achievement level for each student in the treatment group. Within Ms. Gant’s class, 14 students performed at the Mastery level in science; 7 students performed at the Basic level, and 1 student performed at the Approaching Basic level. Additionally, the investigator interviewed two students from Ms. Gant’s first period class (male and female, low-performing and high performing) and, based on their ideas, co-created concept maps on the six concepts which made up the test items.

School B

School B is located in a rural community centrally located between two major cities. School B is a district that continues to grow in population size. There are 22 schools in this district, of which 9 are middle schools. The school site facilitates kindergarten through grade 8. School B is approximately 11 years old but also has been maintained so well that the investigator, upon entering the school, felt that the school was newly constructed.

The school size is large with approximately 1,041 students and 77 faculty members. Of the students, 89 are eighth graders. Within the eighth-grade class, 28 students qualified for free and reduced lunch, 12 students are classified as minority, and 2 students are classified as special education. The average scale score on the LEAP test for the eighth-grade students at this school is 313.86. The demographics for the entire student body are in Table 7.
Table 7

School B Demographics

<table>
<thead>
<tr>
<th>Category</th>
<th>Female</th>
<th></th>
<th>Male</th>
<th></th>
<th>Total</th>
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</thead>
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<tr>
<td></td>
<td>Total</td>
<td>Percent</td>
<td>Total</td>
<td>Percent</td>
<td>Total</td>
<td>Percent</td>
</tr>
<tr>
<td>Gender</td>
<td>515</td>
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<td>5.57</td>
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<td>39.39</td>
<td>806</td>
<td>77.43</td>
</tr>
<tr>
<td>At Risk</td>
<td>212</td>
<td>20.37</td>
<td>199</td>
<td>19.11</td>
<td>411</td>
<td>39.48</td>
</tr>
</tbody>
</table>

The investigator gained permission to work with School B from the principal and had primary contacts with the middle school guidance counselor/school test coordinator and the grade 8 science teacher, Ms. Kelly. School B was very receptive to working with the investigator as was Ms. Kelly who selected her third period class to participate. School B utilized the hour and a half block schedule, so the investigator worked with this class for one and one half class periods, or approximately two hours. The investigator worked with Ms. Kelly’s class the week of the field test and facilitated lessons one and two on Monday. Lesson three was facilitated on Wednesday before School B administered the field test on Thursday.

For each of the 27 students in Ms. Kelly’s class, the investigator utilized spring 2007 LEAP results to determine the range of achievement levels. Within this treatment group 2 students performed at the Advanced level in science; 6 students performed at the Mastery level; 12 students performed at the Basic level; 6 students performed at the Approaching Basic level, and 1 student performed at the Unsatisfactory level. After administering the field test, the
 investigator interviewed two students from Ms. Kelly’s third period class (male and female, low-performing and high performing) and co-created concept maps on the six concepts which made up the test items.

THE TREATMENT

The concept of analyzing photographs was introduced to each class using a PowerPoint presentation (Appendix G) entitled “What do you see in these photographs?” The presentation was divided into three categories: Organisms—Capturing a Moment in Time, Ecosystems—Accurately Display Living and Nonliving Components of an Ecosystem, and Make the Unseen Seen. Questions from the 20-Question Model (Wandersee, 2000) were used to facilitate the class discussion on each photograph. The introductory slide presented three basic concepts about photographs: photographs can capture a moment in time in the life of an organism, they can accurately display various types of ecosystems, and they can make the unseen seen (Wandersee, 2000). In the remaining PowerPoint slides, the class saw a projected image of each photograph and analyzed the photographs using the 20-Question Model (Wandersee, 2000) as a guide.

Lesson 1

The first category of the presentation, Organisms—Capturing a Moment in Time, included eight photographs. In Photograph 1.1, a black bear was splashing in water which had vegetation emerging from its surface. The class was asked to “describe this event biologically.” The students at both schools were able to describe the non-living components of this ecosystem, and to make predictions about the type of habitat and the action of the bear. They were also able to discern what ecosystems were not represented in this photograph, based on prior knowledge of bears and on actual characteristics of the photograph.
In photograph 1.2 an American alligator perched on a log near water with trees in the background. Students were asked, “On what basis do you suspect this organism is a reptile?” The students recognized immediately that the organism was an alligator and many knew that alligators were reptiles. However, the investigator focused the class on using characteristics of the photograph to aid them in answering the question. With the focus returning to the photograph, the students began to describe the habitat and made predictions about the types of ecosystem that this might be. They also discussed the features of the alligator and determined that the scales did the best to identify this alligator as a reptile.

In photograph 1.3, two black, orange, and white butterflies perched on a plant. The students were asked, “What do you observe in this photo?” Some of the students described the contents of the photograph, while others initially made some inferences about what the butterflies were doing. The investigator at this point explained the difference between an observation and an inference. Another question used with this photograph was to “describe this event biologically.” Specifically, the investigator probed the students about the stage of the life cycle that the butterfly represents and the metamorphosis that butterflies go through.

In photograph 1.4, four elephants of various sizes stood in a grassy patch on the savannah. The students were asked to describe the photograph and discuss the ecosystem represented and then were asked to “make an inference about the four organisms.” The students inferred that this photograph was of a family of elephants, possibly a male, female, and two babies. The students also inferred that the animals were in a savannah based on the dry conditions exhibited in the photograph.

In photograph 1.5, an ant on a flower was detailed enough so that the students could see the fibers on the leg and its head inside the center of a flower. Students were presented two
questions to guide the discussion: “What is the biological principle operating here?” and “Predict what may happen next in this situation.” Both classes of students came up with good ideas. The students recognized that the organism was an ant and that it was searching for a food source in the flower. They predicted that pollen could attach to the hairs on the legs of the ant and be carried to another flower, thus aiding pollination of the plant species.

Photograph 1.6 was a group of pelicans near water. The smaller pelicans looked different from the larger pelicans in coloring and type of feather. The initial questions to the classes focused on using evidence in the photograph to determine habitat and relationship between the pelicans. The students exhibited some higher-level thinking processes and presented some good ideas about this photograph. The student inferred from its brown feathers that the large pelican was the adult and from the white down-like feathers that the two smaller pelicans were the babies. The students described the habitat as a beach with some waves. There being no trees in the picture, the students inferred that these pelicans might be near a body of salt water.

Photograph 1.7 depicted a butterfly and bee on a pink flower. The initial questions asked were, “How biologically does the flower help the butterfly and bee?” and “How do the butterfly and bee help the flower?” The students quickly responded that the butterfly and bee extract food from the flower and they in turn help to pollinate the flower.

Photograph 1.8 was of a heron standing in a watery area. The initial question asked the students to describe the habitat and discuss the features of the heron that help it survive. The students discussed the heron, observing that its legs looked like the grass in the water so that prey would not be scared off while the pelican walked through the water. They talked about the shape of its beak and how it might be used to catch prey. They talked about the type of feet that the heron would need to walk in muddy water.
The second category of the treatment presentation, Ecosystems—Accurately Display Living and Nonliving Components of an Ecosystem, included eight photographs. The initial discussion centered around ecosystems that the students had visited previously, and other ecosystems not visited but familiar to them (e.g. tropical rain forest, desert). In the tropical rain forest example, students who had never traveled to one had seen pictures in their textbooks or in movies. The investigator then presented several photographs of ecosystems prior to asking questions about each photograph.

Photograph 1.9 was of a desert. The investigator asked the students to observe the photograph of a desert and describe it and then to determine the limiting factor, or what was missing, from the picture of the desert ecosystem. After a brief discussion about what plants and animals need to survive, some students noticed that there was no plant life in this photograph. They thus inferred there was no rain; no rain was the limiting factor.

Photograph 1.10 was of a rhinoceros on the savannah. The investigator asked the students to make some connections between the savannah ecosystem and the desert ecosystem. For similarities, the students determined that both ecosystems are dry and have wide open spaces. For differences, the students determined that there must be more rain in a savannah because it is a type of grassland. There is larger animal life in a savannah, more so than in a desert, probably because of more water.

Photographs 1.11 and 1.12 showed two rain forest photographs, one lush and green filled with vegetation and the other one deforested. The investigator asked about limiting factors, the types of animals that could not survive in the rainforest, and “evidence from the picture that shows how humans have changed the ecosystem.” The students had a lively discussion about
why rain forests should be preserved (e.g. unknown plant and animals, cures for diseases) but they also discussed why it is important to cut down trees.

Photographs 1.13. and 1.14 showed a healthy wetland ecosystem and a wetland ecosystem that had been drained. The healthy wetland had vegetation, water, and plenty of birds. The drained wetland had a small amount of water left and a small amount of vegetation. The investigator asked students to describe the differences between the two photographs and to find evidence from the photograph that suggests that humans have altered this environment. The students discerned tractor or plow marks in the soil of the second photograph and inferred that this wetland had been drained for farming.

Photographs 1.15 and 1.16 were of a swamp and river ecosystem. The investigator asked the students to make some connections between the two ecosystems based on the characteristics of each photograph. They determined that the water, trees, plant life, and animals were similar in the pictures; however, the swamp has different types and density of trees in and out of the water, whereas the river has trees lining two sides. In the ensuing discussion students made a comparison to a wetland which usually has more grass and fewer or no trees.

Lesson #1 ended with a brief discussion about how the class had analyzed the photographs in the group discussion. The investigator discussed the types of questions that had been asked. The class responded concerning the new concepts they had learned by analyzing photographs.

Lesson 2

The second lesson focused the class discussion on the third category of photographs, Make the Unseen Seen. The investigator probed the class about types of things students recognize but have never seen with their own eyes. The class discussed as examples organs inside our body, the inside of plants, and objects in outer space.
Photograph 2.1 depicted a cluster of red blood cells. The photograph was in color which helped the student correctly identify the cells. The investigator asked the students to describe the cells and as a follow-up to explain the function of the structure. The students described the cells as red circular-shaped cells, and some students observing an indentation in the center said the cell was shaped like a breath mint. The students were able to identify that the red blood cells carry oxygen from the lungs to all the other tissues in the body.

Prior to showing photograph 2.2, the investigator asked if the students had ever seen a white blood cell. None of the students at either school could remember ever seeing a white blood cell. The investigator presented photograph 2.2 in black and white showing red blood and white blood cells. The investigator asked the students to identify the white blood cells and as a follow-up to describe their function. The students recognized the shape of the red blood cells, even though there was no color, and thus were able to correctly identify the white blood cells. They also correctly identified that white blood cells are used to fight infection in the body.

Photograph 2.3 was a paramecium. The investigator asked the students to describe the organism and as a follow-up to explain the function of the cilia (hair-like structure). The students described the paramecium as a one-celled organism which was green and had yellow and red spots. The students also noticed hair like structures on the outside of the cell and engaged in a brief discussion about the movement of the cell.

Photograph 2.4 showed a photograph of a cell being divided, during the telophase 2 division process. The investigator asked the students to describe what happened prior to this division and then to predict what would happen next in the cell division process. A brief discussion about the difference between meiosis and mitosis occurred.
Photograph 2.5 was a black and white photograph of a healthy lung from a CT scan. The photograph showed two lungs and the heart. The investigator asked the students to identify the lungs and then to determine what evidence from the picture would help in inferring which organ was the heart. By correctly identifying the lungs, the students could also identify the heart.

The investigator conducted a final discussion using strategies from the 20-Question Model. This helped the students understand that they can gain much information from a photograph. The Power Point presentation is Appendix G.

Lesson 3

For lesson three, the investigator utilized photographs from the classroom textbook in each class to further facilitate the 20-Question Model. The students were grouped according to pre-arranged classroom assignments into groups sitting at tables (Ms. Gant’s class) and groups of three at individual desks (Ms. Kelly’s class). Each group was given a textbook, a class activity sheet (see Appendix K), and a copy of the 20-Question Model (see Appendix A). The group was assigned to scan a chapter in their textbook, to select one photograph from the chapter, and to fill out the class activity sheet. The investigator posed several questions from the 20-Question Model: give a description of the photograph, describe the event biologically, make a prediction about what may happen next in this photograph, identify the biological principle operating in this photograph, determine any limiting factors shown in this photograph, and ask an important biological question about this photograph. Finally, each group was to select one question from the 20-Question Model that clearly related to the photograph selected, to write the question, and then to answer it.

The students worked really hard to answer these questions. Ms. Gant’s class had a much easier time selecting a photograph because the textbook was integrated and had several life
science chapters. Ms. Kelly’s class was able to complete the activity, but spent more time selecting the photographs because the textbook used was an Earth Science textbook.

The Classrooms

The time spent at each school proved to be very instructive for the study. In many ways the schools were similar, with the exception being the number of grades within the schools. The size of the middle school at School A was very comparable to the size of the middle school at School B. Both schools were set in a rural community approximately 30 miles from a large city within their state. Both districts mandated the use of the Louisiana Comprehensive Curriculum, so both grade 8 classes were taking Earth Science at the time of the research study. Both districts had adopted the Glencoe Series of textbooks; however, School A utilized the integrated series while School B utilized the Earth Science textbook. Both school administrations were very receptive to participate in the study, although the treatment class at School A was initially more receptive to the investigator.

The investigator perceived that teacher enthusiasm and time of day of the instruction determined overall receptivity of the treatment lessons. The lessons at School A were taught during the first period of the day. Ms. Gant had done a very good job of explaining to her class that they were participating as the treatment group within an experiment. This class was very receptive and responsive during all three lessons with the investigator. The lessons at School B were taught during third period, immediately following the students’ lunch period and recess. Ms. Kelly’s class was initially very quiet, with approximately 10 of the 27 students participating in the group discussion. During lesson two more students became involved in the group discussion when their names were called, and by lesson three almost all students participated voluntarily in the group activity.
These two schools were chosen because their student demographics were similar, as well as their scale score performance on LEAP. Although Ms. Gant’s class consisted of 26 students the study group was diminished by 4 students, including 2 African-American males, because of illness or preceding resource room assignments. The treatment group consisted of 10 females (1 Hispanic and 9 white) and 12 males (3 Hispanic and 9 white). Ms. Kelly’s class consisted of 27 students, with 15 females (2 Hispanic and 13 white) and 12 males (1 Hispanic and 11 white). All these students participated in all three treatment lessons and the study.

Initially, the investigator was concerned about the homogeneity of the demographic make-up of the two classes, and potentially the limited generalizability of the study. The investigator was restricted to studying the class that the grade 8 science teacher at each school chose. These similarities between the district, schools, classes, and students thus allowed for comparisons between the two schools to be made on treatment variables. After all three treatment lessons were presented, the classes were administered the field test.

THE FIELD TEST

The grade 8 students at School A were administered Form 3. The grade 8 students at School B were administered Form 4. Each paired item was placed in the same sequence order on both forms (see Table 3). The pitcher plant item, for example, was sequence #1; this sequence was photograph based on Form 3 and text-only on Form 4.

After completion of the field test, all grade 8 students at both schools completed a student questionnaire.

THE STUDENT QUESTIONNAIRE

The student questionnaire was divided into three main questions with several subquestions to which the students responded. Question one asked the students to describe their
science class. Question two asked the students to describe their feelings about the grade 8 LEAP test. Question three asked the students to describe their use of photographs in science class and on tests. The results from School A and School B are in the tables that follow. All grade 8 students at School A (n=142) and School B (n=86) participated in the LEAP grade 8 field test.

**Table 8**

School A Student Responses to Question 1a. – What Science Class Are You Taking This Semester?

<table>
<thead>
<tr>
<th>Student Responses</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science</td>
<td>69</td>
<td>46%</td>
</tr>
<tr>
<td>Physical Science</td>
<td>19</td>
<td>13%</td>
</tr>
<tr>
<td>8\textsuperscript{th} Grade</td>
<td>37</td>
<td>25%</td>
</tr>
<tr>
<td>Life Science</td>
<td>7</td>
<td>5%</td>
</tr>
<tr>
<td>Blank</td>
<td>5</td>
<td>4%</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>5</td>
<td>4%</td>
</tr>
</tbody>
</table>

**Table 9**

School B Student Responses to Question 1a. – What Science Class are You Taking This Semester?

<table>
<thead>
<tr>
<th>Student Responses</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science</td>
<td>79</td>
<td>92%</td>
</tr>
<tr>
<td>Physical Science</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>8\textsuperscript{th} Grade</td>
<td>4</td>
<td>1%</td>
</tr>
<tr>
<td>Blank</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

The students at School A appeared to vary on their perceptions regarding the science class they were taking this semester. Only 46% of the students responded that they were taking
Earth Science this semester, although all eighth-grade students at School A take Earth Science, and only 5% reported taking Life Science. The variation in response may have been associated with the integrated textbook series that the students use. The students at School B had very little variation in their responses; 92% of the students indicated that they were taking Earth Science.

Question 1b was “What textbook are you using?” The categories created by the students at School A and School B were different because each school used a different textbook based on the series adopted by their respective districts. Tables 10 and 11 show the results from School A and School B.

The students at School A varied in their answers to question 1b. Ms. Gant used two textbooks in her class—an Earth science textbook published by Merrill and an integrated grade 8 science text published by Glencoe. Many students identified the textbooks by their colors, brown (Merrill) and blue (Glencoe integrated text). At School B Ms. Kelly used one red textbook (Glencoe Earth Science), and 84% of the students indicated that this was the textbook used.

Table 10
School A Student Responses to Question 1b – What Textbook Are You Using?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science (Brown)</td>
<td>29</td>
<td>20%</td>
</tr>
<tr>
<td>Glencoe (Blue)</td>
<td>59</td>
<td>42%</td>
</tr>
<tr>
<td>8th Grade</td>
<td>18</td>
<td>13%</td>
</tr>
<tr>
<td>Blank</td>
<td>12</td>
<td>8%</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>24</td>
<td>17%</td>
</tr>
</tbody>
</table>
Table 11

School B Student Responses to Question 1b – What Textbook are You Using?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Science/Glencoe (Red)</td>
<td>72</td>
<td>84%</td>
</tr>
<tr>
<td>Physical Science</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>A Science One</td>
<td>4</td>
<td>5%</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>7</td>
<td>8%</td>
</tr>
<tr>
<td>Blank</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

Question 1c asked “How often does your teacher use the textbook for instruction?” Tables 12 and 13, which show the results from School A and School B are presented below.

The students responded by supplying various categories of frequency for textbook use in Question 1c. At School A the students responded that Ms. Gant used the textbook frequently—all the time/often or 3/4 times a week (31%), or less frequently—2 times a week, 1 time a week, or only when needed (69%).

Table 12

School A Student Responses to Question 1c – How Often Does Your Teacher Use the Textbook for Instruction?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>All the time/Everyday</td>
<td>32</td>
<td>23%</td>
</tr>
<tr>
<td>3 /4 times a week</td>
<td>12</td>
<td>8%</td>
</tr>
<tr>
<td>2 times a week</td>
<td>26</td>
<td>18%</td>
</tr>
<tr>
<td>1 time a week</td>
<td>34</td>
<td>24%</td>
</tr>
<tr>
<td>Only when we need it</td>
<td>39</td>
<td>27%</td>
</tr>
</tbody>
</table>
Table 13

School B Student Responses to Question 1c – How Often Does Your Teacher Use the Textbook for Instruction?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everyday/Often</td>
<td>16</td>
<td>16%</td>
</tr>
<tr>
<td>2 times a week</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td>1 time a week</td>
<td>20</td>
<td>20%</td>
</tr>
<tr>
<td>2 times a month</td>
<td>4</td>
<td>5%</td>
</tr>
<tr>
<td>1 time a month</td>
<td>9</td>
<td>9%</td>
</tr>
<tr>
<td>Not often</td>
<td>30</td>
<td>35%</td>
</tr>
<tr>
<td>Blank</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

The investigator had observed in the classroom that both sets of textbooks were lined up on a shelf, and did not observe Ms. Gant using a textbook, although she indicated using both textbooks and the LCC to plan her lessons. At School B, the students responded that Ms. Kelly used the textbook frequently—everyday/often or 2 times a week (21%) or less frequently—1 time a week, 2 times a month, 1 time a month, and not often (74%). While observing Ms. Kelly’s class, the investigator saw an activity and a lesson with the textbook.

Question 1d asked the students if they liked science and asked if the class was similar or different from their other classes. Many students responded that they liked science class and provided some reasons why they liked science class better than other classes.
Table 14

School A Student Responses to Question 1d – Do you like science class? How is science similar or different from some of your other classes?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>63</td>
<td>44%</td>
</tr>
<tr>
<td>Yes, Projects/Hand-on Activities</td>
<td>23</td>
<td>16%</td>
</tr>
<tr>
<td>Yes, Experiments</td>
<td>22</td>
<td>16%</td>
</tr>
<tr>
<td>Yes, Teacher</td>
<td>5</td>
<td>4%</td>
</tr>
<tr>
<td>Yes, taking notes</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>No</td>
<td>20</td>
<td>14%</td>
</tr>
<tr>
<td>Blank</td>
<td>7</td>
<td>5%</td>
</tr>
</tbody>
</table>

Table 15

School B Student Responses to Question 1d – Do you like science class? How is science similar or different from some of your other classes?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>31</td>
<td>36%</td>
</tr>
<tr>
<td>Yes, Projects/Hands-on/Group Activities</td>
<td>25</td>
<td>29%</td>
</tr>
<tr>
<td>Yes, Experiments</td>
<td>10</td>
<td>12%</td>
</tr>
<tr>
<td>Yes, Teacher</td>
<td>4</td>
<td>5%</td>
</tr>
<tr>
<td>No</td>
<td>14</td>
<td>16%</td>
</tr>
<tr>
<td>Blank</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>
Out of the 142 students from School A responding to the questionnaire, 81% responded that they liked science class and many of them provided reasons why. In this favorable group, 32% of the students liked science class because Ms. Gant utilized projects, experiments, and hands-on activities. At School B, 82% of the students indicated that they like science class. Of this favorable group, 41% like science class because of the activity-based instruction and the experiments conducted in class.

Question 2 asked students to describe their feelings about the grade 8 LEAP test. The three subquestions asked the students what they thought about the test, whether they felt prepared to answer the questions on the test, whether they thought the questions were easy or hard, what types of questions were easy, what types of questions were hard, whether they tried their best on the test, and if the questions on LEAP were similar to their classroom assessments.

Question 2a asked the students to describe their feelings about the grade 8 LEAP test. Table 16 and 17 provide the results for School A and School B.

Table 16
School A Student Responses to Question 2a. – What Did You Think About the Grade 8 LEAP Science Test

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>54</td>
<td>38%</td>
</tr>
<tr>
<td>Easy</td>
<td>27</td>
<td>19%</td>
</tr>
<tr>
<td>Mix of Hard and Easy</td>
<td>31</td>
<td>22%</td>
</tr>
<tr>
<td>Boring</td>
<td>7</td>
<td>5%</td>
</tr>
<tr>
<td>Okay</td>
<td>9</td>
<td>6%</td>
</tr>
<tr>
<td>Do not like</td>
<td>4</td>
<td>3%</td>
</tr>
<tr>
<td>Blank</td>
<td>8</td>
<td>7%</td>
</tr>
</tbody>
</table>
Table 17

School B Student Responses to Question 2a. – What Did You Think About the Grade 8 LEAP Science Test

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>29</td>
<td>34%</td>
</tr>
<tr>
<td>Easy</td>
<td>35</td>
<td>41%</td>
</tr>
<tr>
<td>Mix of Hard and Easy</td>
<td>14</td>
<td>16%</td>
</tr>
<tr>
<td>Okay</td>
<td>3</td>
<td>4%</td>
</tr>
<tr>
<td>Do not like</td>
<td>4</td>
<td>4%</td>
</tr>
<tr>
<td>Long</td>
<td>1</td>
<td>1%</td>
</tr>
</tbody>
</table>

The students at both schools provided a variety of responses. The majority of the students indicated that the LEAP test was either easy, hard, or a mix of easy and hard. At School A students said either that LEAP questions were hard (38%), easy (19%), or a mix of easy and hard questions (22%). The rest of the categories included boring, okay, and do not like. At School B, the majority of the students also provided the three categories of easy, hard, and a mix of easy and hard. The students felt the LEAP test was hard (34%), easy (41%), or a mix of easy and hard (16%). The additional categories were okay, do not like, and long.

Questions 2b asked the students if they felt prepared to answer the questions on the test. Table 18 and 19 show the results for School A and School B.

The students at School A and School B came up with the same three categories to question 2b: yes, no, and somewhat/a little. At School A, the students felt prepared to answer the LEAP questions (50%), somewhat prepared (33%), or not prepared (13%). At School B, the
students felt prepared (60%), somewhat prepared (17%), or not prepared (21%). In both schools the majority of students felt at least somewhat prepared to take the LEAP test.

Table 18

School A Student Responses to Question 2b. – Did You Feel Prepared to Answer the Questions on This Test?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>72</td>
<td>50%</td>
</tr>
<tr>
<td>No</td>
<td>18</td>
<td>13%</td>
</tr>
<tr>
<td>Somewhat/A little</td>
<td>47</td>
<td>33%</td>
</tr>
<tr>
<td>Blank</td>
<td>5</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 19

School B Student Responses to Question 2b. – Did You Feel Prepared to Answer the Questions on This Test?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>51</td>
<td>60%</td>
</tr>
<tr>
<td>No</td>
<td>18</td>
<td>21%</td>
</tr>
<tr>
<td>Somewhat/A little</td>
<td>15</td>
<td>17%</td>
</tr>
<tr>
<td>Blank</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

The next question, question 2c, asked the students if they thought the questions were easy or hard. The student responses were divided into 3 categories: easy, hard, and a mix of easy and hard. Tables 20 and 21 show the student responses to question 2c.
Table 20

School A Student Responses to Question 2c. – Did You Think That the Questions Were Easy or Hard?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td>20</td>
<td>14%</td>
</tr>
<tr>
<td>Hard</td>
<td>39</td>
<td>27%</td>
</tr>
<tr>
<td>Mix of Easy and Hard</td>
<td>73</td>
<td>52%</td>
</tr>
<tr>
<td>Blank</td>
<td>10</td>
<td>7%</td>
</tr>
</tbody>
</table>

Table 21

School B Student Responses to Question 2c. – Did You Think That the Questions Were Easy or Hard?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td>19</td>
<td>22%</td>
</tr>
<tr>
<td>Hard</td>
<td>18</td>
<td>21%</td>
</tr>
<tr>
<td>Mix of Easy and Hard</td>
<td>46</td>
<td>53%</td>
</tr>
<tr>
<td>Blank</td>
<td>3</td>
<td>4%</td>
</tr>
</tbody>
</table>

The student responses at School A and School B were very similar. The students three categories were the same with approximately the same percentages of students within each category. At School A students felt the questions were easy (14%), hard (27%), or a mix of each and hard (52%). At School B students felt the test was easy (22%), hard (21%), or a mix of easy and hard (53%). A majority of students at both schools found that the LEAP test to have a mix of
easy and hard questions. These responses are appropriate because the LEAP test is designed to have items with a range of difficulty on each test form.

Question 2d was divided into two questions: what types of questions are easy and what types of questions are hard. The total number of students varied on this one question. At School A some of the students commented that questions were easy (116) and others that questions were hard (97). At School B students were more balanced in their views, responding that questions were easy (75) and were hard (75). Tables 22, 23, 24, and 25 show the results.

Table 22
School A Student Responses to Question 2d – What Types of Questions Were Easy?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=116)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple-Choice Items</td>
<td>72</td>
<td>62%</td>
</tr>
<tr>
<td>Items with Visual (pictures, graphs)</td>
<td>21</td>
<td>18%</td>
</tr>
<tr>
<td>Earth Science Content</td>
<td>5</td>
<td>4%</td>
</tr>
<tr>
<td>Other Content Besides Science</td>
<td>8</td>
<td>7%</td>
</tr>
<tr>
<td>Constructed-Response items</td>
<td>4</td>
<td>4%</td>
</tr>
<tr>
<td>Content Learned</td>
<td>6</td>
<td>5%</td>
</tr>
</tbody>
</table>

While the student responses were varied between each school, there were some definite patterns across both schools. For the first question, “Which types of questions were easy,” some of the categories the students identified were multiple-choice items, items with visuals, and items with content previously learned. For the second question, “Which types of questions were hard,” some of the categories included constructed-response items, items without visuals, and items of
content that the students had not learned prior to testing. In both schools the primary opposing categories were that multiple-choice items were easy and constructed-response items were hard.

In both schools, approximately 18-23% of the students indicated that having some type of visual with the item made the questions easier.

Table 23

School B Student Responses to Question 2d – What Types of Questions Were Easy?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=75)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple-Choice Items</td>
<td>44</td>
<td>59%</td>
</tr>
<tr>
<td>Items with Visual (pictures, graphs)</td>
<td>17</td>
<td>23%</td>
</tr>
<tr>
<td>Content Learned</td>
<td>8</td>
<td>10%</td>
</tr>
<tr>
<td>Earth Science Content</td>
<td>3</td>
<td>4%</td>
</tr>
<tr>
<td>Constructed-Response items</td>
<td>3</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 24

School A Student Responses to Question 2d – What Types of Questions Were Hard?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=97)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructed-Response items</td>
<td>72</td>
<td>74%</td>
</tr>
<tr>
<td>Without Visuals</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>Content not learned</td>
<td>6</td>
<td>6%</td>
</tr>
<tr>
<td>Math/Science Content</td>
<td>12</td>
<td>12%</td>
</tr>
<tr>
<td>Multiple-choice items</td>
<td>4</td>
<td>4%</td>
</tr>
</tbody>
</table>
Table 25

School B Student Responses to Question 2d – What Types of Questions Were Hard?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=75)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructed-Response items</td>
<td>48</td>
<td>64%</td>
</tr>
<tr>
<td>Without Visuals</td>
<td>8</td>
<td>10%</td>
</tr>
<tr>
<td>Content not learned</td>
<td>9</td>
<td>12%</td>
</tr>
<tr>
<td>Not Earth Science Content</td>
<td>3</td>
<td>4%</td>
</tr>
<tr>
<td>Multiple-choice items</td>
<td>2</td>
<td>3%</td>
</tr>
<tr>
<td>Don’t Know/Can’t Remember</td>
<td>5</td>
<td>7%</td>
</tr>
</tbody>
</table>

Question 2e asked the students if they tried their best on the field test and which section of the test they tried the hardest. Tables 26 and 27 show the results.

Table 26

School A Student Responses to Question 2e – Did You Try Your Best on This Field Test? What Section of the Test Did You Try Your Best?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>63</td>
<td>44%</td>
</tr>
<tr>
<td>Yes, multiple-choice section</td>
<td>23</td>
<td>16%</td>
</tr>
<tr>
<td>Yes, constructed-response sections</td>
<td>11</td>
<td>8%</td>
</tr>
<tr>
<td>Yes, all of the test</td>
<td>31</td>
<td>22%</td>
</tr>
<tr>
<td>No</td>
<td>9</td>
<td>6%</td>
</tr>
<tr>
<td>Blank</td>
<td>5</td>
<td>4%</td>
</tr>
</tbody>
</table>
Table 27

School B Student Responses to Question 2e – Did You Try Your Best on This Field Test? What Section of the Test Did You Try Your Best?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>7</td>
<td>8%</td>
</tr>
<tr>
<td>Yes, multiple-choice section</td>
<td>20</td>
<td>23%</td>
</tr>
<tr>
<td>Yes, constructed-response sections</td>
<td>19</td>
<td>22%</td>
</tr>
<tr>
<td>Yes, all of the test</td>
<td>29</td>
<td>34%</td>
</tr>
<tr>
<td>No</td>
<td>9</td>
<td>10%</td>
</tr>
<tr>
<td>Blank</td>
<td>3</td>
<td>3%</td>
</tr>
</tbody>
</table>

The categories of student responses from each school were the same. At School A, 90% of the students responded that they tried hard on the field test. In that group, students tried hard on the multiple-choice section (16%), on the constructed-response section (8%), and on the entire field test (22%). At School B, 87% of the students responded that they tried hard on the test. In that group, students tried hard on the multiple-choice section (23%), on the constructed-response sections (22%), and on all of the test (34%). The majority of the students at each school tried their best when taking the field test, and tried hard on the multiple-choice section.

Question 2f asked the students if the grade 8 LEAP test was similar to their classroom assessments. Table 28 shows the variation of student responses at School A. At School B the categories were limited to yes, no, and somewhat/a little. Table 29 shows the results for School B.
Table 28

School A Student Responses to Question 2f – Was This Test Similar to Your Classroom Assessments?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, Bell Ringer</td>
<td>10</td>
<td>7%</td>
</tr>
<tr>
<td>Yes, Classroom Tests</td>
<td>45</td>
<td>32%</td>
</tr>
<tr>
<td>Yes, LEAP Practice Tests</td>
<td>9</td>
<td>6%</td>
</tr>
<tr>
<td>Somewhat/A little</td>
<td>26</td>
<td>18%</td>
</tr>
<tr>
<td>No</td>
<td>47</td>
<td>33%</td>
</tr>
<tr>
<td>Blank</td>
<td>5</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 29

School B Student Responses to Question 2f – Was This Test Similar to Your Classroom Assessments?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>27</td>
<td>31%</td>
</tr>
<tr>
<td>No</td>
<td>40</td>
<td>47%</td>
</tr>
<tr>
<td>Somewhat/A little</td>
<td>15</td>
<td>17%</td>
</tr>
<tr>
<td>Blank</td>
<td>4</td>
<td>5%</td>
</tr>
</tbody>
</table>

The categories produced by the students were yes, no, and somewhat/a little in similarity to other classroom assessments. At School A many of the students (45%) provided some positive examples as to how the test questions were similar to other assessments in their class, e.g. their bell ringer activity, their classroom tests, and their LEAP practice tests. At School B some of the
students (31%) felt that these items were similar to their classroom assessments. At both schools, however, a majority of the students indicated that the items were not similar.

Question 3 asked the students to describe their use of photographs in science class and on science tests. As with the previous two questions, the students did not respond to the main question but responded to the four subquestions: a) Do you use the photographs in your textbook to help you understand science concepts?, b) Have you seen photographs on a standardized test before?, c) Did you use the photographs to help you answer the questions?, and d) Did the photographs help you understand the text of the question? For all four questions, the students at both schools responded with yes, no, and sometimes. They did not provide further descriptions.

Question 3a asked the students if they used the photographs in their textbook to help them understand science concepts. Tables 30 and 31 show results from School A and School B.

Table 30

School A Student Responses to Question 3a. – Do You Use the Photographs in Your Textbook to Help You Understand Science Concepts?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>78</td>
<td>55%</td>
</tr>
<tr>
<td>No</td>
<td>29</td>
<td>20%</td>
</tr>
<tr>
<td>Sometimes</td>
<td>27</td>
<td>19%</td>
</tr>
<tr>
<td>Blank</td>
<td>8</td>
<td>6%</td>
</tr>
</tbody>
</table>

At School A only 55% of the students indicated that they used the photographs in their textbook to help them understand science concepts, while at school B 76% of the students
indicated that they used the photographs in their textbook. Between 16 and 19% of the students indicated that they used the photograph sometimes.

Table 31

School B Student Responses to Question 3a. – Do You Use the Photographs in Your Textbook to Help You Understand Science Concepts?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>65</td>
<td>76%</td>
</tr>
<tr>
<td>No</td>
<td>5</td>
<td>6%</td>
</tr>
<tr>
<td>Sometimes</td>
<td>14</td>
<td>16%</td>
</tr>
<tr>
<td>Blank</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

Question 3b asked students if they had seen photographs on a standardized test before. Table 32 and 33 show the results.

Table 32

School A Student Responses to Question 3b – Have You Seen Photographs on a Standardized Test Before?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>117</td>
<td>55%</td>
</tr>
<tr>
<td>No</td>
<td>7</td>
<td>20%</td>
</tr>
<tr>
<td>Sometimes</td>
<td>6</td>
<td>19%</td>
</tr>
<tr>
<td>Blank</td>
<td>12</td>
<td>6%</td>
</tr>
</tbody>
</table>

The categories from both schools were similar with responses of yes and no. School A also had a category of sometimes. At School A students indicated that they had seen photographs on
standardized tests definitely or at least sometimes (76%), while at School B students definitely had seen them before (88%).

Table 33

School B Student Responses to Question 3b – Have You Seen Photographs on a Standardized Test Before?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>76</td>
<td>88%</td>
</tr>
<tr>
<td>No</td>
<td>8</td>
<td>10%</td>
</tr>
<tr>
<td>Blank</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

Question 3c asked the students if they used the photographs to help them answer the questions on the test. Tables 34 and 35 show the results.

Table 34

School A Students Responses to Question 3c – Did You Use the Photographs to Help You Answer the Questions?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>109</td>
<td>76%</td>
</tr>
<tr>
<td>No</td>
<td>9</td>
<td>6%</td>
</tr>
<tr>
<td>Sometimes</td>
<td>15</td>
<td>11%</td>
</tr>
<tr>
<td>Blank</td>
<td>10</td>
<td>7%</td>
</tr>
</tbody>
</table>

The responses to question 3c were very similar at both schools. At School A 76% of the students responded positively, while 82% of the students at School B indicated that they used photographs to help them answer the questions. Some students at each of the schools (6%) did
not use the questions, while others—11% at School A and 16% at School B—used the photographs only sometimes to help them answer the questions.

Table 35

School B Students Responses to Question 3c – Did You Use the Photographs to Help You Answer the Questions?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>70</td>
<td>82%</td>
</tr>
<tr>
<td>No</td>
<td>5</td>
<td>6%</td>
</tr>
<tr>
<td>Sometimes</td>
<td>14</td>
<td>16%</td>
</tr>
<tr>
<td>Blank</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

The final question on the questionnaire asked the students if the photographs helped them to understand the question. School A students indicated that the photographs helped (73%), as did School B students (75%). Approximately 16% at School A and 18% of the students at School B answered that they used the photographs sometimes.

Table 36

School A Student Responses to Question 3d. – Did the Photographs Help You Understand the Text of the Question?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=142)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>103</td>
<td>73%</td>
</tr>
<tr>
<td>No</td>
<td>8</td>
<td>5%</td>
</tr>
<tr>
<td>Sometimes</td>
<td>26</td>
<td>18%</td>
</tr>
<tr>
<td>Blank</td>
<td>5</td>
<td>4%</td>
</tr>
</tbody>
</table>
Table 37

School B Student Responses to Question 3d. – Did the Photographs Help You Understand the Text of the Question?

<table>
<thead>
<tr>
<th>Student Response</th>
<th>Number of Students (n=86)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>64</td>
<td>75%</td>
</tr>
<tr>
<td>No</td>
<td>6</td>
<td>7%</td>
</tr>
<tr>
<td>Sometimes</td>
<td>14</td>
<td>16%</td>
</tr>
<tr>
<td>Blank</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

The responses to the student questionnaire provided the investigator with some insight into the feelings of the students about the LEAP test in general. In dealing with photographs, the students at both school felt that the photographs helped them to understand the text of the question.

THE TEACHERS

There were many similarities between the two teachers. Ms. Gant and Ms. Kelly both graduated from the same university with the same elementary education degree with a focus on upper elementary, and both are certified to teach grades 1 – 8. In addition, Ms. Gant has a master’s degree in educational technology. Ms. Kelly identified herself as “highly qualified” to teach sixth, seventh, and eighth grade science because she passed the PRAXIS exam for that focus. Table 38 identifies some similarities and differences between the two teachers. The teacher interview protocol is found in Appendix J.

There were few differences between Ms. Gant and Ms. Kelly. Ms. Gant’s master of educational technology degree was evident in that her classroom was set up with a projection
system and large screen. She also utilized PowerPoint during her lessons. Ms. Kelly indicated to the investigator that she used technology, e.g. Net TV, but this was not observed. Both teachers indicated that they used group projects and activities in their classroom, and this use was observed.

Table 38

Similarities and Differences between Ms. Gant and Ms. Kelly

<table>
<thead>
<tr>
<th>Category</th>
<th>Ms. Gant</th>
<th>Ms. Kelly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree</td>
<td>B.A., Elementary Education (grade 1-8)</td>
<td>B.A., Elementary Education (grade 1-8)</td>
</tr>
<tr>
<td></td>
<td>M.A., Educational Technology</td>
<td>Highly qualified to teach grade 6, 7, and 8 (PRAXIS)</td>
</tr>
<tr>
<td>Years of Experience</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Years Teaching Middle School</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Perceived Expertise</td>
<td>General science</td>
<td>Earth and Space Science</td>
</tr>
<tr>
<td>Curriculum</td>
<td><em>Louisiana Comprehensive Curriculum</em></td>
<td><em>Louisiana Comprehensive Curriculum</em></td>
</tr>
<tr>
<td></td>
<td>Merrill, <em>Earth Science</em></td>
<td></td>
</tr>
<tr>
<td>Teaching Methodology</td>
<td>• Read/answer questions</td>
<td>• take notes</td>
</tr>
<tr>
<td></td>
<td>• Group projects/activities</td>
<td>• read/answer questions</td>
</tr>
<tr>
<td></td>
<td>• Experiments</td>
<td>• exploratory activites</td>
</tr>
<tr>
<td>Use of Pictorial Representation</td>
<td>• daily graph activity</td>
<td>• charts, graphs, diagrams</td>
</tr>
<tr>
<td></td>
<td>• charts and diagrams</td>
<td>• photographs from textbook series</td>
</tr>
<tr>
<td></td>
<td>• concept maps</td>
<td></td>
</tr>
<tr>
<td>Types of Test Items</td>
<td>• multiple choice</td>
<td>• multiple choice</td>
</tr>
<tr>
<td></td>
<td>• short answer with diagrams</td>
<td>• short answer with diagrams</td>
</tr>
</tbody>
</table>
ANALYSIS OF THE RESEARCH QUESTIONS

The investigator analyzed the quantitative data using a variety of methods. Quantitative analysis of the grade 8 LEAP field test data file was conducted to compute \( t \)-tests and Spearman’s rho correlation. SPSS was the program utilized to analyze the data. The qualitative data were also analyzed to identify theme and patterns.

THE PRIMARY RESEARCH QUESTION

Classical Item Statistics for Form 3 and Form 4

How does middle school students’ performance on photograph-based multiple-choice items in a state science achievement test compare to their performance for text-only multiple-choice questions? This question was addressed using item analysis for each item on the field test, including the following analyses:

- Classical item difficulty — (i.e., p-value)
- Classical item discrimination statistic, —(i.e., point-biserial correlation)
- For multiple-choice items, the number of examinees who left the item blank and the percentage of students answering each distracter.

Using classical statistics and student responses from the entire field test sample for Form 3 and Form 4, the investigator compared the statistics on the photograph-based multiple-choice items and the text-only multiple-choice items to determine how the photographs impact student performance. The classical item statistics for Form 3 are presented in Table 39.

The data in Table 39 show the results from the entire student population that was administered Form 3 (n=1180). Depending on the item, the item difficulty ranged from .4339 to
.7638 and the point biserial (Pearson product-moment correlation) ranged from .0366 to .5033.

For purposes of discussion, the investigator analyzed each item separately for Form 3.

Table 39

Classical Item Statistics for Form 3

<table>
<thead>
<tr>
<th>Item</th>
<th>Version</th>
<th>Item Difficulty</th>
<th>Point biserial</th>
<th>% Blank</th>
<th>% A</th>
<th>% B</th>
<th>% C</th>
<th>% D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitcher Plant</td>
<td>photograph</td>
<td>.5004</td>
<td>.0366</td>
<td>0</td>
<td>31</td>
<td>12</td>
<td>50</td>
<td>6</td>
</tr>
<tr>
<td>Desert/ Tundra</td>
<td>photograph</td>
<td>.4958</td>
<td>.3793</td>
<td>0</td>
<td>49</td>
<td>39</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Spider Web</td>
<td>photograph</td>
<td>.6094</td>
<td>.3945</td>
<td>1</td>
<td>19</td>
<td>60</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Marsh</td>
<td>photograph</td>
<td>.7638</td>
<td>.3683</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>76</td>
<td>13</td>
</tr>
<tr>
<td>Heron</td>
<td>text</td>
<td>.4339</td>
<td>.228</td>
<td>0</td>
<td>19</td>
<td>43</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>Puffer Fish</td>
<td>text</td>
<td>.7527</td>
<td>.5033</td>
<td>1</td>
<td>11</td>
<td>7</td>
<td>7</td>
<td>75</td>
</tr>
</tbody>
</table>

For the pitcher plant item, the item difficulty was .5004, which indicates that approximately 50% of the students taking Form 3 answered the pitcher plant item correctly. The point-biserial statistic of .0366 indicates that this item did not discriminate well between students who performed well on the test and students who performed poorly. While 50% of the students answered the item correctly, 31% choose an incorrect response of A. The point biserial is very low, indicating that students who performed well on this field test answered this item incorrectly.

The desert/tundra item difficulty was .4958, which indicates that approximately 50% of the students answered the item correctly on Form 3. The point-biserial value is .3793, which is positive according to test measurement statistics (when designing test forms, psychometricians
prefer that the point-biserial value be above .20). This value of .3793 indicates that the item discriminated well between students who performed well on the test and students who performed poorly. Students who scored highly on this instrument also answered this item correctly. While approximately 50% of the students answered this item correctly, 39% were drawn to the incorrect response of B. The point biserial value is very high, indicating that the students who answered this item correctly performed well on the entire field test. Of the 39% of students who answered the desert/tundra item incorrectly, they performed poorly on this instrument.

The spider web item performed very well on the test. Approximately 60% of the students answered the item correctly. The point biserial correlation was .3945. This finding indicated that the students who performed well on this test answered this item correctly. Only 19% of the students chose A, 7% chose C, and 12% chose D. Of these three distractors, students who performed poorly on the test as a whole chose A, B, or D.

The statistics for the marsh item are favorable. With an item difficulty of .7638 and a point biserial of .3683, the data showed that 76% of the students answered this item correctly. The point biserial indicated that of this 76%, the students who performed well on this test also answered this item correctly. Only 24% of the students were drawn to an incorrect response: 7% chose B, 13% chose D, and 4% chose A.

The heron item was a text item and only 43% of the students answered this item correctly. The item thus appears to be more difficult than the other items in the study. The point biserial is in the acceptable range at .228 and would be available for use on a statewide assessment. The lower point biserial, however, indicates that many of the students who performed well on this instrument chose this incorrect answer for this item. This item did not discriminate as well as some other items in this study.
The puffer fish item had an item difficulty of .7527 and a point biserial of .5033. The data showed that 75% of the students answered this item correctly and that the students who answered the item correctly also performed well on the field test as a whole. The high point biserial correlation of .5033 also indicated that those students who performed poorly on this test also answered this item incorrectly.

The classical item statistics were analyzed for Form 4. The data in Table 40 showed the results from the entire student population that was administered Form 4 (n=1130). Depending on the item, the item difficulty ranged from .4857 to .789 and the point biserial (Pearson product-moment correlation) ranged from .0469 to .3858. For purposes of discussion, the investigator analyzed each item separately for Form 4.

Table 40
Classical Item Statistics for Form 4

<table>
<thead>
<tr>
<th>Item</th>
<th>Version</th>
<th>Item Difficulty</th>
<th>Point biserial</th>
<th>% Blank</th>
<th>% A</th>
<th>% B</th>
<th>% C</th>
<th>% D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitcher Plant</td>
<td>text</td>
<td>.4857</td>
<td>.0469</td>
<td>4</td>
<td>29</td>
<td>13</td>
<td>47</td>
<td>8</td>
</tr>
<tr>
<td>Desert/Tundra</td>
<td>text</td>
<td>.507</td>
<td>.3601</td>
<td>4</td>
<td>49</td>
<td>36</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Spider Web</td>
<td>text</td>
<td>.6146</td>
<td>.3404</td>
<td>4</td>
<td>15</td>
<td>59</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Marsh</td>
<td>photograph</td>
<td>.7567</td>
<td>.3751</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>73</td>
<td>13</td>
</tr>
<tr>
<td>Heron</td>
<td>photograph</td>
<td>.5344</td>
<td>.1738</td>
<td>4</td>
<td>17</td>
<td>51</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>Puffer Fish</td>
<td>photograph</td>
<td>.789</td>
<td>.3858</td>
<td>4</td>
<td>11</td>
<td>5</td>
<td>4</td>
<td>76</td>
</tr>
</tbody>
</table>
On Form 4 the text-only pitcher plant item exhibited an item difficulty of .4857, so approximately 49% of the students answered this item correctly. The point biserial value was .0469; this value indicated that there was not a correlation between the students who answered this item correctly and their performance on the test as a whole. While only 49% of the students answered this item correctly, the student performance of this group in the test was varied.

The text-only version item of the desert/tundra on Form 4 had an item difficulty of .507 and a point biserial of .3601. Approximately, 50% of the students taking Form 4 correctly selected A. Because the point biserial is .3601, the students who answered this item correctly also performed well on the entire field test. About 36% of the students chose an incorrect response of B. Because the point biserial is above .20, however, this finding indicated that students who performed poorly on the test chose B, C, and D.

The text-only version of the spider web item on Form 4 also performed well. About 61% of the students answered this item correctly. The point biserial correlation of .3404 indicates that students who answered this item correctly performed well on the field test. While there was some variation in selection of the distractors—15% chose A, 13% chose C, and 10% chose D—the majority of the students answered this item correctly.

The photograph-based version of the marsh item also appeared on Form 4. The item difficulty for this item was .7567 and the point biserial was .3751. The data showed that 76% of the students answered this item correctly, and of that group the majority performed well on the test as a whole. Other students selected incorrect responses of A (3%), B (7%), and D (13%).

The photograph-based version of the heron item on Form 4 had an item difficulty of .5344 and a point biserial of .1738. Approximately 53% of the students answered this item correctly. Because the point biserial is lower than .20, however, there may have been some guessing; some
of the students who performed well on the test answered the question incorrectly and some students who performed poorly on the test answered the item correctly. Incorrect responses were A (17%), C (10%) and D (17%).

The photograph-based version of the puffer fish item on Form 4 performed very well. This item had an item difficulty of .789 and a point biserial of .3858. Approximately 79% of the students answered this item correctly. Because the point biserial value was so high, a correlation was found between the percentage of students answering the item correctly and their performance on the test as a whole.

There are some similarities and differences between item performance on Form 3 and Form 4. For the pitcher plant item, there was little variation in performance when comparing the photograph-based to the text-only version. The point biserial values on both forms indicated that students may have been guessing if they were not familiar with pitcher plants. The desert/tundra item also performed statistically the same. The item difficulty and point biserial values on each form were the same, as well as the percentage of students answering each distractor. The spider web item performed the same for item difficulty but there was greater variation between the point biserial values on each form. There was a greater discrimination between students on Form 4, which was the text-only version. This could also mean that the middle to lower performing students were also answering the item correctly on the photograph-based version in Form 3. The photograph-based marsh item appeared on both Forms 3 and 4, and the item performed the same on both forms. The photograph-based version of the heron item on Form 3 performed differently on item difficulty, with approximately 10% more of the students answering this item correctly with the aid of the photograph. The puffer fish item had the same item difficulty, but the point biserials were different. The text-only item had a much high point biserial correlation than the
photograph-based version, meaning perhaps that the middle to lower performing students answered this item correctly when a photograph was utilized.

**Six Independent \( t \)-tests of Photograph-Based and Text-Only Items**

The investigator compared students’ performance on the photograph-based items to the text-only version of the same item, using six simple \( t \)-tests. These tests were conducted to compare the mean number correct of the picture group (on the relevant items) in association with the non picture group for the entire field test sample for Form 3 and Form 4. The investigator selected an alpha level of .06 because there were 6 separate \( t \)-tests calculated. The investigator used the Bonferroni Adjustment to maintain an alpha level of .06 divided by six independent \( t \)-tests. Essentially, the alpha level for each \( t \)-test is .01. The only item showing a significant difference in performance on the Forms is the heron item. The percentage of students responding correctly to the heron item is greater with the photograph version. Because the SIG value is .000, which is less than .001, there is a significant difference in performance between the photograph-based item and the text-only item. Table 41 displays the results of the analysis.

**ANALYSIS OF SUBQUESTION 1**

1. Which categories of students, if any, benefited most (based on their scores) from the inclusion of photograph-based multiple-choice items?

   By comparing student performance on the text-only version and the photograph-based version of the item, the investigator determined if there were any categories of students that benefited from the inclusion of photograph-based multiple-choice items. Table 42 shows the results.
Table 41
Six $t$-Tests Comparing Student Performance for Each Topic on Form 3 and Form 4

<table>
<thead>
<tr>
<th>Item</th>
<th>Form 3 Mean (SD)</th>
<th>Form 4 Mean (SD)</th>
<th>$t$</th>
<th>Df</th>
<th>SIG</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitcher Plant</td>
<td>Photograph</td>
<td>Text</td>
<td>.948</td>
<td>2313</td>
<td>.343</td>
<td>1.6798</td>
</tr>
<tr>
<td></td>
<td>.5030(.5002)</td>
<td>.4832(.4999)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desert/Tundra</td>
<td>Photograph</td>
<td>Text</td>
<td>-.612</td>
<td>2313</td>
<td>.541</td>
<td>7.0008</td>
</tr>
<tr>
<td></td>
<td>.4983(.5002)</td>
<td>.5110(.5001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spider Web</td>
<td>Photograph</td>
<td>Text</td>
<td>-.340</td>
<td>2302</td>
<td>.734</td>
<td>2.1815</td>
</tr>
<tr>
<td></td>
<td>.6090(.4882)</td>
<td>.6159(.4867)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marsh</td>
<td>Photograph</td>
<td>Photograph</td>
<td>.433</td>
<td>2312</td>
<td>.665</td>
<td>3.5075</td>
</tr>
<tr>
<td></td>
<td>.7678(.4224)</td>
<td>.7601(.4272)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heron</td>
<td>Text</td>
<td>Photograph</td>
<td>-4.857</td>
<td>2310</td>
<td>.000</td>
<td>4.4573</td>
</tr>
<tr>
<td></td>
<td>.4340(.4958)</td>
<td>.5345(.4990)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Puffer Fish</td>
<td>Text</td>
<td>Photograph</td>
<td>-2.028</td>
<td>2307</td>
<td>.043</td>
<td>7.7275</td>
</tr>
<tr>
<td></td>
<td>.7549(.4303)</td>
<td>.7903(.4073)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The data showed that there was little variation in student performance on the photograph-based items and the text-only based items when comparing student performance at each achievement level. For each item, the performance was approximately the same or the students performed better on the photograph-based items. On the pitcher plant item, students scoring at the Mastery, Approaching Basic, and Unsatisfactory levels performed higher on the photograph-based items when compared to the text-only version. For the desert/tundra item, the students at the Advanced and Approaching Basic levels had a higher percentage of students answering the...
photograph-based item correctly; the Mastery, Basic, and Unsatisfactory levels had similar means. For the spider web item, the Mastery and Basic levels showed higher performance on the photograph-based version, while the remaining achievement levels exhibited similar statistics.

Table 42

Comparison of Mean Number Correct on Photograph-Based Items and Text-Only Items by Achievement Level

<table>
<thead>
<tr>
<th>Item Topic</th>
<th>Item Type</th>
<th>Advanced Mean(SD)</th>
<th>Mastery Mean(SD)</th>
<th>Basic Mean(SD)</th>
<th>Approaching Basic Mean(SD)</th>
<th>Unsatisfactory Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitcher</td>
<td>Photo</td>
<td>.5667 (.5040)</td>
<td>.4857 (.5000)</td>
<td>.4793 (.5002)</td>
<td>.5196 (.5004)</td>
<td>.5349 (.5002)</td>
</tr>
<tr>
<td>Plant</td>
<td>Text</td>
<td>.6000 (.5071)</td>
<td>.4439 (.4982)</td>
<td>.5000 (.5005)</td>
<td>.4667 (.4997)</td>
<td>.4936 (.5016)</td>
</tr>
<tr>
<td>Desert/</td>
<td>Photo</td>
<td>.9333 (.2537)</td>
<td>.7048 (.4572)</td>
<td>.5471 (.4984)</td>
<td>.4048 (.4916)</td>
<td>.2267 (.4200)</td>
</tr>
<tr>
<td>Tundra</td>
<td>Text</td>
<td>.8000 (.4140)</td>
<td>.7968 (.4035)</td>
<td>.5551 (.4975)</td>
<td>.3779 (.4857)</td>
<td>.2628 (.4416)</td>
</tr>
<tr>
<td>Spider</td>
<td>Photo</td>
<td>.9333 (.2537)</td>
<td>.8238 (.3819)</td>
<td>.6790 (.4674)</td>
<td>.4787 (.5003)</td>
<td>.3491 (.4781)</td>
</tr>
<tr>
<td>Web</td>
<td>Text</td>
<td>1.0000 (.0000)</td>
<td>.7861 (.4111)</td>
<td>.6497 (.4776)</td>
<td>.5758 (.4951)</td>
<td>.3526 (.4793)</td>
</tr>
<tr>
<td>Heron</td>
<td>Photo</td>
<td>.5333 (.5164)</td>
<td>.6043 (.4903)</td>
<td>.5723 (.4952)</td>
<td>.5117 (.5007)</td>
<td>.3871 (.4887)</td>
</tr>
<tr>
<td></td>
<td>Text</td>
<td>.6333 (.4901)</td>
<td>.5286 (.5004)</td>
<td>.4782 (.5001)</td>
<td>.3686 (.4832)</td>
<td>.2965 (.4581)</td>
</tr>
<tr>
<td>Puffer</td>
<td>Photo</td>
<td>.9333 (.2582)</td>
<td>.9305 (.2550)</td>
<td>.8684 (.3385)</td>
<td>.7258 (.4469)</td>
<td>.5000 (.5016)</td>
</tr>
<tr>
<td>Fish</td>
<td>Text</td>
<td>1.0000 (.0000)</td>
<td>.9095 (.2876)</td>
<td>.8621 (.3452)</td>
<td>.6626 (.4735)</td>
<td>.4211 (.4952)</td>
</tr>
<tr>
<td>Marsh</td>
<td>Photo</td>
<td>1.0000 (.0000)</td>
<td>.9235 (.2665)</td>
<td>.8529 (.3546)</td>
<td>.6606 (.4742)</td>
<td>.5349 (.5002)</td>
</tr>
<tr>
<td></td>
<td>Photo</td>
<td>1.0000 (.0000)</td>
<td>.9359 (.2457)</td>
<td>.8178 (.3864)</td>
<td>.6900 (.4632)</td>
<td>.4872 (.5015)</td>
</tr>
</tbody>
</table>

The greatest difference in performance was exhibited on the heron and puffer fish items. For the heron item, the Mastery, Basic, Approaching Basic, and Unsatisfactory levels all show at least a 10% difference in student performance in successfully answering the heron question with a photograph-based item. For the puffer fish item, the Mastery and Basic levels show a slight
increase in student performance, but the Approaching Basic and Unsatisfactory level show approximately an 8% increase in student performance when the item is photograph-based.

The marsh item was used on both forms to ensure that the two samples were performing consistently. There was no difference in the means on either form at each achievement level. The two groups were found to perform consistently.

Graphs illustrating student performance were developed on each topic for Form 3 and Form 4. These graphs appear in Appendix M.

ANALYSIS OF SUBQUESTION 2

2. How well does student performance on science-content-equivalent items, using matched pairs of those two types of multiple-choice items, correlate?

The investigator used student data on the grade 8 field test and student achievement level data on the grade 8 operational test (administered in March 2007) to determine if student performance correlated on photograph-based items. Spearman’s rho was used to correlate two variables, one or both of which are ordinal (categorical) values. The Spearman’s rho value for the photograph-based items was .392. It was found that 15% of the variation in percent correct for the photograph-based items was shared with achievement level.

For the text-only items, the Spearman rho value was .325. About 11% of the percent correct of the text only items was shared with achievement level. There is a moderate positive correlation between achievement level and percent correct on the photograph-based items.
ANALYSIS OF SUBQUESTION 3

3. Are there differences in test performance between students who were introduced to and used the 20-Question Model of Photographic Inquiry during science instruction and those who were not?

The investigator separated the statistics from each form of the field test and divided them into two categories: students exposed to the 20-Question Model at School A and School B and the remaining students at School A or School B not exposed to the 20-Question Model. The investigator analyzed student performance between all grade 8 classes at each school, so as to compare student performance in the class that was introduced to the 20-Question Model and the classes that were not introduced the 20-Question Model.

The data showed that at School A (Form 3) there was no difference in mean performance on the photograph-based items between the treatment group and the control group. The mean number of items correct was almost exact. In addition, the significance value of .975 for the t-test for equality at a=0.05 level indicated there was no significant difference between the treatment group and control group.

The data showed at School B (Form 4) there was a 7% difference in mean performance on photograph-based items between the treatment group and the control group. The mean number of items correct on the photograph-based items favored the control group at School B. In addition the significance value of .241 for the t-test for equality at a.0.05 level indicated there was not a significant difference between the treatment group and the control group. Table 43 shows the results from the t-tests for School A and School B.
Table 43

Two t-tests Comparing the Treatment Group to the Control Group at School A and School B

<table>
<thead>
<tr>
<th>School</th>
<th>Treatment Mean(Standard Deviation)</th>
<th>Control Mean(Standard Deviation)</th>
<th>t</th>
<th>df</th>
<th>SIG</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>School A</td>
<td>.6477(.0484)</td>
<td>.6496(.0232)</td>
<td>.032</td>
<td>.142</td>
<td>.975</td>
<td>.0483</td>
</tr>
<tr>
<td>(Form 3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School B</td>
<td>.6667(.2247)</td>
<td>.7419(.2727)</td>
<td>1.182</td>
<td>83</td>
<td>.241</td>
<td>.2028</td>
</tr>
<tr>
<td>(Form 4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The data showed that the treatment for these two schools did not influence student performance on the photograph-based items. The students in the treatment group and the control group performed equally well on the photograph-based test items.

ANALYSIS OF SUBQUESTION 4

4. How did four concept-map-based mini-case studies of a high and a low test performing male and female triangulate with their subscores on the tests’ photograph-based multiple-choice items and their subscores on the text-based multiple-choice items?

The Student Interviews

Interviews were conducted to reveal illuminating information about the thought processes of each student as they answered the study questions. The Student Interview Protocol is Appendix K. The investigator identified some misconceptions held by each student, regardless of ability level. The investigator interviewed four students to participate in the interviews and co-construction of concept maps. There were two students at School A and two students from...
School B, including two females and two males. These students were selected by their teachers as representative of high-performing and low-performing students, based on their class grades. Ms. Gant selected Randy as a high-performing male and Ann as an average performing female. Ms. Kelly selected Molly, a high performing female and Aaron, an average performing male. During the interview of each student, the investigator asked the students to explain how they answered each question.

For the pitcher plant item, none of the students was familiar with the pitcher plant. Randy and Ann were administered the item with the photograph; Randy and Ann both responded that the photograph helped them visualize the plant. Both students were able to make the connection between the green plant and photosynthesis. Molly and Aaron were administered the text-only version. Molly and Aaron incorrectly responded that since the plant ate insects, it didn’t go through photosynthesis. Ann answered the item correctly; Molly, Aaron and Randy responded incorrectly to this item.

For the desert/tundra item, all the students responded that they had seen photographs of these two ecosystems prior to taking the field test. The students all used the process of elimination to answer this question. Each answer choice that described the characteristic of only one ecosystem was eliminated. All students answered this item correctly.

For the spider web item, Randy and Ann were administered the photograph-based version of the item and the others were not. Ann was confused by the word infiltration but this did not prohibit her from answering the item correctly. Molly, Randy, and Aaron responded that they knew the answer immediately. All students responded correctly to this item.

For the marsh item, all four students were administered a photograph-based version of this item. By using photograph, the students identified similarities between marshes and swamps.
and ruled out those choices, to correctly identify the difference between marshes and swamps. Consequently, all four students answered this item correctly.

For the heron item, Molly and Aaron were administered the photograph-based version of this item. Aaron reported that he observed the photograph “like we had done in class,” looked at the parts of the heron, and looked at the ecosystem represented in the picture, then he answered the question. Molly also looked at the photograph first and commented that she couldn’t see the heron’s feet. Both students were able answer the item correctly. Randy and Ann were administered the text-only version of this item. Randy reported that this item would have been easier if he had seen the photograph. All four students answered this item correctly.

For the puffer fish item, Molly and Aaron were administered the photograph-based version of this item. Both students had seen pictures of puffer fish before; however, both indicated that they used the photograph to help them answer the question. Randy and Ann were administered the text-only version of this item. Randy had seen an actual puffer fish before because his father is a shrimper. Ann had also seen a photograph of a puffer fish before. All four students answered the question correctly.

In addition to the six topics, the investigator held a discussion with the students about their experience with the treatment lessons. Ann indicated that the strategies helped her because she used those techniques to help her “draw a whole lot more details about the ecosystem and the animals that live in it.” Randy commented that if he had a photograph of the heron he would be able to “look at the physical features of the heron to see why it was in the environment that it was in.” Molly responded the she “looked at the photograph to try to determine what was happening in the photograph,…tried to make an observation of what was in the picture, …tried to infer what was happening, …then read the question.” Aaron commented that some of the types of
photographs we talked about in class were similar to the types of items on the test. All four students perceived that the photographs helped them answer the questions.

During the interviews the student also co-created six concept maps on the six topics tested: pitcher plant, desert/tundra, spider web, marsh/swamp, heron, and puffer fish. The six concept maps for each student are in Appendix L.

The Concept Maps

Pitcher Plant Concept Maps

Each student was given the superordinate concept of “pitcher plant” to begin his or her map. All four students included that pitcher plants live/grow in swamps. Molly’s map was the most detailed and included several levels of thought processes. She made connections between the tubes holding nectar and attracting insects and also made comparisons to the Venus Fly trap. Randy’s and Ann’s concept maps were very similar in that both utilized four levels of concepts. Randy included that “pitcher plants were adapted to catch insects.” Ann was the only student to explain that the pitcher plant uses “photosynthesis” to make food on her concept map. Aaron’s map was very linear and included only two levels of concepts. It also contained the misstatement that the pitcher plant holds nutrients for the insects, instead of that the insects provided nutrients.

Desert/Tundra Concept Maps

Each student had difficulty creating their concept maps. Molly, Ann, and Aaron started their concept maps with desert/tundra and essentially created two concept maps on one page, half dedicated to desert and half to tundra. Molly made some connections between the two concepts. Randy resolved the two concepts issue by starting his map with “little precipitation” and then dividing his map into two areas—desert and tundra. Ann combined the two concepts and created her map using similarities of the two types of ecosystems—extreme temperature and little
precipitation. Ann stated that deserts and tundra do not support plant life; this misconception
could have been caused by the photographs, which did not include plant life. Aaron’s map was
detailed and had three levels of concepts, however, most of his map described each ecosystem
without making any connections between the two ecosystems.

**Spider Web/Condensation Concept Maps**

Each map began with a superordinate concept of condensation. Molly’s map included three
levels of concepts that included two arrows connecting concepts. Her thoughts included water
droplets that become dense and the dense droplets that become precipitation. Randy’s map
concentrated on the condensation on the spider web; he concluded that condensation was the
water droplets on the spider web and string. Ann’s map was very clear and included one
propositional phrase, that “condensation is when water groups into droplets and forms clouds.”
Aaron’s map was very simple in stating that condensation is part of the water cycle and that
water is trapped in clouds and on the spider web.

**March Ecosystem Concept Maps**

The superordinate concepts on each map varied between marsh, marsh ecosystem, and
marsh and swamps. Molly began her map with the superordinate concept of marsh ecosystem;
she was able to provide details about the marsh having water, grass, and vegetation, but no trees.
She also provided some examples of organisms within the swamps, added information about the
grass stopping erosion, and made connections about food providing energy to long-legged birds.
Randy began his map with marsh and swamps, divided the map into similarities and differences,
and provided examples of each similarity (animal type) and difference (trees). Ann’s map
included that marsh ecosystems support life; she also provided examples of animal types and
made a connection that birds eat fish. Aaron was able to identify that a marsh is land that is
separate from water and doesn’t have trees; he was also able to provide examples of animals that live in a marsh.

**Heron Concept Maps**

For this map, Ann provided the most comprehensive map. She included that herons live in water areas like swamps and marshes, have sharp beaks, and find their food in the water. Molly’s and Randy’s maps were very similar utilizing three linear strings of information. Both maps indicated the heron’s physical characteristics, however, Molly indicated that the long legs look like grass and Randy’s indicated that the legs stand in water. Both stated that heron’s eat fish, but Randy included that the heron catches the fish with its beak. Aaron’s map included several concepts but was very simple. Aaron stated that the heron had long legs to walk in the mud, long beaks to snatch fish, and thick/broad feathers to help it float. Aaron’s concepts maps also showed some misconceptions about herons, e.g. that herons have webbed feet so that they do not get stuck in the mud.

**Puffer Fish Concept Maps**

Each student began their concept map with the superordinate concept of puffer fish. All four students could describe that puffer fish have spikes. Molly, Ann, and Randy were able to explain that puffer fish live in the ocean. Molly’s map provided information about the shape and coloring of the puffer fish, and provided connections between the spikes and protection of the puffer fish. She had a minor misconception that the puffer fish inflates itself to hide from predators. Ann’s map included additional information that the puffer fish can sense predators and that sense causes them to puff out. Randy’s main concept was that “puffer fish are scared by predators, which causes them to blow up and which makes them look bigger.” Aaron’s map just
listed characteristics of the puffer fish without any connections; however, he included that puffer fish don’t have exotic colors.

After interviewing the four students and co-creating six concept maps per student, the investigator began to see some real differences in cognitive levels of each student. For the most part, Molly’s maps were the most descriptive and included connections between concepts. Randy and Ann’s maps were generally consistent in range of complexity. Aaron’s maps were the least descriptive with no connections between concepts and more inaccuracies in content. After reviewing all concept maps, the investigator reviewed each student’s science score on the grade 8 LEAP test. Molly scored Advanced in science; Randy scored Mastery; Ann scored Mastery, and Aaron scored Basic. This disparity in achievement levels seemed to explain the difference in level of complexity in concepts maps between Molly and Aaron, and the similarity in complexity of maps between Randy and Ann.
CHAPTER FIVE

CONCLUSIONS

OVERVIEW

The instruction and assessment of science concepts has catapulted into the forefront of state education initiatives with the onset of NCLB. By 2008, every state must assess science at least three times during a student’s educational career—once in the elementary grades, once in the middle grades, and once during the high school years. Louisiana has been a pioneer in science assessment for many years. Standards-based science testing has been mandated since 1999 in grades 4 and 8, and since 2002 at grade 11. Prior to that, science testing was mandated as a component of the former GEE.

The purpose of this investigation was to identify more effective ways to measure conceptual understanding of science concepts, specifically life science concepts, by studying photographs as the stimulus material on multiple-choice items on a state science achievement test. Biology is a visual science (Wandersee, 2000) and biology textbooks are filled with photographs (Pozzer-Ardenghi & Roth, 2004; Roth et al., 1999). Students are learning with the aid of visual materials and should be assessed the same way that they are taught. New approaches to instruction of science concepts including these materials may improve individual student performance. New ways to assess students’ conceptual understanding of the life sciences using visual stimuli, specifically photographs, were investigated in this study.

INSTRUCTIONAL CONCLUSIONS

The investigator observed in both school settings the primary use of the textbook series. Even though the textbook was filled with photographs, the teachers at both schools indicated that limitations in time prohibited them from discussing all the photographs within the textbook.
However, each teacher indicated that they did spend time using graphs and diagrams. Photographs were used infrequently and only when it supported the concepts being learned. The investigator spent the same amount of time at each school prior to the field test instructing the students on how to use the 20-Question Model (Wandersee, 2000) to analyze photographs for instructional and assessment purposes. At School A, the students were very receptive to the investigator and participated in the two discussion lessons and activity. At School B, some of the students were receptive to the class discussion lessons but all participated in the group activity. This matched well with the instructional style of each teacher. Ms. Gant from School A utilized PowerPoint on a daily basis and started every class with a graph stimulus projected on a screen and group discussion about how to answer several questions about that graph. Ms. Kelly from School B relied more on the textbook and activities. There was evidence of group activities and projects in both classrooms; this was confirmed by the student responses to the questionnaire. Many students indicated that they liked science class because of the group activities and experiments.

The purpose of the three lessons was to make the students aware of how to analyze photographs for information. For many of the photographs in the lessons, the students would quickly describe what they observed in the photograph by providing a brief description identifying one part of the photograph, like bee on a flower. However, using questions from the 20-Question Model (Wandersee, 2000), the investigator encouraged the students to think about additional science concepts related to each photograph (e.g. how is the bee helping the flower, how is the flower helping the bee). The 20-Question Model (Wandersee, 2000) was very useful when designing Lessons 1, 2, and 3. The probing questions facilitated group discussion. Initially, the students just described the photograph. After using questions from the model, the students
began to realize that through answering the questions, they were learning much more about the organisms in each photograph and their habitats.

The PowerPoint presentation was also a useful tool to deliver the colored photographs used for class discussion on a large scale. The investigator also had group sets of each PowerPoint presentation in color; however, they were not needed. The projected photograph was large enough for all students to see and allowed the students to see minor details in the photographs (e.g., the down feathers on the young pelicans). The students responded well to the photographs and participated in the class discussion. While all of the photographs were of common organisms and habitats, the directing questions and the large photographs likely aided the students in observing finer details of each photograph. The investigator directed the students to look at the entire picture to gain understanding of an organism or habitat, not just the central focal point of the photograph.

For the group activity, the students utilized their textbooks. Ms. Gant’s class had an easier time with the group activity because the integrated science book included several life science chapters. The students could easily answer the questions from the 20-Question Model because of the biological focus of the model. Ms. Kelly’s class had a little more difficulty because they were using an Earth science textbook. However, the investigator and the students in Ms. Kelly’s class were able to adapt the biological questions to have geological focus.

During the course of the three lessons, the students became more involved with analyzing the photographs. At first, some of the students at both schools were hesitant to participate in the discussions. The students who were more reticent initially were drawn in to the group discussion of each photograph. As the photographs became more involved, the students began to realize that
much more could be learned from each photograph than the initial observation of objects within the photograph.

**ASSESSMENT CONCLUSIONS**

**Student Questionnaire Conclusions**

The student questionnaire was a useful tool to assess the students’ feelings about LEAP, to determine the types of questions that were perceived to be easy or hard, and to determine the students use of photographs to help them understand concepts and answer test items. Almost every grade 8 student at School A (n=142) and School B (n=86) completed the student questionnaire. For questions 1a through 1d, the students provided general information about science. All students were taking Earth science and primarily liked science class because of the group projects and experiments.

For questions 2a through 2f, the students provided information about their perceptions about the grade 8 LEAP test. Most the students perceived the multiple-choice items to be easy and the constructed-response items to be more difficult. In addition, some of the students reported that questions with some type of visual (graphs, diagrams, tables, photographs) were easier while text-only items were more difficult.

For questions 3a through 3d, the students were asked to describe their use of photographs in science class and on science tests. The majority of the students at each school responded that they use the photographs in their textbook to help them understand science concepts as well as to answer photograph-based items on the field test.

The responses to the student questionnaire revealed that students perceive that photographs make a test item easier and help them when answering test questions. By analyzing the data from the student questionnaire, student interviews, and teacher interviews, the
investigator noted some discrepancies. While all students were taking Earth science, there was great variation in what the students thought they were taking as well as the textbook being used. Both teachers indicated that they used the textbook and *Louisiana Comprehensive Curriculum (LCC)*, as well as projects and group activities. This was confirmed by the student questionnaire; many students responded that they like science class because of the experiments, hand-on activities, and group projects. The investigator observed direct instruction as well as group projects within both classrooms.

The second section of the student questionnaire revealed the most interesting information. The students had varying opinions about the difficulty level of the LEAP test. Specifically, the students responded that constructed-response items were more difficult than the multiple-choice items. In addition, the students responded that multiple-choice items which included stimulus material (including photographs) were perceived to be easier. The students reportedly had more confidence when answering items with stimulus. This was confirmed by the student interviews. In all four cases, the students used the strategies from the 20-Question Model (Wandersee, 2000) to assist them when answering the questions with photographs. Through each discussion, the students explained how they analyzed each photograph to help them answer the question. In many cases, the students reported that these strategies helped them to answer the question correctly.

The third section of the student questionnaire focused on how the student used photographs in the textbooks and on tests. The majority of students responded that they used photographs to help them understand content and had seen photographs before on standardized tests. However, this was not evidenced during the classroom observations or teacher interviews. In both cases, the teachers felt that they did not have to time to utilize all the photographs from
the textbook. With the push to finish the *LCC* prior to LEAP testing, the teachers felt time prohibited them from delving into the deeper understanding that the photographs might offer to their students. These findings support the research of Wandersee (2000) and Nixon (2003) which indicated that teachers primarily ignore the photographs in textbooks. Although the students reportedly felt that the photographs provided greater understanding, the teachers reported that they did not have the time. This practice contradicts the AAAS (1989, 1999, 2000) and NSES (1996) standards-based focus of spending more time delving deeper into fewer topics. However, these teachers reported that they felt pressured from their districts to “cover everything before the LEAP test.”

The next section discusses what each research question revealed. The conclusions for each data collection and analysis phase follow each question.

**Primary Research Question Conclusions**

How does middle school students’ performance on photograph-based multiple-choice items in a state science achievement test compare to their performance for text-only multiple-choice questions?

**Classical Item Statistics Conclusions**

For the primary research question, the investigator analyzed classical item statistics and computed an individual *t*-test for each topic: pitcher plant, desert/tundra, spider web, marsh, heron, and puffer fish. Statistics from the entire grade 8 sample on the spring 2007 LEAP field test were used for each form (Form 3, *n*=1182; Form 4, *n*=1130). The classical item statistics were used from Form 3 and Form 4: item difficulty, point biserial, and distractor analysis (% of students at each distractor: A, B, C, and D).
For 3 of the 6 items (pitcher plant, desert/tundra, and spider web) there was no difference in item difficulty when comparing the photograph-based version (Form 3) to the text-only version (Form 4). The marsh item was photograph-based on both forms and performed equally well. The heron item and the puffer fish item indicated differences in performance. There was a difference in student performance on the puffer fish item, with approximately 4% more of the students answering the photograph-based item correctly when compared to the text-only version of the item. There was a larger difference in student performance on the heron item; approximately 10% more students answered the item correctly with the photograph-based item.

While the classical statistics indicated no difference in students’ performance on four of the six items, the data show that the photograph-based items did not cause any harm to the students who were taking the traditional text-only item or to the students who were taking the photograph-based item. A positive finding occurred while analyzing the qualitative data. Analysis of the student responses during the lessons, on the student questionnaires, and the student interviews show that students perceived that the photograph-based items were easier to answer. During the classroom discussion, students from both schools indicated that the photographs helped them understand the content in their textbook. On the student-generated response questionnaire, the students added information that items with stimulus (including photographs) were easier than items without stimulus; they also responded that they used the photographs to help them answer the test questions with photographs. The student interviews suggested that the middle-performing and high-performing students all utilized the photographs when answering the questions. In addition, all four students indicated that the 20-Question Model (Wandersee, 2000) helped them analyze the photographs. Molly said,
I looked at the photograph to try to determine what was happening in the photograph. I tried to make an observation of what was in the picture, then I tried to infer what was happening. Then I read the question. Sometimes it helped me to answer the question. Sometimes it didn’t.

Ann said that she, “was able to draw a whole lot more details about the ecosystem and the animals that live in it,” after the lessons using the 20-Question Model (Wandersee, 2000). Ann felt that the photograph helped her focus on the topic of the question.

The heron item and the puffer fish item both showed an increase in student performance on the item—10% more students answered the photograph-based heron item correctly than the text-based item and 4% more students answered the photograph-based puffer fish item correctly than the text-based item. For these two items, in comparison with the other four items, the focal point of the photograph was a specific animal. If students were unfamiliar with the characteristics of a heron or a puffer fish, those students were able to see the characteristics within the photograph and use those to help them answer the question. The students without the aid of the photograph had to rely on experience with or content knowledge about these two organisms to help them answer the question. For the remaining photographs, the photograph included an organism or habitat, however, it was set in the context of an ecosystem. The marsh item was very involved with birds, trees, water, and grass; the pitcher plant item included a clump of pitcher plants within a swamp; the spider web was set around a green patch of grass; and the desert and tundra ecosystems encompassed an entire area of each ecosystem.

The heron and puffer fish photograph each had one focal point. For the heron photograph, the students saw a heron standing in water. The heron photograph showed specific characteristics of the heron standing in water; the students did not appear to be distracted by extra information
of habitat. For the puffer fish photograph, the students saw a puffer fish resting in a human hand. In addition, the puffer fish item added a scale component; the students knew how large the puffer fish was because it rested in the palm of a human hand. Both of these photographs follow Tuftian guidelines (1990, 1997, 2001, 2006); the photograph was not cluttered; the focal point of the photograph was one organism, and provided a scale (for the puffer fish). One may hypothesize that perhaps when photographs are too cluttered, student performance is impaired.

Six Independent $t$-tests Conclusions

The six independent $t$-tests were calculated to determine if there was a significant difference in student performance when comparing the photograph-based version of the item to the text-only version. Using Bonferoni’s Adjustment, the investigator set the alpha level at 0.06 and divided the alpha level by the 6 independent $t$-tests. The alpha level for each $t$-test to measure significance is 0.01. For five of the $t$-tests, no significant difference was found (pitcher plant, desert/tundra, spider web, marsh, and puffer fish). The heron item showed a significant difference in performance. The SIG value was 0.00.

For both sets of analysis the heron item indicated a significant difference in student performance on the photograph-based item. This finding could be attributed to the student’s recognition of the heron organism. Students may not be familiar with the characteristics of herons, so the photograph may have helped the students with high ability and low ability answer the question. When topics are unfamiliar or the content difficult, student understanding of the concept and therefore successful performance on a test item may be aided by the use of a photograph. This was also confirmed by the student questionnaire; 76% of the student at School A and 82% of the students at School B responded that they used the photographs to help them answer the questions on the LEAP field test.
This significant difference was also confirmed by the student interviews. When asked if the techniques of the 20-Question Model were used to analyze photograph, Aaron said,

First, I looked at the picture and observed the parts of the heron and the ecosystem. There was a lot of water in the picture. I couldn’t see the heron’s feet, but I could see the long legs that help it to walk in the water more easily.

Molly said that she looked at the photograph first and remembered the things that we had talked about in our lessons, then she tried to answer the questions. Aaron and Molly had the photograph-based version of the heron item and both utilized the photograph to help them answer the question.

**Subquestion 1 Conclusions**

Which categories of students, if any, benefit most (based on their achievement level) from the inclusion of photograph-based multiple-choice items?

All students that were administered the field test also took the spring operational test. The investigator was able to match the student data files to connect the student’s achievement level on LEAP to their answer responses on the grade 8 LEAP field test. The investigator analyzed student performance (mean number correct) on each item by matching the mean number correct to the achievement level scored on LEAP. Each item showed a variation of student performance. For the pitcher plant item, the students scoring at Mastery, Approaching Basic, and Unsatisfactory exhibited a higher mean number correct on the photograph-based items. For the desert/tundra photograph-based item, the students scoring at the Advanced and Approaching Basic level exhibited a higher mean number correct on the photograph-based item. For the spider web item, the Mastery and Basic level exhibited a higher mean number correct on the photograph-based item.
The heron and puffer fish items displayed greater difference in performance between the photograph-based and the text-only version of each item. The heron item had a 10% difference favoring the photograph-based item at four achievement levels: Mastery, Basic, Approaching Basic, and Unsatisfactory. The puffer fish item saw a slight increase in student performance on the Mastery and Basic levels. However, there was an 8% increase in student performance on the photograph-based items at the Approaching Basic and Unsatisfactory.

These results indicated that there is an association between achievement level and student performance on photograph-based items. Although the findings were inconsistent, student performance did improve with the photograph-based items as the achievement level increased.

Clearly, this data set yields the most positive information. On every item, there were at least two groups of students performing better on the photograph-based items in comparison to the text-only version of that item. With the exception of the spider web item, the students performing at the Unsatisfactory or Approaching Basic levels scored better on the photograph-based items. This suggested that low-performing students benefited most when provided an alternative to the text-only versions of test items. The low-performing students appeared to benefit from photographs as the stimulus material.

Subquestion 2 Conclusions

How well does student performance on science-content-equivalent items, using matched pair of those two types of multiple-choice items, correlate?

The Spearman’s rho technique was calculated to determine if a correlation existed between student performance on matched pairs of items and achievement level performance on LEAP. The rho value for photograph-based items was .1536, or 15% of the variation in the percent of photograph-based items correct is shared with achievement level. The rho value for
the text-only items was .1056, or 11% of the variation in the percent of text-only items correct is shared with achievement level. These values indicated a moderate positive correlation between percent correct on the photograph-based items and achievement level.

This finding confirmed the analyzed data from subquestion 1 and suggested a relationship between achievement level and correct responses on the photograph-based items. As the achievement level increases, student performance on the photograph-based items may increase. For the heron and puffer fish item, more of students performing at the Approaching Basic and Unsatisfactory levels answered the photograph-based correctly when compared to the text-only item. This could be caused by unfamiliarity with the characteristics of the two organisms; the photographs may have helped the lower ability students.

Subquestion 3 Conclusions

Are there differences in test performance between students who were introduced to and used the 20-Question Model of Photographic Inquiry during science instruction and those who were not?

The study findings exhibited no significant difference between the treatment group and the control group at either school. The mean number of photograph-based items correct was essentially the same between the treatment group and the control group. With an alpha level at 0.05, the SIG value for School A was 0.975 and the SIG value for School B was 0.241. The finding revealed that that the presence of photograph-based instruction was not able to discriminate student scores by achievement level.

There are many reasons why this finding could have occurred. Although all the schools in the Form 3 and Form 4 samples were randomly selected and were representative of the entire state population, the investigator purposefully sampled School A and School B. The two schools in the study were selected from the field test sample by utilizing an average scale score.
performance on LEAP for the school. By trying to ensure that each school was comparable, the investigator purposefully sampled two average performing schools. In addition, both classes were selected by the teachers to participate in the study, and it is likely that each teacher selected their best class to participate. The schools selected were average performing and the treatment classes selected were average to high performing. There was little variation in the ability level of the students at each school, hence not allowing for a variation in results when comparing the treatment group to the control group.

Because there was no significant difference between the treatment group and the control group, the introduction of the 20-Question Model (Wandersee, 2000) to the students in the treatment group provided no harm to the students. The classroom discussions during the three lessons exposed biological conceptual knowledge as well as misconceptions. In addition, the probing nature of the questions may have added to the biological literacy of each student within the treatment group.

During the subsequent student interviews, two of the students revealed misconceptions about photosynthesis—they said that pitcher plants were carnivorous and eat insects so they don’t need photosynthesis. The other two students read in the item that the pitcher plant was green so they knew it needed photosynthesis, however, they both indicated that plants don’t use cellular respiration.

Subquestion 4 Conclusions

How do four concept-map-based mini-case students of a high and a low test performing male and female triangulate with their subscores on the tests’ photograph-based multiple-choice items and their subscores on the text-based multiple-choice items?
The student interviews and six concept maps per student were very helpful in
determining if retention of concepts was maintained on life science concepts. Molly scored
Advanced in science on the LEAP test. Consistently, her concept maps were more descriptive,
included several levels of concepts, and provided connections between concepts. Randy and Ann
scored Mastery in science on LEAP. For most of the six concept maps, Randy and Ann created
solid concepts maps that described the content accurately, included several levels of concepts
and connected various concepts. Aaron performed at the Basic level on LEAP. Consistently,
Aaron’s maps were simple and included misconceptions for several of the topics (e.g. herons
have webbed feet).

The findings imply that achievement level does influence student understanding of
scientific concepts. Aaron scored at the Basic level on LEAP; his concept maps revealed some
misconceptions as well as gaps in conceptual understanding of plant and animal life. Molly
scored at the Advanced level; although one of her concept maps had some misinformation, her
maps revealed a higher level conceptual understanding of the six topics.

The 20-Question Model (Wandersee, 2000) proved to be an excellent tool to probe
students’ conceptual understanding of life science concepts. The 20-Question Model guided the
development of the three lessons used with the treatment. Several students learned new
knowledge through the class discussion about organisms and their ecosystems. Many students
had never seen a white blood cell before, yet were able to identify it on a subsequent photograph
after seeing a red blood cell and discovering its function. All four students interviewed,
regardless of achievement level, enjoyed analyzing the photographs and provided additional
information about life science conceptual understanding.
The student interviews including the concept mapping were enlightening. The investigator learned much about the students’ biological conceptions while answering the questions. Many of the interviewed students used process of elimination to select their answers on the multiple-choice items. Ann answered the pitcher plant item correctly, however, misconceptions about cellular respiration were revealed. Aaron answered the heron question correctly, however, the concept mapping activity revealed a misconception that herons have webbed feet. Molly’s discussion of items was detailed and her maps were the most complex, but misinformation about puffer fish was revealed in her concept map, even though she answered the item correctly. Randy’s concept map on pitcher plants was good, however a misconception about cellular respiration was revealed while explaining how he answered the question. These findings support Stern and Ahlgren’s (2002) research which indicated that high performance on test may not reveal actual conceptual understanding by students.

Clearly quantitative data alone cannot reveal the students’ conceptions about biological concepts. In several cases, the students interviewed answered the question correctly, however, their explanation of how they answered the question and created the concept maps revealed misconceptions. The qualitative data piece revealed more about students’ conceptual understanding of biological science concepts.

LIMITATIONS

One limitation to this study included generalizability; it may have been difficult to generalize the findings of this study to the entire grade 8 student population. This limitation was the diversity of the sample; the investigator would have preferred to complete the study on a more diverse student population. When selecting the schools, the student population was more
diverse than the classes subsequently selected by each teacher. Minority groups were underrepresented in this study.

Another limitation is accessibility to data. The investigator had easier access to certain data files because professional responsibilities allowed her to place items on the grade 8 field test. Another researcher trying to replicate this study may have difficulty sequencing items like this on a state assessment. However, the study can be replicated using class and district level assessments for further study.

RECOMMENDATIONS FOR FUTURE STUDY

First, the investigator suggests that this study be replicated using a treatment group and control group on schools with lower performing students to determine if the treatment is effective with that student population. The investigator should select the treatment group for the study to ensure the sample includes lower-performing students. By selecting the classes at the two schools that were both high-performing, the teacher may have blurred the possible differences between the treatment group versus control group results.

In another study, the design could be altered to measure student performance at the Approaching Basic and Unsatisfactory achievement level groups. The design could be set up to select a lower performing middle school, administer a pre-test to all grade 8 classes in the school, apply the treatment to one class in the school, and administer a post-test to all grade 8 classes at the school. This may reveal difference in performance with the treatment group and the control group.

In the coming years, the Louisiana Department of Education is changing administration its high school exam from the Graduation Exit Exam to End-of-Course (EOC) tests. The Biology EOC test will be initially administered in 2010. The EOC test will be administered online. This
change presents a variety of opportunities to assess concepts using photographs and graphics in color and in a variety of ways. Future study on assessment using photographs as the stimulus material in an online setting needs to be completed.

SUMMARY

Although the quantitative analysis did not produce a significant difference between the photograph-based items and the text-only based items, except for the heron and puffer fish items, the qualitative data indicated that students perceived that items were easier when a photograph was attached. Although the student performance did not distinguish between the treatment group and the control group, the questionnaire indicated that most students used the photograph when answering the photograph-based multiple-choice items. This was confirmed by the four students interviewed indicating that photographs helped them answer the questions. Student perception of the photograph-based items was positive.

The qualitative data provided much information to the investigator about how students’ conceptual understanding of science concepts is revealed when answering test questions. Although students answered the multiple-choice questions correctly, their explanations of how they answered the question revealed misconceptions. Multiple-choice items alone cannot illuminate all conceptual understanding. Within this study, the student interviews and concept mapping provided the vehicle to reveal student conceptual understanding of life science concepts. In regular classroom settings and on statewide achievement tests, constructed-response items using photographs as the stimulus material may provide more information to the teacher and reveal the student’s actual knowledge of life science concepts.
Results of the study suggested that some of the photograph-based items performed better than others. The study found that the heron and puffer fish photograph-based items were more successful than the text-only version. Selection of the photographs used for stimulus materials may be improved to stimulate higher order thinking. Perhaps future studies using novel photographs could be utilized to probe student understanding (e.g. small multiples of time-lapse photography of plant growth (Shultz, 2007; Tufte, 1990, 1997, 2001, 2006), underwater views of ducks swimming, inside views of the human body, high speed view of sneeze droplets being expelled from a student's mouth). In addition, textbooks could include some novel photographs, rather than traditional nature photographs, to probe students understanding of the human body, how communicable diseases are transmitted, how birds' feet are adapted for survival, how plants grow. If the textbooks include these novel photographs such as these, then the assessment items utilizing novel photographs may follow.

Because biology is a visual science, the textbooks are visual resources (Wandersee, 2000), the data show that there was a moderate correlation with achievement level and performance on photograph-based items, the assessments should be visual as well.
REFERENCES


Improving America’s Schools Act, PL 103-382 (1994).


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**APPENDIX A**

**WANDERSEE’S 20-QUESTION MODEL OF IMAGE-BASED BIOLOGY TEST ITEM DESIGN**

<table>
<thead>
<tr>
<th>Question</th>
<th>Code Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Describe this event biologically…</td>
<td>describe event</td>
</tr>
<tr>
<td>2. Give the function(s) of this/these structure(s)…</td>
<td>give function(s)</td>
</tr>
<tr>
<td>3. Provide the next step in this process…</td>
<td>give next step</td>
</tr>
<tr>
<td>4. How else could this event be explained biologically…</td>
<td>give alternative explanation</td>
</tr>
<tr>
<td>5. Predict what will happen next…</td>
<td>predict results</td>
</tr>
<tr>
<td>6. What evident do you see that suggests…</td>
<td>tell what evidence suggests</td>
</tr>
<tr>
<td>7. What is the limiting factor in this process…</td>
<td>give limiting factor(s)</td>
</tr>
<tr>
<td>8. What biological principle is operating here…</td>
<td>specify principle operating</td>
</tr>
<tr>
<td>9. If we didn’t have or couldn’t use…what could we use instead…</td>
<td>suggest could use–instead of</td>
</tr>
<tr>
<td>10. What is the connection between…</td>
<td>give connection between</td>
</tr>
<tr>
<td>11. In the past, how was this event explained by scientists</td>
<td>supply past scientific explanation</td>
</tr>
<tr>
<td>12. On what basis do you suspect this organism is a…</td>
<td>give organism I.D. basis</td>
</tr>
<tr>
<td>13. Biologically, this organism is most closely related to…</td>
<td>what most closely related to</td>
</tr>
<tr>
<td>14. How would you go about measuring…</td>
<td>tell how you’d measure</td>
</tr>
<tr>
<td>15. Make a biological estimation how long it would take for…</td>
<td>make time estimate</td>
</tr>
<tr>
<td>16. What is the concept a biologist would use here to…</td>
<td>suggest valid concept</td>
</tr>
<tr>
<td>17. Ask an important biological question about this photograph…</td>
<td>ask important question</td>
</tr>
<tr>
<td>18. What would a …graph of this event look like…</td>
<td>sketch graph of event</td>
</tr>
<tr>
<td>19. Design a device to monitor an important variable in this environment</td>
<td>design monitoring device</td>
</tr>
<tr>
<td>20. Apply what you read in your last assignment to this photo…</td>
<td>apply reading to photo</td>
</tr>
</tbody>
</table>

**Scoring Rubric:** No relevant biological understand demonstrated = 0 points; very limited relevant biological understanding demonstrated = 1 point; partial relevant biological understanding demonstrated = 2 points; complete relevant biological understanding demonstrated = 3 points;  
**Note:** Item score depends on the number of aspects posted in parentheses on the test item as being necessary for a full 3-point rating.

(2000, p. 137)
APPENDIX B

INTERVIEW PROTOCOL FOR PILOT STUDY

Spring 2004

Question # 2

1. Which answer did you select as the correct answer?

2. Did you use the picture to help you answer the question? If yes, which part of the photograph did you use?

3. Could you have answered this question without a picture?

4. Show the student the color picture. Would seeing the picture in color help you answer the question? If so, how?

Question #10

5. Which answer did you select as the correct answer?

6. Did you use the picture to help you answer the question? If yes, which part of the photograph did you use?

7. Could you have answered this question without a picture?

8. Show the student the color picture. Would seeing the picture in color help you answer the question? If so, how?

Question #15

9. Which answer did you select as the correct answer?

10. Did you use the picture to help you answer the question? If yes, which part of the photograph did you use?

11. Could you have answered this question without a picture?
12. Show the student the color picture. Would seeing the picture in color help you answer the question? If so, how?

Question #21

13. Which answer did you select as the correct answer?

14. Did you use the picture to help you answer the question? If yes, which part of the photograph did you use?

15. Could you have answered this question without a picture?

16. Show the student the color picture. Would seeing the picture in color help you answer the question? If so, how?

Question #29

17. Which answer did you select as the correct answer?

18. Did you use the picture to help you answer the question? If yes, which part of the photograph did you use?

19. Could you have answered this question without a picture?

20. Show the student the color picture. Would seeing the picture in color help you answer the question? If so, how?

Question #34

21. Which answer did you select as the correct answer?

22. Did you use the picture to help you answer the question? If yes, which part of the photograph did you use?

23. Could you have answered this question without a picture?

24. Show the student the color picture. Would seeing the picture in color help you answer the question? If so, how?
Question #38

25. Which answer did you select as the correct answer?

26. Did you use the picture to help you answer the question? If yes, which part of the photograph did you use?

27. Could you have answered this question without a picture?

28. Show the student the color picture. Would seeing the picture in color help you answer the question? If so, how?

Question #40

29. Which answer did you select as the correct answer?

30. Did you use the picture to help you answer the question? If yes, which part of the photograph did you use?

31. Could you have answered this question without a picture?

32. Show the student the color picture. Would seeing the picture in color help you answer the question? If so, how?
APPENDIX C

IRB EXEMPTION FORM

IRB #: 3564
LSU Proposal #: ____________ Revised: 10/04/2006

LSU INSTITUTIONAL REVIEW BOARD (IRB) for
HUMAN RESEARCH SUBJECT PROTECTION
578-8692 FAX 6792
Office 203 B-1 David Boyd Hall

APPLICATION FOR EXEMPTION FROM INSTITUTIONAL OVERSIGHT

Unless they are qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/projects using living humans as subjects, or samples or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the PI determine if a project may be exempted, and is used to request an exemption.

Instructions: Complete this form.
Exemption Applicant: If it appears that your study qualifies for exemption send:

(A) Two copies of this completed form,
(B) a brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts A & B),
(C) copies of all instruments to be used. If this proposal is part of a grant proposal include a copy of the proposal and all recruitment material.
(D) the consent form that you will use in the study. A Waiver of Written Informed Consent is attached and must be completed only if you do not intend to have a signed consent form.
(E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project (including students who are involved with testing or handling data) at http://cme.cancer.gov/clinicaltrials/learning/human/participant-protections.asp. (Unless already on file with the IRB.)

to: ONE screening committee member (listed at the end of this form) in the most closely related department/discipline or to IRB office.

If exemption seems likely, submit it. If not, submit regular IRB application. Help is available from Dr. Robert Mathews, 578-8692, irb@lsu.edu or any screening committee member.

Principal Investigator: Susannah F. Craig
Student? Yes
Ph: 225-936-0768 E-mail: susannah.craig@la.gov
Dept/Unit: Department of Educational Theory, Policy, and Practice

If Student, name supervising professor: James H. Wandervue, Ph. D. Ph: 225-578-2368
Mailing Address: 223 Peabody Hall, Baton Rouge, LA 70803 Ph: 225-578-8687
Project Title: Comparison of Middle School Student Performance on Photograph-based Multiple-choice items and Text-based Multiple-choice items on a State Science Achievement Test

Agency expected to fund project: N/A

Subject pool (e.g. Psychology Students) Grade 8 students
Circle any "vulnerable populations" to be used: children <18, the mentally impaired, pregnant women, the aged, other). Projects with incarcerated persons cannot be exempted.

I certify my responses are accurate and complete. If the project scope or design is later changed I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU institutions in which the study is conducted.

PI Signature: __________________________ Date: __________

Screening Committee Action: Exempted Not Exempted Category/Paragraph __________________________

Reviewer: ___________________________________________ Signature: __________________________ Date: __________

Study exempted by
Louisiana State University
Institutional Review Board
203 B-1 David Boyd Hall
225-578-8692
Robert C. Mathews, Chair
Part A: DETERMINATION OF "RESEARCH" and POTENTIAL FOR RISK

This section determines whether the project meets the Department of Health and Human Services (HSS) definition of research involving human subjects, and if not, whether it nevertheless presents more than "minimal risk" to human subjects that makes IRB review prudent and necessary.

1. Is the project involving human subjects a systematic investigation, including research, development, testing, or evaluation, designed to develop or contribute to generalizable knowledge?

(Note some instructional development and service programs will include a "research" component that may fall within HSS' definition of human subject research).

☐ YES

☐ NO

2. Does the project present physical, psychological, social or legal risks to the participants reasonably expected to exceed those risks normally experienced in daily life or in routine diagnostic physical or psychological examination or testing? You must consider the consequences if individual data inadvertently become public.

☐ YES  Stop. This research cannot be exempted—submit application for IRB review.

☐ NO  Continue to see if research can be exempted from IRB oversight

3. Are any of your participants incarcerated?

☐ YES  Stop. This research cannot be exempted—submit application for IRB review.

☐ NO  Continue to see if research can be exempted from IRB oversight.

4. Are you obtaining any health information from a health care provider that contains any of the identifiers listed below?
   A. Names
   B. Address: street address, city, county, precinct, ZIP code, and their equivalent geocodes. Exception for ZIP codes: The initial three digits of the ZIP Code may be used, if according to current publicly available data from the Bureau of the Census: (1) The geographic unit formed by combining all ZIP codes within the same three initial digits contains more than 20,000 people; and (2) the initial three digits of a ZIP code for all such geographic units containing 20,000 or fewer people is changed to '000'. (Note: The 17 currently restricted 3-digit ZIP codes to be replaced with '000' include: 036, 059, 063, 102, 203, 556, 692, 790, 821, 823, 830, 831, 878, 879, 884, 890, and 893.)
   C. Dates related to individuals
      i. Birth date
      ii. Admission date
      iii. Discharge date
      iv. Date of death
      v. And all ages over 89 and all elements of dates (including year) indicative of such age. Such ages and elements may be aggregated into a single category of age 90 or older.
   D. Telephone numbers;
E. Fax numbers;
F. Electronic mail addresses;
G. Social security numbers;
H. Medical record numbers; (including prescription numbers and clinical trial numbers)
I. Health plan beneficiary numbers;
J. Account numbers;
K. Certificate/license numbers;
L. Vehicle identifiers and serial numbers including license plate numbers;
M. Device identifiers and serial numbers;
N. Web Universal Resource Locators (URLs);
O. Internet Protocol (IP) address numbers;
P. Biometric identifiers, including finger and voice prints;
Q. Full face photographic images and any comparable images; and
R. Any other unique identifying number, characteristic, or code; except a code used for re-identification purposes; and
S. The facility does not have actual knowledge that the information could be used alone or in combination with other information to identify an individual who is the subject of the information.

☐ YES Stop. This research cannot be exempted—submit application for IRB review.

☒ NO Continue to see if research can be exempted from IRB oversight.

Part B: EXEMPTION CRITERIA FOR RESEARCH PROJECTS

Research is exemptable when all research methods are one or more of the following five categories. Check statements that apply to your study:

☒ 1. In education setting, research to evaluate normal educational practices.

☒ 2. For research not involving vulnerable people [prisoner, fetus, pregnancy, children, or mentally impaired]: observe public behavior (including participatory observation), or do interviews or surveys or educational tests:

The research must also comply with one of the following:

either that

☒ a) the participants cannot be identified, directly or statistically;

or that

☐ b) the responses/observations could not harm participants if made public;

or that

☐ c) federal statute(s) completely protect all participants' confidentiality;
3. For research not involving vulnerable people [prisoner, fetus, pregnancy, children, or mentally impaired]: observe public behavior (including participatory observation), or do interviews or surveys or educational tests:
   • all respondents are elected, appointed, or candidates for public officials.

4. Uses only existing data, documents, records, or specimens properly obtained.
   The research must also comply with one of the following:
   either that:
   a) subjects cannot be identified in the research data
directly or statistically, and no-one can trace back from research data to identify a participant;
   or that
   b) the sources are publicly available

5. Research or demonstration service/care programs, e.g. health care delivery.
   The research must also comply with all of the following:
   a) it is directly conducted or approved by the head of a US Govt. department or agency.
   and that
   b) it concerns only issues under usual administrative control (48 Fed Reg 9268-9), e.g., regulations, eligibility, services, or delivery systems;
   and that
   c) its research/evaluation methods are also exempt from IRB review.

6. For research not involving vulnerable volunteers [see "2 & 3" above], do food research to evaluate quality, taste, or consumer acceptance.
   The research must also comply with one of the following:
   either that
   a) the food has no additives;
   or that
   b) the food is certified safe by the USDA, FDA, or EPA.

NOTE: Copies of your IRB stamped consent form must be used in obtaining consent. Even when exempted, the researcher is required to exercise prudence in protecting the interests of research subjects, obtain informed consent if appropriate, and must conform to the Ethical Principles and Guidelines for the Protection of Human Subjects (Belmont Report), 45 CFR 46, and LSU Guide to Informed Consent; (Available from OSP or http://www.lsu.edu/irb)
HUMAN SUBJECTS SCREENING COMMITTEE MEMBERS can assist & review:

<table>
<thead>
<tr>
<th>COLLEGE OF ARTS AND SCIENCES:</th>
<th>MASS COMMUN/SOC WK/AG:</th>
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<tr>
<td>Dr. Noell *(Psych) 578-4119</td>
<td>Dr. Nelson *(Mass C) 578-6686</td>
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<tr>
<td>Dr. Geiselman *(Psych) 763-2695</td>
<td>Dr. Keenan*(Hum Ecol) 578-1708</td>
</tr>
<tr>
<td>Dr. Beggs *(Socio) 578-1119</td>
<td>Dr. Belleau *(Hum Ecol) 578-1535</td>
</tr>
<tr>
<td>Dr. Honeycutt(Comm.Stu.) 578-6676</td>
<td>Dr. Osborne *(Mass C) 578-9296</td>
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<tr>
<td>Dr. Dixit *(Comm Sc./Dis) 578-3938</td>
<td>Dr. Timothy F. Page *(Soc Wk) 578-1358</td>
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<tr>
<td>Dr. Copeland*(Psych) 578-4117</td>
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<td>Dr. McKee *(Marketing) 578-8788</td>
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<td>Dr. Landin*(Kinesiol) 578-2916</td>
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<tr>
<td>Dr. MacGregor *(ELRC) 578-2150</td>
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<tr>
<td>Dr. Gansle *(Curric &amp; I) 578-7213</td>
<td></td>
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<tr>
<td>Dr. Ann Trousdale*(Curric &amp; I) 578-2330</td>
<td></td>
</tr>
</tbody>
</table>

(* = IRB member)
APPENDIX D

HUMAN SUBJECTS RESEARCH COURSE COMPLETION CERTIFICATE

This is to certify that

susannah craig

has completed the Human Participants Protection Education for Research Teams
online course, sponsored by the National Institutes of Health (NIH), on 02/07/2007.

This course included the following:

- key historical events and current issues that impact guidelines and legislation on
  human participant protection in research.
- ethical principles and guidelines that should assist in resolving the ethical issues
  inherent in the conduct of research with human participants.
- the use of key ethical principles and federal regulations to protect human participants
  at various stages in the research process.
- a description of guidelines for the protection of special populations in research.
- a definition of informed consent and components necessary for a valid consent.
- a description of the role of the IRB in the research process.
- the roles, responsibilities, and interactions of federal agencies, institutions, and
  researchers in conducting research with human participants.
APPENDIX E

STUDENT CONSENT FORM

Student Consent Form

Comparison of Middle School Student Performance on Photograph-Based Multiple-Choice items and Text-Based Multiple-Choice items on a State Science Achievement Test

Principal Investigator: Susannah F. Craig  Faculty Advisor: James Wandersee, Ph.D.
2035 Terrace Avenue  Louisiana State University
Baton Rouge, LA 70806  225-578-2348

Purpose of the Research:
The purpose of this study is to compare student performance on photograph-based multiple-choice items and text-based multiple-choice items on a state science achievement test.

Procedures for the Research:
This study will take place over a five week time period during April and May, 2007. You will continue with your regular grade 8 science class. Instruction on how to use photographs in textbooks to aid in understanding science content knowledge will be provided. A comparison of student performance on the grade 8 LEAP field test will be conducted.

Potential Risks:
There are no risks involved in this study. It is strictly for educational purposes. If you have any questions or concerns about your participation in this study, please feel free to contact the Principal Investigator.

Potential Benefits:
Additional instruction on how to analyze photographs used in textbooks and as stimulus material on state mandated tests may facilitate better understanding of challenging content. Participation in this study will help you become more aware of how to use the photographs to learn as well as succeed on test items which use photographs as the stimulus material.

Right to Refuse:
You may choose not to participate or to withdraw from the study at any time without penalty or consequence.

Privacy:
All information collected during this study is anonymous. Results of this study may be published, but no names or identifying information will be included in the publication.

Your participation will be greatly appreciated. Please feel free to contact Susannah Craig if you have any questions. Please sign and return this consent form if you agree to participate.

I have been fully informed of the above-described procedure. I give my permission to participate.

The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about subjects' rights or other concerns, I can contact Robert C. Mathews, Chairman, LSU Institutional Review Board, (225) 578-8692. I agree to participate in the study described above and acknowledge the researchers' obligation to provide me with a copy of this consent form if signed by me.

Signature __________________________ Date __________

Study exempted by
Louisiana State University
Institutional Review Board
203 B-1 David Boyd Hall
225-578-8692
APPENDIX F

PARENT/GUARDIAN CONSENT FORM

Comparison of Middle School Student Performance on Photograph-Based Multiple-Choice items and Text-Based Multiple-Choice items on a State Science Achievement Test

Principal Investigator: Susannah F. Craig  Faculty Advisor: James Wandersee, Ph.D.
2035 Terrace AvenueLouisiana State University
Baton Rouge, LA 70806225-578-2348

Purpose of the Research:
The purpose of this study is to compare student performance on photograph-based multiple-choice items and text-based multiple-choice items on a state science achievement test.

Procedures for the Research:
This study will take place over a five week time period during April and May, 2007. Students will continue with their regular grade 8 science class. Instruction on how to use photographs in textbooks to aid in understanding science content knowledge will be provided. A comparison of student performance on the grade 8 LEAP test will be conducted.

Potential Risks:
There are no risks involved in this study. It is strictly for educational purposes. If you have any questions or concerns about your son or daughter participating in this study, please feel free to contact the Principal Investigator.

Potential Benefits:
Additional instruction on how to analyze photographs used in textbooks and as stimulus material on state mandated tests may facilitate better understanding of challenging content. Participation in this study will help students become more aware of how to use the photographs to learn as well as succeed on test items which use photographs as the stimulus material.

Right to Refuse:
Your child may choose not to participate or to withdraw from the study at any time without penalty or consequence.

Privacy:
All information collected during this study is anonymous. Results of this study may be published, but no names or identifying information will be included in the publication.

Your child's participation will be greatly appreciated. Please feel free to contact Susannah Craig if you have any questions. Please sign and return this consent form if you agree to allow your child to participate.

The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about subjects' rights or other concerns, I can contact Robert C. Mathews, Chairman, LSU Institutional Review Board, (225) 578-8692. I agree for my child to participate in the study described above and acknowledge the researchers' obligation to provide me with a copy of this consent form if signed by me.

Signature ___________________________ Date ________________

Study exempted by
Louisiana State University
Institutional Review Board
203 B-1 David Boyd Hall
225-578-8692
Robert C. Mathews Chair
What do you see in these pictures?
Photographs can

- capture a moment in time in the life of an organism.
- accurately display various types of ecosystems.
- make the unseen seen.
Organisms

Capturing a Moment in Time
Black Bear -

Photograph 1.1

R. I. Bridges, USFWS
Alligator

Photograph 1.2

USFWS Photo
Butterflies

Photograph 1.3

USFWS Photo
Elephants

Photograph 1.4

Miriam Westervelt, USFWS
Ant

Photograph 1.5

ant.edb.miyakyo-u.ac.jp
Pelican

Photograph 1.6

Steve Van Riper, USFWS
Butterfly and Bee

Photograph 1.7

John & Karen Hollingsworth, USFWS
Heron

Photograph 1.8

USFWS Photo
Ecosystems

Accurately display living and nonliving components of an ecosystem
Desert

Photograph 1.9

DHD Multimedia Gallery
Savannah

Photograph 1.10

John & Karen Hollingsworth, USFWS
Rainforest

http://www.indianetzone.com/2/indian_forests.htm
Rainforest Destruction

http://whyfiles.org/238earthday/index.php?g=3.txt
Wetland

Photograph 1.13

USFWS Photo
Wetland Destruction

Photograph 1.14

USFWS Photo
Swamp
River

USFWS Photo
Make the Unseen Seen
Red Blood Cells

http://www.lmp.ualberta.ca/resources/pathoimages/PC-R.htm
White and Red Blood Cells

http://www.answers.com/topic/white-blood-cell
Photograph 2.3

Paramecium

facstaff.uww.edu/wentzl/Paramecium.jpg
Cell Division
Healthy Lung

http://www.radiologyregional.com/ultrafastlungctscan.html
APPENDIX H
CLASS ACTIVITY SHEET

1. Give a description of the photograph.

2. Describe this event biologically. What do you think is happening in this photograph?

3. Make a prediction about what may happen next in this photograph.

4. What biological principle is operating in this photograph?

5. Are there any limiting factors shown in this photograph?

6. Ask an important biological question about this photograph.

7. Pick one question from the 20-Question Model that clearly relates to the photograph your group is working with. Write the question or code words, and then answer the question.
APPENDIX I

STUDENT QUESTIONNAIRE

(This is for all Grade 8 students in the study.)

1. Describe your science class.
   a. What science class are you taking this semester?
   b. What textbook are you using?
   c. How often does your teacher use the textbook for instruction?
   d. Do you like science class? How is it similar or different from some of your other classes?

2. Describe your feelings about the Grade 8 LEAP test.
   a. What did you think about the Grade 8 LEAP science test?
   b. Did you feel prepared to answer the questions on this test?
   c. Did you think that the questions were easy or hard?
   d. What types of questions were easy? What types of questions were more difficult?
   e. Did you try your best on this field test? What section of the test did you try your best?
   f. Was this test similar to your classroom assessments?

3. Describe your use of photographs in science class and on science tests.
   a. Do you use the photographs in your textbook to help you understand science concepts?
   b. Have you seen photographs on a standardized test before?
   c. Did you use the photographs to help you answer the questions?
   d. Did you find the photographs helped understand the text of the question?
APPENDIX J

TEACHER INTERVIEW PROTOCOL

1. Describe your teaching background.
   a. What degrees and certifications have you earned?
   b. How many years have you been teaching in the middle school?
   c. What grades and subject areas have you taught?
   d. How many years have you been teaching at this school?
   e. How many years have you been teaching this subject?
   f. What do you consider your area of expertise?

2. Describe the curriculum that you use.
   a. What textbook series do you use?
   b. Describe the strengths/weaknesses of your textbook series.
   c. Do you use the Louisiana Science Framework, Grade Level Expectations, and Comprehensive Curriculum as part of the curriculum in your classroom? If so, how?

3. How would you describe your teaching methods?

4. Do you use the pictorial representation of scientific knowledge in your teaching practice?
   a. Do you use the photographs in your textbook? If so, how?
   b. Do you use visual tools (e.g. graphs, maps, tables, diagrams, concept maps, and photographs) during instruction? If so, how?

5. Describe your classroom testing procedures.
   a. What types of items do you use for classroom assessment purposes?
   b. Are your test questions aligned with the types of questions that appear on the Grade 8 LEAP Science assessment?
c. Do you use visual tools (e.g. graphs, maps, table, diagrams, concept maps, and photographs) as the stimulus material for test items? If so, which types do you use and how often?
APPENDIX K

STUDENT INTERVIEW PROTOCOL

(to be used with 4 students within the mini-case study)

1. Tell me about your school experiences.
   a. How long have you attended this school?
   b. Where did you go to elementary school?
   c. What is your favorite subject?
   d. What science classes have you taken at this school?

2. Describe a typical science class.
   a. What subject are you taking in science this semester?
   b. What types of activities do you complete in science class?
   c. Do you complete any laboratory work in this science class?
   d. Do you use graphs, diagrams, concept maps, or photographs to learn science concepts?
      If so, how?
   e. Do you use graphs, diagrams, concept maps, or photographs to present information in
      science class? If so, describe how you used one or all of these.
   f. Have you answering test questions using graphs, diagrams, concept maps, or photographs?

3. Describe the type of tests that you take in class.
   a. What types of questions are on the tests?
   b. How often are you tested?
   c. How similar are your classroom tests to the Grade 8 LEAP science test?

4. After being introduced to the 20-Question Model, have you used it to analyze photographs for
information in your science class? Or on science tests?

5. Do you have any additional comments that you would like to share?

6. Do you have any additional questions?
Randy’s Concept Map of Pitcher Plant
Randy’s Concept Map of Desert/Tundra

- Little Precipitation
  - Desert
    - Has: little plants, almost no trees
  - Tundra
    - Has: dry soil, dry plants

To support: water
Randy’s Concept Map of Spider Web/Condensation

Condensation

- is caught by
  - spider string
    - float in the
    - air
  - water droplets
    - show up as
    - spider web
Randy’s Concept Map of Marsh

Marsh and Swamps

- similarities
  - water
  - grass
  - birds
  - e.g.

- differences
  - open spaces
  - trees
  - e.g.
Randy’s Concept Map of Heron

- **Heron**
  - **beaks**
    - use
    - to catch **fish**
  - **feet**
    - spread wide
    - to catch **claws**
  - **long legs**
    - to stand in **water**
  - **claws**
    - to grip
  - **mud**
Randy’s Concept Map for Puffer Fish

Puffer Fish

- round
  - with
    - spikes
- predators
  - cause them to
    - blow up
      - which makes them look
        - bigger
- live in the

Randy's Concept Maps
Ann’s Concept Map for Pitcher Plant

Pitcher Plant

- lives in swamp
- made of water
- uses physical features
  - need to catch insects
  - to make sugar
- uses photosynthesis
  - to make

food

Ann’s Concept Maps
Ann’s Concept Map for Desert/Tundra

Desert/Tundra

- have
- has little
- could be
- doesn’t support

- extreme temperature
- precipitation
- uncomfortable
- plant life

- to

live

Ann’s Concept Maps
Ann’s Concept Map for Spider Web/Condensation

Condensation

- after
- is when
- forms
  - water
    - groups into
      - droplets
        - forms

- evaporation
  - before

- precipitation

Ann's Concept Maps
Ann’s Concept Map of Marsh

Marsh

- has
  - a lot of water
  - some grass

- supports
  - life

- is identified as
  - animals
    - fish
    - birds

- eats
Ann’s Concept Map of Heron

Heron

- lives in watery areas
  - e.g. swamps, marsh

- has sharp beaks
- has long legs

- jabs food
- used to walk in water
- looks like grass

Ann's Concept Maps
Ann’s Concept Map of Puffer Fish

Puffer Fish
  - lives in ocean
  - sense predators
    - have spikes
      - hurt
      - cause puff out
  - extension

Ann's Concept Maps
Aaron’s Concept Map for Desert/Tundra

- **Desert**
  - Very dry
  - Cracked soil
  - Sand
  - Cactus
e.g. doesn’t need
  - Lots of water

- **Tundra**
  - Has
  - Water
  - Hills
  - Snow
  - Animals
  - Trees
  - Snow caps
e.g. used to
  - Cold weather

---

Aaron’s Concept Maps
Aaron’s Concept Map for Spider Web/Condensation

condensation

is part of the

water cycle

is

water

trapped in

clouds

sticks to

spider web

Aaron's Concept Maps
Aaron’s Concept Map of Marsh

- Marsh
  - can see
  - have: land, water
  - doesn't have: trees
  - live in: water
    - e.g.: beaver, nutria, birds
  - is separate from: land

Aaron's Concept Maps
Aaron’s Concept Map of Heron

Heron

- has
  - thick/broad feathers
  - long legs
  - long beaks
  - webbed feet

- to help
- help walk in
- snatch
- do not
- float
- mud
- fish
- get stuck
Aaron’s Concept Map of Puffer Fish

Puffer Fish

- expand
- are usually
- don’t have
- have

- when scared
- small
- exotic colors
- spikes

- as a form of
- when not
- expanded

- e.g.
- brown

Aaron's Concept Maps
Molly’s Concept Map for Pitcher Plant

Pitcher Plant

- Lives in a swamp
- Has a big tube
- Leaf on top

- Must need water
- Holds nectar
- Goes into ground
- Traps insects

- Also eats
- Is like a Venus Fly Trap

Molly's Concept Maps
Molly’s Concept Map for Desert/Tundra

- Desert
  - Very hot
  - Sand
  - Dry air
  - Different animals: e.g., Snake

- Tundra
  - Very cold
  - Ice
  - Vegetation
  - Covers
    - Arctic fox

Both have dry air and different animals.
Molly’s Concept Map for Spider Web/Condensation

- condensation
  - is when
  - takes place after
  - water
    - is
    - forms
    - dense
      - are
      - become
  - droplets
  - evaporation
    - is
    - last step
      - before
      - precipitation

Molly's Concept Maps
Molly’s Concept Map of Marsh

**Marsh Ecosystem**
- **doesn’t have**
  - trees
- **has**
  - water
  - grass
  - vegetation
  - long-legged birds
  - food
  - habitat
  - oxygen
  - erosion
  - stops
- provides energy
- provides
- houses
Molly’s Concept Map of Heron

Molly’s Concept Maps

- Blue Heron
  - eats
    - fish
  - walks in
    - water
  - has
    - thick feathers
    - long beak
  - long legs
  - long neck
  - looks like
    - grass
Molly’s Concept Map of Puffer Fish

- **puffer fish**
  - **has**
    - dark & light spots
    - spikes
  - **inflates**
  - **lives in**
    - ocean
  - **is**
    - very small
  - **to hide from**
    - predators
  - **protect**

Molly's Concept Maps
APPENDIX M

GRAPHS OF MEAN NUMBER CORRECT OF EACH TOPIC
FOR FORM 3 AND FORM 4

Estimated Marginal Means of pitcherplant

Achievement Level

Estimated Marginal Means

0.62
0.60
0.58
0.56
0.54
0.52
0.50
0.48
0.46
0.44

Unsatisfactory
Approaching
Basic
Mastery
Advanced

form
3
4
Estimated Marginal Means of spiderweb

Achievement Level

Estimated Marginal Means

- Unsatisfactory
- Approaching Basic
- Basic
- Mastery
- Advanced

form
- 3
- 4
Estimated Marginal Means of marsh

Achievement Level

Estimated Marginal Means

Unsatisfactory  Approaching Basic  Basic  Mastery  Advanced

form

3
4
Estimated Marginal Means of heron

Achievement Level

Estimated Marginal Means

form
3
4
Estimated Marginal Means of pufferfish

Estimated Marginal Means

Achievement Level

Unsatisfactory  Approaching Basic  Basic  Mastery  Advanced

form

- 3
- 4
VITA

Susannah Fowler Craig received a Bachelor of Science degree (1991) in elementary education and a Master of Arts degree (1994) in curriculum and instruction from Louisiana State University. She was an elementary education teacher for six years. While teaching, Ms. Craig served on several writing committees for the Louisiana Science Framework and the Teacher's Guide to Statewide Assessment-Science (currently named LEAP Assessment Guide and GEE Assessment Guide). In 1997, she accepted a position at the Louisiana Department of Education.

Ms. Craig is currently the Education Consultant for Science Assessment in the Division of Standards, Assessments, and Accountability at the Louisiana Department of Education and has served in that capacity for 10 years. Part of Ms. Craig’s professional responsibilities include the development of science test items, the development of science test forms (LEAP, GEE, iLEAP, LAA 2, and EOC), the development of auxiliary material that supports the science testing program, the development grade level expectations, and guidance in the development of the Louisiana Comprehensive Curriculum. She also provides professional development of science assessment issues for professional organizations, districts and schools, and at national conferences.

The degree of Doctor of Philosophy will be awarded to Ms. Craig at the December 2007 Commencement.