Monkeying around: examining the effects of a community zoo on the science achievement of third graders

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A Dissertation

Entitled

Monkeying Around: Examining the Effects of a Community Zoo on the Science Achievement of Third Graders

by

Heather A. Kenny

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the Doctor of Philosophy Degree in Curriculum and Instruction

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This investigation examined the efficacy of a model of integrated science and literacy instruction situated at a community zoo. Three intact cohorts of third grade urban students received instruction via different treatments: inquiry-based instruction at a zoo; inquiry-based instruction at school; and activity-based instruction at a zoo. All three treatment conditions promoted increased science achievement. There was no difference between the zoo groups at post-test; however the classroom group outperformed both zoo groups. When examined in light of contextual factors (differences in socioeconomic status, teacher level of experience, familiarity of the learning environment), results suggest the effectiveness of the integrated instructional model in promoting increased science achievement. In planning instruction, teachers should consider the novelty of a learning environment, student interest, and how texts can support inquiry.
As always, for Paul, Lauren, and Claire.
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Chapter One

Introduction

Statement of the Problem

Improving Science Instruction is an Issue of National Concern

The quality of science instruction provided in U.S. elementary and secondary schools is an issue of intense national concern. A scientifically well-educated student population is vital to ensuring a steady stream of highly skilled and knowledgeable workers into the fields of science and technology. Advances in these fields contribute substantially to the high standard of living that Americans enjoy (National Research Council [NRC], 2005). Recent reports have stated, in no uncertain terms, that scientific and technological advances are also vital to the security and prosperity of the nation. According to the Hart-Rudman Commission on National Security, “the inadequacies of our system of research and education pose a greater threat to U.S. national security over the next quarter century than any potential conventional war that we might imagine” (cited in NRC, 2005, p. 1-3).

The President’s Council of Advisors on Science and Technology was equally definitive in its statement:

Civilization is on the brink of a new industrial order. The big winners in the increasingly fierce global scramble for supremacy will not be those who simply make commodities faster and cheaper than the competition. They will be those
who develop talent, techniques and tools so advanced that there is no competition.
(cited in NRC, 2005, p. 1-3)

The economic prosperity of the U.S. has recently been challenged, and in this age of globalization some suggest that technological advances are the only way to ensure the nation’s long-term prosperity (NRC, 2005). In fact, economic studies have estimated that “as much as 85% of measured growth in US income per capita is due to technological change” (Solow & Abramovitz cited in NRC, 2005, p. 1). Scientific and technical knowledge fuels the innovation that has the potential to ensure economic prosperity, create new industries, protect and promote public health and well-being, and preserve the environment while supplying the ever-increasing energy needs of our nation (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies, 2005).

The science education of U.S. students is also important from a public policy standpoint. Effective democratic policy-making has always required the informed input of the citizenry, yet the issues facing the nation have never been more complex and controversial. Intelligent participation in the debate surrounding today’s issues - such as researching and developing alternative fuels, creating and sustaining anti-terrorism programs, and initiating stem cell research, just to name a few - require a much higher level of scientific understanding than ever before in America’s history (Organization for Economic Co-Operation and Development [OECD], 2006). Bereiter, Scardamalia, Cassells, and Hewitt (1997) observed that “science, which used to be separated from other human concerns with its own subject matters and methods, is now becoming an integral part of people’s daily lives. Increasingly, to be alienated from science is to be
alienated from society” (p. 338). Clearly, if today’s students are to be well-equipped to face the political, economic, and social challenges of tomorrow educators must strive to ensure that students achieve proficiency in science today.

Proficiency in Science, Scientific Literacy, the Importance of Inquiry

In previous generations, scientific proficiency implied discipline-specific factual knowledge and process skills such as “making observations and measurements of natural phenomena, articulating hypotheses, and designing and carrying out experiments” (NRC, 2007, p. 14). More recently conceptualizations of “proficiency in science” and “scientific literacy” have broadened to include an awareness of the purpose and nature of scientific inquiry.

The Board of Science Education at the National Academies (NRC, 2007) recently coordinated a study to examine: (a) how science is learned; (b) how science should be taught; and (c) what further research is needed “to increase understanding about how students learn science” (p. 1). The resulting publication defined “proficiency in science” as follows:

Students who are proficient in science:

1. know, use, and interpret scientific explanations of the natural world;
2. generate and evaluate scientific evidence and explanations;
3. understand the nature and development of scientific knowledge; and
4. participate productively in scientific practices and discourse. (p. 2)

It can be argued that students who are proficient in science are necessarily scientifically literate. The OECD’s (2007) conceptualization of “scientific literacy” is consistent with the aforementioned description of “proficiency in science” as both
definitions emphasize an understanding of science as a tool that can be used to better understand the natural world. The OECD defined scientific literacy as the extent to which an individual:

- Possesses scientific knowledge and uses that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues.
- Understands the characteristic features of science as a form of human knowledge and enquiry.
- Shows an awareness of how science and technology shape our material, intellectual and cultural environments.
- Engages in science-related issues and with the ideas of science, as a reflective citizen. (p. 12)

At the cornerstone of each of these definitions is the concept of scientific inquiry, a complex form of thinking. The National Academy of Sciences (1996) explained:

Inquiry is central to science learning. When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. In this way, students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills. (p. 2)

Clearly Simon (cited in NRC, 2000) was correct in that “the meaning of ‘knowing’ has shifted from being able to remember and repeat information to being able
to find and use it” (p. 5). Such a philosophical shift necessitates a corresponding shift in pedagogy from the traditional knowledge-transmission model to a model of student engagement. Unfortunately, instructional conditions in the U.S. are far less than ideal for promoting proficiency in science, particularly through scientific inquiry. The next section examines U.S. student performance with respect to international comparative assessments as well as national standards.

**U.S. Students are not Achieving Proficiency in Science**

**Performance of U.S. students on international assessments.** Currently, fifteen year-olds in the U.S. lag significantly behind many of their global counterparts in terms of scientific literacy skills. In 2006, the Programme for International Student Assessment [PISA] surveyed “more than 400,000 students from 57 countries making up close to 90% of the world economy” (OECD, 2007, Title page, para. 2). The purpose of this assessment was to measure “scientific literacy across a continuum from basic literacy skills through high levels of knowledge of scientific concepts” and to examine “students’ capacity to use their understanding of these concepts and to think scientifically about real-life problems” (p. 13).

Students in the U.S. ranked 21st among 30 OECD nations, behind nations/economies such as Finland, Canada, Japan, Korea, and the European Union. While the mean scores of students in the aforementioned countries/economies were “statistically significantly above the OECD average,” U.S. students scored “statistically significantly below the OECD average” (OECD, 2007, p. 22). The same assessment revealed that 24.4% of U.S. students scored below Level 2, the level at which “students start to demonstrate the competencies that will enable them to participate actively in life
situations related to science and technology” (p. 3). These results suggest that the scientific literacy skills of students in the U.S. are inadequate. This conclusion is further supported by the failure of elementary students to meet the national science standards as described below.

Performance of elementary students on national assessments. According to the No Child Left Behind Act of 2001 [NCLB] (U. S. Department of Education, 2007), all children should “reach, at a minimum, proficiency on challenging state academic achievement standards and state academic assessments” (p. 1439) in the area of science. Yet elementary students in the U.S. are far from reaching that goal. Data published in The Nation’s Report Card (National Assessment for Educational Progress, n.d.) in 2005 demonstrate that only 29% of fourth grade students in the U.S. scored at or above the proficient level on science content measures. These statistics also demonstrate that urban students in particular struggle with science as a mere 18% of fourth graders whose schools were located in large cities scored at or above the proficient level in that content area.¹ It can be argued then that instructional conditions in the U.S. have not been effective in helping all students, particularly urban students, achieve proficiency in science. These conditions (which include a lack of teacher preparedness, less time devoted to science instruction, and a lack of emphasis on inquiry-based science instruction) are discussed below.

Instructional conditions in the U.S.

Lack of teacher preparedness. The National Academy of Sciences (1996) contends that “students cannot achieve high levels of performance without access to skilled professional teachers [and] adequate classroom time” (p. 2). Yet according to the

¹ These statistics represent the most recent data available at the time of writing.
2000 National Survey of Science and Mathematics Education (Fulp, 2002) although 89% of the elementary teachers surveyed considered themselves to be well prepared to encourage their students’ interest in science “fewer than one-third of elementary teachers reported feeling very well qualified to teach each of the science disciplines [life science, earth science, and physical science]” (p. 5). Of those surveyed, 72% of elementary teachers reported a perceived need for deepening their own science content knowledge while 65% expressed a need for “learning how to use inquiry/investigation-oriented teaching strategies” (p. 8). Yet despite these concerns the elementary teachers surveyed typically spent very little time engaging in professional development activities related to science; 75% reported having spent a total of 15 or fewer hours on science-related in-service education in the previous three years.

**Less classroom time devoted to science instruction.** Elementary teachers’ lack of preparedness to teach science is not the only instructional condition which is likely to adversely affect elementary students’ science proficiency. Since the enactment of NCLB in the 2001/02 academic year, the average amount of time devoted to science instruction in elementary classrooms has diminished substantially. From November 2006 to February 2007 the Center on Education Policy surveyed school districts in an attempt to sift out the effects of NCLB, which mandates the nation-wide testing of elementary students in the areas of reading and mathematics. McMurrer (2007) reported that since the passage of NCLB 62% of school districts sampled reported that they increased time for English language arts and/or math at the elementary level, while 44% of districts reduced the time devoted to other subjects such as science. More than a quarter of all school districts sampled reported that instructional time in science had decreased since
the implementation of NCLB. The average reported decrease was a disturbing 75 minutes per week. Of the districts that had at least one school identified for NCLB improvement, 43% reported decreasing the amount of instructional time in science. The average decrease for these schools was 94 minutes per week.

*Lack of emphasis on inquiry-based science instruction.* In an attempt to respond to the considerable challenges facing the U.S. in the future, the National Academies Committee on Prospering in the Global Economy of the 21st Century was commissioned to recommend “specific steps that can best strengthen quality of life in America – our prosperity, our health, our security” (NRC, 2005, p. 1). Among other suggestions, the Committee strongly recommended that inquiry-based learning be expanded so as to be available to all elementary students. Yet despite this appeal and the emphasis placed upon inquiry-based science instruction by the National Science Education Standards, Fulp (2002) reported that “fewer than half [of elementary school science teachers] place a heavy emphasis on … learning science process/inquiry skills” (p. 11). Further a disturbing 64% of elementary science teachers described themselves as “not at all familiar” with the national science standards.

Data also indicate that “activities considered more traditional in nature, reading in class and the use of textbook or worksheet questions, increase as elementary grade ranges increases with engagement in hands-on/laboratory activities becoming less frequent in grades 3-5” (Fulp, 2002, p. 15). The 2000 National Survey of Science and Mathematics Education revealed that while students in grades K-2 spent an average of 35% of their time in science class working with hands-on, manipulative, or laboratory materials, this percentage shrunk to 25% for students in grades 3-5 who spent a full 52% of their time in
science class on traditional instructional activities. In another study involving 1,222 K-12 mathematics and science teachers, Marshall, Horton, Igo, and Switzer (2009) found that on average the elementary teachers surveyed considered 60% of instructional time to be the ideal amount of time to devote to inquiry-based instruction. Yet those same teachers reported that they only spent on average 41% of available time on such instruction.

Marshall and his colleagues speculated that teachers may avoid inquiry-based instruction because of its inherent complexity or because of their own lack of knowledge or experience related to inquiry-based teaching methods.

The climate in today’s mainstream elementary classrooms - characterized by a lack of teacher preparedness, insufficient time devoted to science instruction, and a lack of emphasis on inquiry-based instruction - is not conducive to promoting the science proficiency of average U.S. students let alone urban students. Urban students typically face even greater challenges than their suburban counterparts and require additional support to experience success with respect to content area subjects such as science. The characteristics of urban students and the unique challenges they face are discussed next.

**Characteristics of urban elementary students.** The demographic characteristics of urban areas differ qualitatively from those of the U.S. population in general. Hannaway (2005) reported that urban areas are “more likely to be language minority, Hispanic, African American, and poor” (p. 4). Over 26% of the population in U.S. cities speaks a language other than English at home as compared to a national average of 17.5%. In urban areas 24% of children fall below the poverty line as compared to 16.1% of the children across the nation. Blacks or African Americans and Hispanics represent 40.9% of the urban population, whereas these groups represent only 24.8% in the general
population (p. 4). Of even greater concern is the fact that children enrolled in urban public schools tend to be “even more poor and minority than the city population generally” (p. 5). While poverty, language minority status, and cultural minority status do not cause children to be academically disadvantaged, these factors are all associated with reduced student achievement (Hannaway, 2005; National Assessment for Educational Progress, n.d.). Gee (2004) described this phenomenon in terms of the differences between “privileged” and “less privileged” children.

Privileged and less privileged children. Privileged children are those who are born to families within the economic, linguistic and cultural mainstream of the U.S. Long before they reach school-age, these children are exposed to forms of language and discourse patterns that map well to the specialist varieties of language that are used at school. Such “early prototypes of academic varieties of language” (Gee, 2004, p. 19) prepare them for success in an academic setting.

In contrast less privileged children (who are often urban students) typically hail from families outside of the economic, linguistic, and/or cultural mainstream. The everyday forms of language that these children encounter in their early years is often historically and culturally rich (Delpit, 2006; Gee, 2004; Heath, 1983; Purcell-Gates, 1995) however such varieties of language can be strikingly different from the academic language patterns that are encountered at school. Consequently these children, to whom academic language sounds strange or even foreign, are at a decided disadvantage with respect to learning subject-specific language forms and discourse patterns, particularly in content area subjects such as science which “are tied to academic specialist varieties of language (and other special symbol systems) that are complex, technical, and initially
alienating to many learners” (Gee, p. 3). Less privileged children are far less likely than their more privileged peers to have encountered academic forms of language before attending school. Although less privileged children may keep up with their more privileged peers in the early grades when learning the basic processes of reading, they typically fall behind when they encounter challenging content-area texts that require them to acquire information through reading. Chall, Jacobs, and Baldwin (1990) observed this phenomenon and used the phrase “the 4th grade slump” to describe the achievement gap that appears around the 4th grade between low-income children and children from higher-income homes.

The 4th grade slump. Chall, Jacobs, and Baldwin (1990) compared the literacy achievement of low-income below-average readers with low-income above average readers and national norms to discern when and how the achievement gap between low-income students and their more privileged counterparts occurs and what can be done to counteract that phenomenon. The researchers asserted that the 4th grade slump can be explained in terms of Chall’s developmental model of reading. According to this model, in the early years (grades K-3) children’s major reading task is to recognize words in print. These words are “common, familiar, concrete words” (p. 45) that are typically part of children’s speaking and/or listening vocabularies. At this early stage of reading development “most children in the primary grades (1 to 3), even those with limited English, are more advanced in language and thinking than in reading skills” (p. 44). Thus early reading primarily consists of mapping letter symbols onto words and concepts that are already familiar.
Beginning in 4th grade however the emphasis of reading shifts from word identification to the “comprehension of harder texts that use more difficult, abstract, specialized, and technical words” (Chall, Jacobs, and Baldwin, 1990, p. 46). Further concepts presented through text become increasingly abstract requiring “more sophisticated levels of background knowledge and cognition” (p. 46). It was at this stage that the low-income below-average readers participating in the study began to struggle, and the achievement gap between them and their more privileged peers widened as the grade levels increased. The above-average low-income readers tended to hold their own until 6th or 7th grade; however, at that time, they too began to struggle.

Chall and her colleagues (1990) hypothesized that the students began to encounter challenging vocabulary (longer, less familiar, more abstract, and more technical words) around 4th grade. Although the above-average readers had well-developed word identification and fluency skills that enabled them to compensate for their unfamiliarity with such terms, the performance of the below-average readers began to decline markedly. By around the 7th grade even the above-average readers were struggling in comparison to normative standards. Chall et al. concluded that these children needed help in learning the abstract and specialized vocabularies that constitute the content of content area subjects.

Most contemporary urban students would be considered far less privileged than the 30 participants in Chall, Jacobs, and Baldwin’s (1990) study. The latter group came from relatively stable home environments, most of which were classified as two-parent households. They spoke English as a first language. Their neighborhoods were described as “familiar and safe for parents and for children” (p. 20), and the students attended
schools in a district that was rated as “above average.” If these children succumbed to the 4th grade slump, it should be unsurprising that contemporary urban students do not fare as well as other students in the U.S. with respect to academic achievement in the content area of science. These urban students are disproportionately poor, frequently of language and cultural minority status, potentially living in neighborhoods that are characterized by urban violence, and/or attending struggling schools. It is therefore incumbent upon educators to explore alternative instructional approaches to science that have the potential to bridge the achievement gap and promote success among all students. Ideally such approaches should: (a) adequately prepare elementary teachers to teach science content; (b) increase the amount of time devoted to science instruction; and (c) emphasize inquiry-based science learning.

The Toledo Zoo Thinking Works Lessons: An Alternative Approach

One alternative approach to science instruction that is recommended by the National Academy of Sciences (1996) is for school districts to partner with informal learning environments such as zoos, museums, and science centers. Such environments are inherently motivating for students. The objects and living collections showcased in the exhibits “stimulate children’s curiosity and support inquiry-guided learning” (Paris & Hapgood, 2002, p. 46).

The Toledo Zoo is an authentic scientific community that is replete with living collections, objects, and scientific artifacts. This environment has the potential to support student learning in the content area of science and encourage scientific thinking through inquiry-based learning. In an attempt to capitalize on the learning potential of the zoo and thereby promote science proficiency amongst local elementary students, Toledo Zoo
education staff partnered with university researchers and elementary teachers from a large urban school district. The result of this collaboration was the creation of the Toledo Zoo Thinking Works [TZTW] lessons, which are inquiry-based units of study that combine classroom-based instruction with visits to zoo exhibits. These lessons were designed to be used at the Toledo Zoo or adapted for use at other zoos across the United States.

TZTW lessons prepare elementary teachers. The creators of the TZTW lessons recognized that elementary teachers must have sufficient background knowledge about the topics under investigation in order for them to be able to effectively teach the content of the lessons. To that end Toledo Zoo education staff created a Teacher Overview to accompany each of the TZTW lessons. The content of the overviews was intended to equip teachers with the information they need to “orchestrate student observations, thinking and interactions to engage them [the students] in scientific inquiry and enhance their learning” (Magdich & Carr, 2005, p. 2). These resources provide a means by which teachers - even those with limited background in the biological sciences - can build the background knowledge needed to teach science topics effectively.

Kenny (2009) interviewed ten teachers who had taught the TZTW lessons. These teachers acknowledged that the TW lessons supported their own learning about animals. Kenny reported:

The background information packages provided to teachers by the zoo were beneficial in that they were well-written and provided a great deal of accurate information that teachers could refer to “if those kids ask you something you don’t know”. The materials provided teachers with “guidance,” prompting one
teacher to admit “I’m not [an animal person]…but honestly, looking at this, I could do this, and I could do this well.” (p. 19)

**TZTW lessons increase time devoted to science.** In this era of NCLB teachers frequently complain that there is insufficient classroom time for science instruction (Kenny, 2009; McMurrer, 2007). One potential solution to this problem is to integrate “reading and math instruction into other core academic subjects [such as science, so that] students will be ensured of a rich, well-rounded curriculum” (McMurrer, p. 2); however, as McMurrer reported, “that’s very tricky; it takes a pretty highly skilled teacher to be able to do that” (p. 19). The TZTW lessons provide elementary teachers with support in integrating science instruction with literacy instruction, thereby enabling teachers to devote more classroom time to science instruction without affecting the amount of literacy instruction provided.

The TZTW lessons are situated within Carr, Aldinger, and Patberg’s (2004) Thinking Works [TW] framework: a lesson-planning guide that promotes the use of evidence-based strategy instruction. Research suggests that instruction in comprehension strategies can be effective in promoting increased reading achievement (Dewitz, Carr, & Patberg, 1987; Duffy, 2002; Duke & Pearson, 2002; Pressley, 2002; National Institute of Child Health and Human Development, 2000; Snow, 2002). Carr and her colleagues (2004) identified 12 superordinate cognitive processes that are “essential for the comprehension of text and the application of learning” (p. 11). These processes can be activated through the use of reading strategies. The goal of the TZTW lessons is to guide students in the use of strategies, thereby activating the cognitive processes as they read, write, and think about science content.
Reading and writing, though widely considered to be general literacy skills, are the cognitive tools by which students construct discipline-specific knowledge (Gee, 2004; McKenna & Robinson, 2009). Thus instruction via the TZTW lessons simultaneously promotes: (a) science content knowledge; (b) general literacy skills; and (c) content literacy skills, which McKenna and Robinson (2009) defined as “the ability to use reading and writing for the acquisition of new content in a given discipline” (p. 6).

**TZTW lessons emphasize inquiry-based science learning.** The NRC (2007) recommended that teachers be provided with inquiry-based models of science instruction in which students “talk and write about their observations of phenomena, their emerging understanding of scientific ideas and ways to test them” (p. 6). Further, the NRC asserted that while experiments have traditionally been the focus of classroom-based science instruction, today’s students should have opportunities to engage in multiple forms of scientific investigation, including observation.

The TZTW lessons were designed with the specific intention of engaging students in observation-based inquiry. The lessons integrate instruction in four strategy components: a background knowledge component, a vocabulary component, a comprehension component, and application/extension component. Each lesson presents a different combination of research based learning strategies with “particular emphasis... placed on developing students’ vocabulary knowledge, comprehension, and critical thinking by supporting them through the synthesis, evaluation and analysis of information learned and the application of that knowledge in new ways to novel learning situations” (Magdich & Carr, 2005, p. 2). Each lesson also engages students in the language processes of reading, writing, speaking, and listening. As students actively construct their
own scientific understandings by observing, describing, questioning, and discussing, they participate fully in the scientific inquiry process and develop concomitant scientific habits of mind.

The 2006/2007 TZTW Project

In 2006 the Toledo Zoo received funding from the National Department of Education to investigate the effectiveness of the TZTW lessons in promoting the science achievement of elementary students. From January 2006 until March 2007 the TZTW lessons were field-tested by second and third grade teachers and their students during the course of the 2006/2007 TZTW project. Approximately 1,000 elementary students from 15 urban and suburban schools in the greater Toledo, Ohio area participated in this two year longitudinal study. Investigators matched schools according to size and demographic information (urban or suburban location and percentage of students receiving free or reduced cost lunch), and then randomly assigned one school in each pair to either the TW condition, or to a comparison group.

Participating students completed lessons during the spring of their second grade year (Birds, Amphibians, and Fish), and an additional three lessons during the fall of their third grade year (Cats, Primates, and Savannah). Both groups spent the same amount of time on task and visited a related zoo exhibit in connection with each lesson; however, students in the comparison group were taught via a traditional lesson (created to mirror what Toledo Zoo educators and university researchers considered to be the type of instruction elementary students typically receive in connection with a field trip to the zoo) whereas students in the TW condition were taught via the TW lessons. For their own
Reference teachers of students in the TW condition also received the background information packages prepared by Toledo Zoo educators.

Prior to each lesson and the accompanying zoo visit students were pre-tested on their science content knowledge. The same tests were then used as post-tests upon completion of the lessons and again as delayed post-tests four weeks later. For five of six of the lessons students in the TW group significantly outperformed their peers in the comparison group at post-test and delayed post-test ($p < .001$) although the groups exhibited no significant differences with respect to the dependent variable at pre-test for four of those five lessons. (Students in the comparison group scored statistically significantly lower than students in the TW group at pre-test with respect to the Cats lesson.) The Primates lesson however did not produce statistically significant results ($p > .05$) (Kenny, Carr, & Magdich, 2009).

**Unresolved Issues**

If, as the results of aforementioned study suggest, TZTW lessons are effective in promoting increased science achievement amongst elementary students then the widespread use of these lessons has the potential to dramatically increase the number of urban students who pass state proficiency standards in science. However, the original investigation leaves several compelling issues as yet unresolved. For example, is the Primates lesson truly ineffective in promoting increased science achievement, or might it be effective with a different cohort of students at a different time, under a different set of circumstances? Researchers in the original investigation conjectured that other factors may have confounded the results of the Primates lesson. For example weather-related problems prevented some students from accessing the exhibit (Kenny, 2009). Alternate
researchers speculated that participating students may have experienced testing fatigue (E. Carr, personal communication, October 30, 2008).

Given this set of circumstances the TZTW Primates lesson appears worthy of further attention. Another issue that is as yet unresolved is whether the TZTW lessons can be used effectively in other zoo settings. Finally it remains to be seen as to whether the zoo environment contributes to student achievement over and above the TZTW lessons. The current investigation was undertaken in order to examine those issues.

**Purpose of the Study and Research Question**

The purpose of this investigation was to compare the average science achievement scores of three groups of students at three points in time (pre-test, post-test, and four-week delayed post-test). Third grade students from the urban school district that participated in the investigation were assigned to one of three treatment groups:

1. The TW Zoo group [TWZ group] which received instruction via the TZTW Primates lesson in connection with a visit to the participating zoo’s primates exhibits.

2. The Comparison Zoo group [CZ group] which received instruction via a traditional lesson in connection with a visit to the participating zoo’s primates exhibits.

3. The TW Classroom group [TWC group] which received classroom-based instruction via the TZTW Primates lesson.

The results of this study are intended to be generalized to future third grade students at schools with similar demographic characteristics.
Research Question

This study addressed the following research question: How do the science achievement scores of students in the TWZ, CZ, and TWC groups compare at pre-, post-, and delayed post-test?

Research Hypothesis

The research hypothesis is as follows.

A. Students in the three groups scored the same at pre-test.

H₀: μ_{twz} = μ_{cz} = μ_{twc} (There was no statistically significant difference among the groups in terms of their average pre-test scores.)

B. All groups significantly improved over time from pre- to post-test, however the two TW groups maintained those gains from post- to delayed post-test, while the scores of the CZ group decreased from post- to delayed post-test.

C. At post- and delayed post-test, students in the TWZ group outperformed students in the TWC group, who in turn, outperformed students in the CZ group.

Conclusion

If the U.S. is to enjoy security and prosperity well into the future, then today’s elementary students must achieve proficiency in the area of science. Contemporary conceptions of “proficiency in science” have shifted from an emphasis on factual knowledge and process skills to an understanding of science as a tool for making sense of the world. Contemporary students are expected to engage scientific inquiry. Yet instructional conditions in today’s elementary classrooms are far less than optimal for
promoting proficiency in science through scientific inquiry. U.S. students are currently failing to meet national standards for science proficiency and they are lagging behind their global counterparts with respect to scientific literacy skills.

Overall elementary teachers can be characterized as unprepared to teach science through inquiry as recommended by the National Science Standards. Of further concern is the fact that since the implementation of NCLB the amount of time devoted to science instruction has been reduced considerably. Finally there is a general lack of emphasis on inquiry-based science instruction. Alternative approaches to science instruction are therefore needed to: (a) adequately prepare teachers to teach science; (b) increase the amount of time devoted to science instruction; and (c) emphasize inquiry-based science instruction. The TZTW lessons are one such approach that support elementary teachers and students by: (a) building teachers’ background knowledge so that they are better prepared to teach science content; (b) increasing the amount of time devoted to science instruction by integrating science content with literacy instruction; and (c) engaging students in authentic inquiry-based science learning.

Although the original 2006/2007 TZTW investigation determined that five of the six TZTW lessons were effective in promoting the increased science achievement of elementary students, the Primates lesson did not produce statistically significant results. Thus the current investigation was intended to re-examine the Primates lesson with a different population in a different zoo. The current study was also undertaken to extend the original investigation by further examining the effect of instruction situated at a community zoo.
The unique affordances of community zoos have the potential to contribute to the science achievement of elementary students as demonstrated by the original 2006/2007 TZTW Project (Kenny, Carr, & Magdich, 2009). The results of that investigation are encouraging however more must be understood about the TZTW lessons in general and the Primates lesson in particular. Further it is important to examine the distinct contribution of a zoo setting to elementary students’ science achievement above and beyond the lessons themselves. Finally, before the TZTW lessons can be adopted by other zoos on a widespread basis, it must be determined whether those lessons can be used effectively in other zoo settings. This investigation is intended to shed light on those issues and contribute to the existing body of literature related to science education and informal learning environments.

Chapter Two discusses bodies of literature related to the current investigation. First, it defines key terms, presents a rationale for integrating science and literacy instruction, and reviews pedagogical models of integrated science and literacy instruction which inform the current investigation. Second, it situates the TZTW Primates lesson in the context of the overall TW framework, as well as a sociocultural conception of learning. Third, the chapter examines literature related to learning in informal learning environments [ILEs]\(^2\) in general, and learning from animals in connection with zoo environments, in particular.

Chapter Three describes the methodology of the investigation, including the study participants, the research sites, and the materials used. It also outlines the protocols employed, data sources, and data analysis procedures. Finally, Chapter Three includes a discussion of the limitations of the study. Chapter Four reports the findings of the

\(^2\) ILEs include such cultural institutions as zoos, museums, and botanical gardens (Paris & Hapgood, 2002).
investigation, while Chapter Five considers the implications of these findings as well as directions for future research.
Chapter Two
Review of Related Literature

The Organization of the Chapter

This chapter explores important ideas related to inquiry-based science instruction, instruction in reading comprehension strategies, and learning in zoo environments. The chapter is divided into three sections. Although it is customary to begin such a review with an overview of the theoretical frameworks which inform the investigation, this chapter differs in that regard.

Before examining the theoretical underpinnings of this investigation it is important for the reader to understand the study-specific meanings of some key terms that are bandied about frequently in educational circles. These terms are so pervasive in the literature that their definitions are occasionally overlooked. Yet a precise understanding of the meanings of these terms must be achieved in order for the reader to fully appreciate the nuances of this investigation. In addition it is important for the reader to understand the rationale for integrating science and literacy instruction. Consequently the first section of this chapter is devoted to examining key terms related to literacy and science and providing a rationale for integrated instruction. Thus a broader discussion of the theoretical frameworks and related literature is prefaced by an explanation of key terms and a discussion of the benefits of integrating science and literacy instruction. This first section also examines previous investigations related to integrated science and literacy.

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3 For an example related to the term “literacy,” see Temple, Ogle, Crawford, & Freppon (2008).
instruction (including the original TZTW study) and considers how these previous investigations inform the current study.

The second section describes the nested theoretical frameworks which undergird the investigation. Specifically, it discusses the structure of the TW framework (Carr, Aldinger, & Patberg, 2004) and the research base which supports its use. This section also describes the specific elements of the TZTW Primates lesson and situates the lesson within the TW framework as well as within the broader context of a sociocultural conception of learning. The third and final section, which is further divided into two major sub-sections, examines the literature in two distinct yet overlapping realms: (a) learning within the context of ILEs; and (b) learning related to zoo environments. Interwoven within these discussions is an account of the potential of such environments to motivate students and the role of motivation in promoting student learning.

**Literacy and Science**

Although the outcome measure in this investigation is science achievement, it is well-established that literacy skills are essential to student achievement in all content areas (Chall, Jacobs, & Baldwin, 1990; Dishner, Bean, Readence, & Moore, 1992; McKenna & Robinson, 2009), and that literacy is a fundamental tool necessary for conducting science (Phillips & Norris, 2009; Palinscar & Magnusson, 2001; Varelas & Pappas, 2006; Yore et al., 2004). Consequently this investigation does not fall squarely within the traditional paradigm of either science instruction or literacy instruction but rather examines the intersection of the two and draws from literature related to both.
This approach is not without precedent. Yore et al. (2004) stated that “it is now timely for colleagues in science education and language and literacy education to jointly construct initiatives that investigate…science literacy” (p. 351). Hapgood and Palinscar (2006/2007) strongly recommended integrating literacy instruction with inquiry-based science, suggesting that “the two subjects can be more powerful when combined” (p. 60). Other researchers, such as Rosebery, Warren, and Conant (1992), Varelas and Pappas (2006), and Hapgood, Palinscar, and Magnusson (2004), have explored a variety of instructional approaches that enable students to successfully use literacy as a tool for scientific inquiry. These approaches are examined in detail in this literature review as they inform and relate to the current investigation. This section is divided into three major sub-sections. Within these literatures are many terms that have multiple meanings in different contexts. For the sake of clarity an explanation of several key terms is provided below.

**Key Terms**

The following discussion of the terms “literacy,” “inquiry-based science instruction,” “content area literacy,” “comprehension,” and “comprehension strategies” is intended to provide the reader with specific definitions of terms used throughout the broader discussion. These explanations also serve to orient the reader to the focal point of this investigation - specifically the intersection of science and literacy instruction.

**Literacy.** The term “literacy” means different things to different groups of people. To the layperson literacy typically refers to a general ability to read and write. In educational circles however that definition is insufficient. Educators recognize that literacy is not a unity construct. The same person can be literate in one sense and yet
illiterate in another. A person who loves reading novels may be unable to follow the online directions for downloading a computer program. A person who can write fluently in Spanish may be unable to fill out a form in English.

Although traditionally literacy has been thought of specifically in relation to written language, recent conceptions have broadened to include oral language. DeTemple and Snow (2001), for example, promoted a “conversation-enhanced view of literacy” (p. 56), arguing that conceptions of literacy need not be constrained to interactions with written text:

Literacy can be rather narrowly defined as what one does while reading, or as the capacities that make reading possible. Much more broadly, it can be defined as participation in certain kinds of socio-cultural activities typically associated with but neither limited to nor even absolutely requiring the reading of text. (p. 56)

In this investigation such a broad view of literacy was adopted. The conception of literacy that undergirds this study is reflected by the following definition: literacy is the context-specific ability to effectively understand and communicate ideas through oral and/or written language. Thus literacy, in the context of this investigation, encompasses not merely text-based events but a broad range of communicative events including many that are embedded in inquiry-based science instruction.

**Inquiry-based science instruction.** Traditionally science instruction is conceived of as either hands-on, or text-based. Either students engage in experimental investigations, often following prescriptive instructions offered by the teacher or the
textbook, or they are seated at desks reading about scientific phenomena. Neither of the two scenarios described above conjures up an image of what the National Science Education Standards (National Academy of Sciences, 1996) referred to as “hands-on, minds-on” science.

Inquiry-based science instruction is a pedagogical practice that is intended to be active both in a physical and in a cognitive sense. The Standards describe it as “multifaceted activity” that encompasses diverse ways to explore the natural world. Hapgood and Palinscar (2006/2007) described it as students “using the tools of science to answer questions about real-world phenomena” (p. 56): tools which include reading, writing, speaking and listening.

Phillips and Norris (2009) balked at the traditional characterization of reading in the science classroom as a “passive” approach to learning. Instead they suggested that reading is a form of inquiry: a legitimate means by which students can explore real-world scientific questions for the purpose of generating explanations based on evidence. In addition it is a means by which students can further develop their knowledge about scientific ideas and the way in which scientists generate knowledge (National Academy of Sciences, 1996).

Inquiry-based science instruction is neither merely hands-on, nor is it exclusively text-based. It is a hybrid that encourages students to use the diverse tools and informational sources at their disposal (including text-based resources and human resources such as their teachers and peers) to actively seek answers to questions about the natural world. Such instruction strives to teach and reinforce scientific behaviors such as:

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4 Although Martin-Hansen (2002) refers to such investigations as “structured inquiry,” she is quick to point out that “simply following directions in a cookbook manner does not actively engage students’ minds. Therefore, one could argue that structured inquiry does not include much true inquiry” (p. 37).
observing; questioning; planning investigations; predicting; evaluating claims based on evidence; gathering, analyzing, and interpreting data; proposing answers; and communicating results (National Academy of Sciences, 1996, p. 23). In short inquiry-based science instruction is hands-on, minds-on science that integrates scientific and literacy practices.

**Content area literacy.** Researchers widely recognize that the construct of literacy is not merely a generalized set of skills that can be indiscriminately applied to any and all types of texts (Dishner, Bean, Readence, & Moore, 1992; McKenna & Robinson, 2009). Rather an individual’s level of literacy must be considered in relation to the context in which that individual is expected to function. Different situations call for different skill sets. So too do different content area subjects – those associated with real-world disciplines such as science, mathematics, and history - place subject-specific demands upon learners. Targeted instruction in content area reading is aimed at helping students cope with the subject-specific content, materials, and tasks that students will encounter in a given subject area (Moore, Readence, & Rickelman, 1992).

McKenna and Robinson (2009) identified “content literacy” as one aspect of literacy, defining it as “the ability to use reading and writing to acquire new content within a given subject area” (p. 12). For the purpose of this investigation, McKenna and Robinson’s definition is expanded to include the use of oral language to construct new understandings. This definition implies that content literacy is domain-specific. Further it suggests that content literacy is not knowledge per se, but rather a set of skills needed to acquire knowledge in a particular domain.
McKenna and Robinson (2009) further suggested that content literacy encompasses “three principal cognitive components: (1) general literacy skills, (2) prior knowledge of the content, and (3) content-specific literacy skills” (p. 6). Thus by supporting the acquisition of science content or the development of literacy skills (applied to subject-specific content) teachers automatically promote their students’ science content literacy skills, regardless of whether or not those skills are developed through the reading of traditional texts.5

It has been well established that language (both oral and written) is used differently in different disciplines. Content area subject matter and materials are characterized by technical vocabulary, dense conceptual loads, and subject-specific discourse patterns and symbol systems. For example, Wilson (2008) described the materials typically encountered in science classrooms as “multimodal” in that they communicate meaning through multiple sign systems (p.154). She cited the example of students attempting to make meaning from a three-dimensional model of the digestive system accompanied by an explanatory text (p. 153). Inquiry-based science instruction places additional demands on learners, requiring that they make sense of observed phenomena. Thus science, like all content area subjects, presents the learner with subject-specific challenges (Moore, Readence, & Rickelman, 1992; Phillips & Norris, 2009). Happily these challenges can be ameliorated by appropriate instruction in comprehension strategies (McKenna & Robinson, 2009; Wilson, 2008; Wood, 1992). In the next section,

5 Traditional elementary science texts are described by Palinscar and Magnusson (2001) as “considerate, nonrefutational, [and] expository” (p. 160).
the concept of “comprehension”⁶ are addressed, followed by a discussion of “comprehension strategies.”

**Comprehension.** The comprehension of oral or written language is a highly abstract phenomenon. As Johnson-Laird (cited in Snow, Griffin, & Burns, 2005) stated, “to understand a proposition is to know what the world would be like for it to be true” (p. 22). Since human beings are incapable of accessing one another’s thoughts directly, communication between them must be mediated by language, either spoken or written. Vygotsky (Vygotsky & Kozulin, 1986) described this dilemma as follows:

> Thought, unlike speech, does not consist of separate units. When I wish to communicate the thought that today I saw a barefoot boy in a blue shirt running down the street, I do not see every item separately….I conceive of all this in one thought, but I put it into separate words. A speaker often takes several minutes to disclose one thought. In his mind the whole thought is present at once, but in speech it has to be developed successively. (p. 123)

Language, then, is an imperfect, if powerful tool for communication. As Snow, Griffin, and Burns (2005) observed, “the reader or listener has to read between, above, and beyond the line to comprehend….Language does not provide enough material to specify fully the knowledge of the world that a reader or listener uses to comprehend” even relatively simple messages (p. 22). Thus comprehension can be conceived of as the process of actively constructing meaning. It is the process by which learners construct

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⁶ As this investigation is specifically concerned with the intersection of science and literacy, the topic of comprehension is addressed from a language-mediated perspective.
mental representations of concepts by reconciling what they already know about the world with new information.⁷

Although spoken and written language obviously differ in important respects (most obviously the method of delivery), the cognitive processes (thinking skills) that underlie their comprehension remain constant (Snow, Griffin, & Burns, 2005). Written language is but the means by which humans superimpose visual symbols on spoken language (McKenna & Robinson, 2009), enabling them to engage in what are merely technologically-advanced versions of age-old communicative processes: speaking and listening. Literacy in the form of reading and writing is therefore a secondary system that is dependent upon spoken language as the primary system (Adams, 1990; Snow, Griffin, & Burns). The comprehension of spoken and written language can be improved through the use of comprehension strategies.

**Comprehension strategies.** If understanding breaks down when listening, a listener can take deliberate action to repair comprehension. For example, the listener may ask a question, or request that the speaker repeats information. These actions are referred to as “strategies.” “Comprehension strategies” are deliberate actions that learners engage in before, during, and/or after a literacy event to improve their level of comprehension. Stated differently, a comprehension strategy is “a cognitive or behavioral action that is enacted under particular contextual conditions, with the goal of improving some aspect of comprehension” (Graesser, 2007).

Sinatra, Brown, and Reynolds (2002) explained that there is a cognitive “overhead” to all tasks. Human beings have limited attentional resources. Conscious

⁷ The specific cognitive structures which are thought to support active meaning-making are described in a subsequent section.
tasks require more cognitive capacity than tasks which have become automated. Thus conscious activity leaves less cognitive capacity for the integration of new knowledge with previously-held knowledge. The goal of comprehension instruction should be the automatization of as many comprehension processes as possible. Such automatization occurs only when, through repeated practice, skills are over-learned to the extent that a reader no longer needs to devote conscious attentional resources to the task at hand. Consequently “skilled readers [are] those who have automated as many decoding and comprehension processes as possible, thus allowing them to conserve adequate cognitive resources to behave in a strategic manner when necessary” (Sinatra, Brown, & Reynolds, p. 70).

Comprehension strategy instruction promotes student comprehension both in the short-term (as students are applying the strategy or strategies to specific content) and in the long-term (by promoting automaticity in activating and applying cognitive processes during literacy events). Strategy instruction also promotes the development of metacognitive awareness so that students are aware of any break-downs in comprehension. If such a break-down occurs, students are better equipped to consciously and flexibly employ deliberate strategies that will be effective in helping them repair comprehension.

**Summary.** An understanding of the constructs of “literacy,” “inquiry-based science instruction,” “content area literacy,” “comprehension,” and “comprehension strategies” can contribute to an understanding of how science and literacy intersect. The discussion surrounding these terms implies that pedagogical models that integrate science and literacy instruction have the potential to promote achievement in both domains. Such
is indeed the case. A more explicit rationale for such an integrated model of instruction is outlined below.

**A Rationale for the Integration of Science and Literacy Instruction**

Admittedly amongst many classroom teachers literacy instruction is not considered to fall within the traditional purview of science educators (Dishner, Bean, Readence, & Moore, 1992; McKenna & Robinson, 2009) despite the long-standing call of researchers for content area teachers to think of themselves as “teachers of reading” (Gray cited in Moore, Readence, & Rickelman, 1992). In fact many science teachers consider themselves to be “information dispensers” (Dishner et al.) and are resistant to the idea that in addition to teaching the content of their subject they must be responsible for teaching literacy skills (McKenna & Robinson; O’Brien & Stewart, 1992). After all, to be responsible for instructing students in discipline-specific reading and writing means adding several more items to their ever-increasing curricular loads.

This “additive” viewpoint however fails to acknowledge: (a) the essential nature of science as a discipline; (b) the fact that literacy is a major component of real-world science; and (c) the subject-specific literacy demands of science. Figure 2.1 is a graphic representation of a rationale for integrated science and literacy instruction.
Figure 2.1: A Rationale for Integrating Science and Literacy Instruction

Science is a quest for new knowledge. Reading, writing, and oral communication are fundamental to the manner in which phenomena are investigated.

Real-world scientists spend more time participating in literacy-related activities than they do engaged in hands-on experimental activities (Philips & Norris, 2009).

Scientific discourse patterns are qualitatively different than narrative discourse patterns in terms of: argumentative structure, vocabulary, types of nouns, and verb tenses.

**Why should science teachers teach content literacy?**

**The essential nature of science as a discipline.** Pollak (1993) stated that “science is looking for patterns in nature” (p. 516). This simple yet insightful definition is an excellent point of departure for a discussion on the nature of science as a discipline.

Science is a quest. It is a search for understanding that demands an attitude of questioning, even doubt. All great discoveries from Galileo’s heliocentric model of the solar system to Einstein’s theories of relativity are rooted in a fundamental dissatisfaction with extant explanations of phenomena.
This characterization of science is diametrically opposed to the attitudes and practices that are frequently fostered in contemporary science classrooms. The existing science culture in the typical U.S. classroom focuses on the propagation of knowledge (Reiser et al., 2001). Teachers dispense information and students are charged with “swallowing” that information in a manner similar to the way in which one swallows “a kind of bad-tasting medicine, unpleasant, but ultimately to be vindicated by its benefits” (Pollak, 1993). When “hands-on” type activities do take place in the classroom, they are most often what Wong and Hodson (2009) referred to as “cookbook and verification-type practical work” (p. 124). Rather than a means by which to generate new understandings among students, these experiences simply replicate and reinforce what has been taught to them as “truths.”

Pollak (1993) viewed this contradiction in terms of Fromm’s conception of “the having mode” and the “being mode.” Fromm (cited in Pollak) described students in the having mode as follows:

Content does not become part of their own individual system of thought, enriching and widening it. Instead, they transform the words they hear into fixed clusters of thought, or whole theories, which they store up. The students and the content... remain strangers to each other except that each student has become the owner of a collection of statements made by somebody else (who had either created them or taken them over from another source).

Students in the having mode have but one aim: to hold on to what they “learned”... They do not have to produce or create something new. In fact, the having-type individuals feel rather disturbed by new thoughts or ideas about a
subject, because the new puts into question the fixed sum of information they have. (p. 514).

In contrast, students in the being mode are engaged in “being” a scientist in the sense that they approach science content with the appropriate attitudes and dispositions of critical thinking, relying on evidence, and distinguishing between actual experience and interpretations of experience. Fromm described the being mode in the following manner.

Instead of being passive receptacles of words and ideas, they [students in the being mode] listen, they hear, and most important, they receive and they respond in an active, productive way. What they listen to stimulates their own thinking processes. New questions, new ideas, new perspectives arise in their minds. Their listening is an alive process….They do not simply acquire knowledge that they can take home and memorize. Each student has been affected and has changed: each is different. (cited in Pollak, 1993, pp. 514-515)

Science education experts consider inquiry-based learning to be an essential aspect of science instruction (NRC, 2005). Inquiry-based science instruction engages students in the process of “being” classroom-based scientists. They participate in the practices of science, using the tools of the discipline (including specialized vocabulary and language patterns) to examine compelling questions about real-world phenomena (Hapgood and Palinscar, 2006/2007). Students are not directed to simply accept explanations; they are encouraged to hypothesize, question, and test explanations.

Through the process of scientific inquiry students engage with ideas in multiple ways, but the primary means by which human beings engage with ideas is through
language, both oral and written. Literacy is therefore fundamental to the very nature of science:

Reading and writing are inextricably linked to the very nature and fabric of science, and by extension, to learning science. Take them away and there goes science and proper science learning also, just as surely as removing observation, measurement, and experiment would destroy science and proper science learning. (Norris & Phillips cited in Phillips & Norris, 2009, p. 314)

Since literacy is so fundamental to the practice of authentic science, it should hold true that real-world scientists rely heavily on reading, writing, and oral communication in order to conduct their work. Such is indeed the case. The next section describes the manner in which literacy is vital to the practice of “professional” science.

**Literacy as a major component of real-world science.** Real-world science is the process of testing existing theories and building new knowledge about the natural world. Although scientists must necessarily construct personal understandings of phenomena, those personal understandings are bolstered and informed by the work of many others within the scientific community. Contemporary scientific theories and practices are, in fact, built upon the work of many previous generations as well as the current generation of scientists. Thus much of the knowledge that any scientist holds is acquired “through learning in a 2nd hand way” (Palinscar & Magnusson, 2001, p. 152).

The scientific community is a community because it shares a body of collective knowledge; that knowledge is transmitted - either from the broader community to the individual, or vice versa - through literacy practices. Real-world scientists read and discuss seminal studies. They communicate with one another, either through electronic or
more traditional means. They read and publish articles in professional journals and attend and present at professional conferences. In short scientists participate in the established literacy practices of their discipline.

In an investigation reported by Tenopir and King (cited in Phillips & Norris, 2009), “scientists rated reading as essential to their work and as their primary source of creative stimulation” (p. 314). The scientists surveyed reported spending, on average, 553 hours per year reading with “high-achieving” and/or award-winning scientists tending to read more than the average. Those surveyed further reported spending 58% of their total work time engaged in communicative activity (such as reading, writing, or speaking). Phillips and Norris concluded:

Describing even experimental science as hands-on, as if that were its primary characteristic, is to misrepresent. It appears that the nitty-gritty, hands-on activity of data gathering is surrounded by an even more pervasive and consuming activity of communication, defined not by the physical but by the mental – reading, writing, and speaking – minds-on activities. (p. 314)

There can be no doubt that literacy skills are essential to the practice of science - not merely in the classroom, but in the real world. That practice however places very specific literacy demands upon its participants. Those demands can create particular challenges for students who are just learning to participate in the practices of science.

**Science-specific literacy demands.** The language used in any discipline is specific to that the discipline. This statement is particularly true of science, which is characterized by highly specialized and technical vocabulary as well as a unique argumentative discourse pattern. In the field of science, authors state a problem, generate
questions, describe methods of investigation (including data collection and analysis), offer interpretations of evidence, and examine interpretations in light of counterevidence. Phillips and Norris (2009) described scientific discourse as both “textured” and “structured”:

Textured in that not all of its statements have the same reported or implied truth status (e.g., true, probably, uncertain, false); and structured in that not all of its statements have the same epistemic status and role (e.g., cause, effect, observation, hypothesis, method, motivation). (p. 316)

Rather than blindly accepting statements as fact, scientific literacy requires adopting a critical, skeptical, argumentative stance. Readers or listeners must evaluate claims based on evidence and use logical reasoning skills to follow a line of argument. Yet most students are inexperienced at interpreting scientific evidence or recognizing the underlying structure of scientific texts (Phillips & Norris, 2009).

Varelas and Pappas (2006) noted other features of informational texts (such as those typically used in science classrooms) that differ qualitatively from the features of the narrative texts with which students are far more familiar (Duke, 2000). For example, informational texts rely on “coclassification patterns as opposed to [the] coreferentiality” patterns that dominate narrative text; nouns and referent items in informational texts tend to refer to general classes of objects or phenomena rather than specific nouns such as characters, objects, or settings (Varelas & Pappas, p. 213). The verb tenses used in these two types of text also differ. Informational texts use the “timeless” present whereas narrative verbs (with the exception of those embedded in dialogue) are predominantly
past tense. Narrative texts also focus on character’s internal processes whereas science texts focus on physical processes.

By the time they leave elementary school, children are expected to be able to read and interpret scientific text yet they are rarely prepared to do so (Phillips & Norris, 2009). To remedy this situation, elementary science teachers must pay particular attention to the discipline-specific literacy demands of science: “If science educators show little concern for text, see reading as merely a tool to get to science [rather than a tool for understanding science], they are likely to…underestimate the complexity and importance of reading in science” (Phillips & Norris, p. 318).

**Summary.** This discussion highlights the importance of literacy skills to science learning and underscores a rationale for integrating science and literacy instruction. Literacy is a fundamental, even crucial, element of scientific inquiry and a major component of real-world science. Further, instruction in subject-specific science literacy is important since the discipline of science places subject-specific demands upon learners. A variety of researchers have reported success with inquiry-based pedagogical models that integrate science and literacy instruction. The manner in which these models inform and relate to the current study is discussed below.

**Integrated Instructional Models**

**The Cheche Konnen Project.** Rosebery, Warren, and Conant (1992) reported on the Cheche Konnen project: a “collaborative inquiry approach to science” (p. 61) used with language minority urban middle- and high-school students. In this project, students’ first and second languages were valued as “a means for constructing scientific meaning” (p. 62). Talking, reading, and writing played a “crucial, mediating role in collaborative
inquiry as a system both for thinking and talking scientifically and for communicating and sharing ideas” (p. 62).

Students were interviewed in September prior to their participation in a year-long collaborative inquiry project, during which they planned and carried out investigations of local water systems. During the course of the project the students collaborated amongst themselves, with their classroom teachers, and with the researchers. The students were interviewed again in June after the treatment for the purpose of examining “changes in students’ conceptual knowledge and use of hypotheses, experiments, and explanations to organize their reasoning in the context of two thinking aloud problems” (Rosebery, Warren, & Conant, 1992, p. 61). The first of these problems represented a near-transfer task (a problem related to a water system) while the second represented a far-transfer task (a problem related to school children coming down with an unexplained illness).

The researchers used a mixed method approach to analyze the data. The quantitative analysis indicated that students’ thinking with respect science had changed over the course of the academic year. There was a statistically significant increase in the use of science content knowledge to offer solutions to the hypothetical problems asked about during the interview protocol. The qualitative analysis suggested that while prior to treatment the students did not engage in scientific reasoning, post-treatment the students demonstrated that they had appropriated new scientific discourse patterns. Their science content knowledge had increased, and they showed evidence of understanding how to use that knowledge to aid them in conducting inquiry (generating hypotheses, planning experiments, considering alternative explanations).
The cohort of students that participated in Rosebery, Warren, and Conant’s (1992) study was considerably older than the third graders who participated in the current investigation. Further, the intervention in the former lasted for the duration of an academic year while the intervention in the latter lasted only a week. Nevertheless, Rosebery and her colleagues were able to demonstrate that an integrated inquiry-based instructional model can increase the science content knowledge of language minority urban students and enable them to appropriate scientific discourse patterns.

**Dialogically-oriented read-alouds.** While the students with whom Rosebery and her colleagues worked were at the middle- and high-school level, other researchers have reported success with elementary-level students. For example Varelas and Pappas (2006) reported on an instructional intervention that was effective with first- and second-grade urban students, many of whom were from diverse cultural and linguistic backgrounds. The students who participated in that investigation learned about “States of Matter and the Water Cycle” via a unit of study that integrated science instruction with “dialogically-oriented read-alouds” (p. 212) of children’s informational books. Dialogic read-alouds are described as text-based discussions in which “children’s ‘voices’ are encouraged, and teachers’ contingent remarks are made to sustain and extend children’s efforts” (p. 212).

The researchers used a qualitative design to examine the manner in which intertextuality – the juxtaposition of multiple texts and genres, including students’ recounts of experiences (Wells cited in Varelas & Pappa, 2006) – promoted the emergence of scientific discourse patterns in the classroom. In particular it was noted that text-initiated dialogue helped students develop discourse patterns consistent with the academic social language of science (Gee, 2004), enabling them to bridge their everyday
experiences with “scientific concepts” (Vygotsky & Kozulin, 1986). The researchers concluded that these dialogic experiences were crucial to students’ construction of scientific knowledge.

Through the course of the current investigation students in the two TW conditions participated in similar dialogically-oriented learning experiences. Students in the TWZ group observed primates first-hand and engaged in discussions relating to their observations. These discussions took place both at the zoo exhibit and later back in the classroom. In this sense students' experiences and observations became “texts” from which they could construct meaning through reflection and discussion. Students in the TWC group relied on multiple informational texts which were read aloud and discussed in a manner similar to the read-aloud sessions described by Varelas and Pappas (2006).

**Guided inquiry supporting multiple literacies [GIsML].** Hapgood and Palinscar (2006/2007), Hapgood, Magnusson, and Palinscar (2004), and Palinscar and Magnusson (2001) reported on GIsML, a pedagogical model that integrates science and literacy instruction. GIsML is described as a particular orientation to instruction in which elementary teachers “guide their students in sustained inquiry about specific topics…using both firsthand investigations (during which students collect and analyze data themselves) and secondhand investigations (during which the teacher and students read and ask questions about specifically written texts)” (Hapgood & Palinscar, p. 59).

The type of text developed and used in relation to GIsML instruction is described as an innovative “hybrid of exposition, narration, description, and argumentation” (Palinscar & Magnusson, 2001, p. 174). Modeled on a scientist’s notebook, the hybrid
texts represent a fictitious scientist’s “think-alouds” about various scientific topics. The text related to each topic recounts:

The purpose of her [the scientist’s] investigation, the question(s) guiding her inquiry, the investigative procedures in which she is engaged, the ways in which she is gathering and choosing to represent her data, the claims emerging from her work, the relationships among these claims and her evidence, the conclusions she is deriving, and the new questions that are emerging from her inquiry. (p. 174)

The motion of balls down inclined planes. In one GIsML investigation, second grade students used a hybrid text as a basis for second-hand inquiry related to the motion of balls down inclined planes and as the inspiration for first-hand inquiry. When interacting with the text (which was read aloud by the teacher who promoted text-based discussion), the students “puzzled over how Leslie [the fictitious scientist] developed the questions she asked, whether the methods she described were adequate, what patterns appeared in her data, and how to interpret those data” (Hapgood & Palinscar, 2006/2007, p. 59). The students then engaged in complementary first-hand inquiry; collecting, representing, and interpreting their own data. Pre- and post-test data collected during the course of the investigation indicate that “the unit produced a significant increase in the students’ conceptual understandings about motion” (p. 59). These results are particularly encouraging since the intervention only lasted for a two-week period as compared to the longer-term interventions described by Rosebery, Warren, and Conant (1992), and Varelas and Pappas (2006).

Like the scientist notebook texts in the GIsML investigation, the TZTW lesson components – particularly the comprehension component – are intended to be “discussed
in a highly interactive manner” (Hapgood, Magnusson, & Palinscar, 2004, p. 461). This approach appears to have supported the development of scientific discourse patterns and reasoning skills in the GIsML study (Hapgood & Palinscar, 2006/2007). It should be noted however that students who participated in the GIsML investigation differed from the target population of the current investigation in that the former can be considered more advantaged with respect to socio-economic factors. Although the researchers reported that the families of participating students “had a wide range of incomes and educational levels” (Hapgood, Magnusson, & Palinscar, 2004, p. 462), the racial profile of the school district population investigated in the GIsML study was described as “quite homogeneous.” Only 14.5% of students in the participating district qualified for free or reduced cost lunch, while “90% were of European descent” (Hapgood, Magnusson, & Palinscar, 2004, p. 462). Whether or not such findings would be replicated in an urban school environment is as yet unclear.

**Reflection and refraction of light.** In another GIsML investigation, fourth grade students in two different school districts participated in two units of study related to light: reflection and refraction. The study employed a within-subject, across-group design in which “each child served as his or her own control and read both the notebook and traditional version of a text” (Palinscar & Magnusson, 2001, p. 175). The demographic characteristics of the students in the first school district were similar to those of the students in the GIsML study described above (rural, racially homogeneous, with relatively few students qualifying for free or reduced cost lunch). In contrast, the demographic characteristics of the students in the second participating school district were similar to the student population targeted in the current investigation (urban, racially
heterogeneous, with a substantial proportion of the student body eligible for free or reduced cost lunch).

Each text was read aloud by the classroom teachers who subsequently engaged students in related text-based discussions. A pencil and paper assessment was administered before and after each read aloud. These assessments were designed to examine students’ content knowledge and ability to make inferences. The results of the investigation indicate that regardless of the topic (reflection or refraction) students in the rural school performed statistically significantly better on “substantive knowledge items” and “substantive knowledge + reasoning items” when using the hybrid text. Students in the urban school also performed statistically significantly better when using the hybrid text in relation to the topic of refraction. However, there were no statistically significant differences by text type with respect to the urban students’ performance in relation to the topic of reflection. These results highlight the differential responses of more privileged students and less privileged students to integrated inquiry-based instruction.

The 2006/2007 TZTW Project. As described in Chapter One, the 2006/2007 TZTW Project was a Toledo Zoo initiative that examined the effectiveness of the TZTW lessons in promoting the science achievement of elementary students. Over 900 urban and suburban students participated in a series of six lessons over the course of their second and third years. This investigation employed a quasi-experimental design as intact school groups were randomly assigned to either the TW group (the members of which received science instruction via the TZTW lessons) or a comparison group (the members of which received science instruction via the type of lesson researchers deemed typical of
students preparing to visit the zoo). The teachers of students in both conditions delivered all related instruction, which was principally situated in students’ home classrooms and enhanced by visits to related zoo exhibits.

Each lesson was taught over a one-week period. Prior to instruction students were pre-tested on content related to the lesson. The same test was used at the end of the week as a post-test, and again four weeks later as a delayed post-test. For five of the six lessons (Birds, Amphibians, Fish, Cats, and Savanna) students in the TW group statistically significantly outperformed their peers in the comparison condition at post-test and delayed post-test (p< .001). It should be noted however that students in the TW group also statistically significantly outperformed students in the comparison group at pre-test with respect to the Cats lesson (Kenny, Carr, & Magdich, 2009). Of the six lessons examined in the investigation, the Primates lesson was the only lesson for which the TW students did not statistically outperform students in the comparison condition at post-, and delayed post-test (p> .05) (Kenny, Carr, & Magdich, 2009).

The 2006/2007 TZTW Project demonstrates that the TW lessons can be used successfully by classroom teachers to teach science content to primary students and that these lessons support science learning to a greater extent than the typical manner in which science content is taught in relation to a zoo visit. This investigation did not however examine the effects of a zoo visit specifically on urban elementary students, nor did it attempt to sift out the effects of the zoo environment on student learning.

**Summary.** When viewed together the aforementioned investigations suggest that inquiry-based instruction that integrates science and literacy has the potential to significantly increase urban student achievement in the content area of science - both in

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8 For a more detailed review of the treatment conditions in this investigation, see Chapter Three.

Despite the considerable potential of integrated inquiry-based models of instruction to promote student learning, it is important for educators to carefully consider the impact of specific instructional models on the learning of urban students. As was demonstrated by the results reported by Palincsar and Magnusson (2001), urban students may respond to instruction differently than their more privileged peers. Educators should take care to adopt instructional approaches that will meet the needs of these less privileged children.

It is hoped that the discussion in this section has provided a firm foundation upon which the reader can build an understanding of the study as a whole. In the next section the discussion is broadened to examine the theoretical frameworks within which the investigation is nested.

**Theoretical Frameworks**

This investigation is informed by two nested theoretical frameworks. First, the study and the TZTW Primates lesson itself are situated within the Thinking Works [TW]
framework (Carr, Aldinger, & Patberg, 2004), a model of instruction that acknowledges the importance of developing students’ cognitive processing skills through explicit strategy instruction before, during, and after a literacy event. This model is nested within a broader sociocultural conception of learning which posits that learning cannot be separated from the specific social and physical contexts in which it occurs (Gee, 2004; Lave & Wenger, 1991; Rogoff, 1990). Figure 2.2 is a diagram which depicts the Primates lesson situated within these nested frameworks.

Figure 2.2: Diagram of Theoretical Frameworks

The following section begins with a discussion of the TW framework and how it supports the learning of both students and teachers. The specific elements of the TZTW Primates lesson are then described in detail and related to the TW framework. A
subsequent discussion of learning as a sociocultural phenomenon further serves to situate the Primates lesson within these nested frameworks.

**The TW Framework**

The Primates lesson is nested within the TW framework, a teacher-friendly lesson planning guide that supports teachers in selecting and instructing students in research-based reading comprehension strategies. The goals of the TW framework are twofold. First, the framework is intended to support teachers in their development of expertise related to teaching comprehension strategies. Second, the framework is intended to promote the use of comprehension strategies amongst students so that students will improve their overall reading comprehension skills.

**Supporting teacher learning.** The National Institute of Child Health and Human Development (2000) recognized that many teachers find teaching comprehension strategies to be very challenging, “most likely because they have not been trained to do such teaching” (p. 4-7). If teachers are to be effective in such instruction then they must “have a firm grasp not only of the strategies that they are teaching the children but also of instructional strategies that they can employ to achieve their goal” (p. 4-7). The TW framework supports teachers in becoming familiar with: (a) how, when, and why students should use various comprehension strategies; and (b) how to teach the strategies effectively.

Carr, Aldinger, and Patberg’s (2004) resource, *Teaching Comprehension: A Systematic and Practical Framework with Lessons and Strategies*, organizes 52 research-supported strategies according to four components that comprise each of the TW lessons: (1) a background knowledge component; (2) a vocabulary component; (3) a
comprehension component; and (4) an application/extension component.\(^9\) The resource further subdivides the strategies according to their efficacy with narrative or expository (informational) text. To plan a lesson within the framework, teachers need only select one strategy appropriate to the content of the lesson from each of the four component menus. In the case of the TZTW Primates lesson, strategies were pre-selected for the teachers and explained on the lesson materials.

Duke and Pearson (2003) stated that effective comprehension instruction should include: (a) explicit strategy instruction; (b) modeling of the strategy in action; and (c) the collaborative use of the strategy between teacher and students. Duffy and Roehler’s (cited in Williams, 2003) Direct Explanation Model is consistent with this description of effective instruction. Prior models of comprehension strategy instruction tended to emphasize the use of a strategy over thinking about how and when to use the strategy. The Direct Explanation Model focuses on “helping students to (a) view reading as a problem-solving task that necessitates the use of strategic thinking and (b) learn to think strategically about solving reading comprehension problems” (Williams, p. 246).

Teachers using the TW framework are directed to introduce each TW strategy via the Direct Explanation Model, which shifts students’ attention from the reading content to their own reading processes. This model simplifies comprehension strategy instruction for teachers since all strategies are taught the same way. First, the teacher explains the strategy to the students, emphasizing how, when and where to use the strategy. Next, the teacher models the use of the strategy using a think-aloud technique. Finally, the teacher provides students with guided opportunities to practice using the strategy (Carr, Aldinger, & Patberg, 2004).

\(^9\) Each strategy component will be described in detail in a subsequent section.
**Supporting student learning.** As Carr, Aldinger, and Patberg (2004) explained, the goal of comprehension strategy instruction is not to teach students a set of rote procedures that they will then indiscriminately apply to texts. Instead the goal is for students to become metacognitively aware (aware of their own thinking processes) and ultimately develop flexibility and automaticity in applying such cognitive processes to the “comprehension of text, and the application of learning” (p. 11). After all the comprehension of text is not a matter of simply executing a routine procedure. Rather “proficient reading involves a constant, ongoing adaptation of many cognitive processes” (National Institute of Child Health and Human Development, 2000, p. 4-7).

The use of comprehension strategies activates cognitive processes required for comprehension. For example, Questions, Clues, Response [QCR] (Carr, Aldinger, & Patberg, 2004) is a strategy whereby students are faced with a question. The students must seek out clues that they find in their own background knowledge as well as clues that can be discovered in a text or lesson in order to create a response. Each set of clues is recorded in a separate column on a graphic organizer so as to guide students’ thinking. In a third column, students must consciously integrate the clues from both sources of information in order to construct an appropriate response to the question. The cognitive process that is activated through the use of this strategy is “inferring.” By repeatedly using this and other strategies which require inferring students will begin to automatically activate that particular cognitive process during literacy events. Eventually students will no longer need to rely on the behavioral action (the strategy); they will employ the cognitive process of inferring automatically as they read (Carr, Dewitz, and Patberg, 1989).
The four components of the TW framework. Carr, Aldinger and Patberg (2004) argued that “an effective comprehension lesson…must contain these four strategy components: background knowledge, vocabulary, comprehension, and application/extension” (p. 15). Consequently lessons situated within the TW framework are comprised of one or more strategies for each of the four components. These components are described below.

The importance of the background knowledge component. Background knowledge is an important factor in learning from text. Research demonstrates that background knowledge “influences what students attend to, what inferences they make, and what they remember after reading” (Reutzel, Camperell, & Smith, 2002, p. 324). In the 1980s considerable research was conducted to explain how prior knowledge “provides a conceptual framework for comprehending” (Reutzel, Camperell, & Smith, 2002, p. 321). One theory with respect to how background knowledge facilitates the acquisition of new knowledge is schema theory. Schema theory posits that “a schema is an abstract description of a thing or event. It characterizes the typical relations among its components and contains a slot or place holder for each component that can be instantiated with particular cases” (Pichert & Anderson, 1977, p. 314).

During a literacy event, a reader attends to clues which indicate which schema should be activated. If information is not explicitly stated, the reader’s schema guides the making of inferences that are consistent with both the learner’s background knowledge and the new information. Background knowledge therefore supports and mediates the comprehension of new material. The more relevant background knowledge a learner brings to a literacy event, the better prepared the learner is to comprehend.
Schema theory is a top-down proposition. Other researchers have demonstrated that comprehension can be built from the bottom up (Graesser, and Kintsch cited in Pressley, 2002). Learners process multiple ideas (propositions) and their relations to each other thereby constructing “macropropositions”. When new ideas relate to previously held background knowledge the reader can use that knowledge to aid comprehension, for example in making inferences (Pressley). It should be noted however that although there are a multitude of inferences that could be made, “skilled thinkers do not make inferences unless understanding of the text demands them” (McKoon & Ratcliff cited in Pressley, p. 550).

Van Den Broek and Kremer (2000) described the manner in which background knowledge supports comprehension:

First, as people accumulate information about a specific topic, their internal representation of that becomes richer and more densely interconnected….readers can use this expanded representation to recognize a wider array of concepts and the causal/logical connections between them in the text. Second, the more extensively interconnected the readers’ background knowledge is, the more rapidly and easily each piece of information can be accessed from memory. (p. 12)

Thus background knowledge supports comprehension; however, the reverse is also true. When information is comprehensible a learner is able incorporate that information into background knowledge, thus expanding and enriching existing knowledge structures.

Successful comprehenders have extensive background knowledge networks and actively seek to make connections between what they already know and the new ideas
that they encounter during a literacy event (van den Broek & Kremer, 2000). However even students with sufficient background knowledge may experience difficulty in comprehending if they adopt a passive approach to learning and fail to activate relevant background knowledge (Bransford et al. cited in Reutzel, Camperell, & Smith, 2002). Alternately less privileged students may not have sufficient background knowledge to enable them to connect with ideas in the text. Thus the background knowledge component of the TW framework is intended to help teachers teach strategies that will activate and build students’ background knowledge, better enabling students to recognize what they already know about a topic and to use that knowledge to support their comprehension. A specific form of background knowledge that has a strong influence on comprehension is vocabulary knowledge which is discussed in the next section.

**The importance of the vocabulary component.** Vocabulary has been termed the “currency of education” (Blachowicz & Fisher, 2003, p. 89). A knowledge of the meanings of words is central to the ability to make sense of oral and written language and experience success in vocabulary-dense content area subjects. It is well established that reading comprehension is strongly influenced by vocabulary knowledge (Beck, McKeown, & Kucan, 2002; Nagy & Scott, 2000; National Institute of Child Health and Human Development, 2000; Snow, 2002; Stahl & Fairbanks, 2006). In their classic meta-analysis of the effects of vocabulary instruction conducted in 1985, Stahl and Fairbanks examined all available vocabulary studies that met two selection criteria. First, each study had to have included a control group. Second, the report had to include sufficient statistical information for calculating an effect size. From their findings, Stahl and Fairbanks concluded that “vocabulary instruction generally facilitates growth in reading
comprehension, both on measures containing and not containing taught words” (p. 251). These findings have since been confirmed by the National Reading Panel (National Institute of Child Health and Human Development, 2000) and the RAND Reading Study Group (Snow, 2002).

Beck, McKeown, & Kucan (2002) synthesized extant research regarding vocabulary instruction in contemporary classrooms. They summed up their findings by stating simply “there isn’t much” (p. 2). This situation is unfortunate for all students as robust vocabulary instruction has been demonstrated to be effective in increasing word learning and reading comprehension (Beck, McKeown, & Kucan). It is particularly unfortunate for urban students who tend to be from lower socioeconomic backgrounds and language minority groups. These students often differ profoundly from students in the economic and cultural mainstream in terms of vocabulary knowledge and reading comprehension, particularly in content area subjects such as science (Chall, Jacobs, & Baldwin, 1990).

Graves and colleagues reported that lower socioeconomic 1st graders know approximately half the number of words of their higher socioeconomic peers (cited in Beck, McKeown, & Kucan, 2002). By the time students reach 12th grade, high-performers know approximately four times as many words as lower-performers (Smith cited in Beck, McKeown, & Kucan). This lack of vocabulary knowledge is likely to result in substantial differences in reading comprehension ability (Chall, Jacobs, & Baldwin, 1990; Cunningham & Stanovich, 1998).

Thus it is evident that while all students benefit from robust vocabulary instruction, such instruction is particularly critical for urban students whose early
language experiences may not have provided them with the “substantial foundation in the vocabulary of literate and academic English” (Nagy & Scott, 2000, p. 280) that is needed for long-term academic success. The vocabulary component of the TW framework is intended to instruct students in research-supported vocabulary-learning strategies that will help them increase their lexicons in the short-term and improve their overall reading comprehension in the long-term.

The importance of the comprehension component. In the 1978/1979 issue of Reading Research Quarterly, Dolores Durkin shocked the educational community by reporting her findings after visiting a series of 3rd and 6th grade classrooms to look for evidence of comprehension instruction during their reading and social studies periods. During the three days that she spent in each of the classrooms, “almost no comprehension instruction was found. The attention that did go to comprehension focused on assessment which was carried on through questions” (p. 482) which Durkin subsequently described as “interrogations.”

At the end of her article, Durkin (1978/1979) posed the following question:

Is reading comprehension teachable? Or, to phrase it differently, if the observed teachers had been found giving time to procedures that we think represent comprehension instruction, would their students be better comprehenders than they are? We don’t know. (pp. 526-527)

That question spurred a flurry of research relating to comprehension strategy instruction (Duffy, 2002), and the educational research community responded to Durkin’s query with a resounding “Yes!”
Researchers determined that: (a) comprehension strategies can be directly taught to students; (b) these strategies can be effectively taught by classroom teachers (not merely by the researchers themselves); and (c) appropriate comprehension strategy instruction leads to significant, transferable, and durable gains in student comprehension, particularly in struggling readers (Dewitz, Carr, & Patberg, 1987; Duffy, 2002; Pressley, 2002).

In 2000, the National Reading Panel (National Institute of Child Health and Human Development) synthesized the findings of extant investigations related to comprehension strategy instruction. The report stated that “teaching a variety of reading comprehension strategies leads to increased learning of the strategies, to specific transfer of learning, to increased memory and understanding of new passages, and, in some cases, to general improvements in comprehension” (p. 4-51). Progress in the use of strategies was observed even after brief exposure to instruction. The RAND Reading Study Group (Snow, 2002) further reported that explicit instruction in the use of comprehension strategies is particularly beneficial to low-achieving students and that “teachers who provide comprehension instruction that is deeply connected within the context of subject matter learning, such as…science, foster comprehension development” (Snow, p. 39).

Unfortunately, despite such compelling arguments to teach comprehension strategies, Pressley, Wharton-McDonald, Hampston, & Echevarria (cited in Pressley, 2001) observed that in the decades since Durkin’s article first appeared not much has changed. Little comprehension instruction appears to take place in most contemporary classrooms (Pressley et al. cited in Pressley, 2001; Snow, 2002). To complicate matters, research has demonstrated that it is very challenging to become an effective
comprehension strategies teacher (National Institute of Child Health and Human Development, 2000; Snow, Griffin, and Burns, 2005; Williams, 2003).

The TW framework is a deliberate attempt to support teachers in the development of their expertise related to teaching comprehension strategies. In that manner it supports students in learning strategies that will improve their overall reading comprehension skills. The specific goal of the comprehension component of the TW framework with respect to student learning is twofold: first, to promote student learning of the use of research-supported comprehension strategies through the explicit instruction of those strategies; and second, to promote deep-level comprehension of the subject content to which those strategies are applied.

The importance of the application/extension component. If, as Durkin (cited in National Institute of Child Health and Human Development, 2000) suggested, comprehension is the “essence of reading” (p. 4-1), then the application and extension of knowledge should be the purpose for reading. Students should not read merely for the sake of trying to understand what is written. Instead reading and learning should be viewed as transformative events that have the potential to fundamentally change students’ understandings about the world and the manner in which they interact with the world. New knowledge should not be relegated to the context in which it was learned. Instead students should be able to “apply and extend what they understand to new situations” (Carr, Aldinger, & Patberg, 2004, pp. 22-23). Pearson (2007) referred to this concept as “transfer” and he described it as the “gold standard to which all students and teachers should aspire” (p. 146).
Bloom’s *Taxonomy of Educational Objectives* (cited in Krathwohl, 2002) identifies and defines six major cognitive categories and organizes these categories from “simple to complex and from concrete to abstract” (p. 212). They are (in order): knowledge, comprehension, application, analysis, synthesis, and evaluation. Mastery of the higher-order cognitive processes (application through evaluation) presumes mastery of lower-order cognitive processes. Bloom’s taxonomy has been used frequently to classify curricular objectives. However “almost always these analyses have shown a heavy emphasis on objectives requiring only recognition or recall of information” (p. 213).

Krathwohl (2002) recently revised Bloom’s taxonomy to reflect more current conceptualizations of knowledge within the cognitive domain (see Figure 2.3). This updated version is represented in chart form with the vertical axis depicting levels of knowledge, organized from simple to more complex. The levels of knowledge are identified in that order below:

A. *Factual knowledge*, which refers to the basic elements of a given discipline.

B. *Conceptual knowledge*, which refers to an understanding of “the interrelationships among the basic elements within a larger structure that enable them to function together” (p. 214).

C. *Procedural knowledge*, which refers to an understanding of how to use disciplinary knowledge in a practical way.

D. *Metacognitive knowledge*, which refers to a strategic understanding of the demands of cognitive tasks within the discipline, and one’s own capabilities with respect to that discipline.
The Cognitive Process Dimension

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(Krathwohl, p. 216)

Figure 2.3: The Taxonomy Table

The horizontal axis of the chart depicts the cognitive process dimension: Bloom’s original six categories, renamed and refined according to current conceptualizations of the hierarchy of thinking processes. These cognitive processes are (in order):

1. Remember - recognizing and recalling information.
2. Understand - constructing meaning from a message by interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
3. Apply - executing or implementing a procedure in a particular context.
4. Analyze - considering elements of a whole discretely and in relation to other elements by differentiating, organizing, and attributing.
5. Evaluate – making criteria-based judgments by checking and critiquing.

Although Krathwohl (2002) contended that “understand through create are usually considered the most important outcomes of education” (p. 216), Pearson (2007)
lamented that the current era of high-stakes testing is characterized by “low level multiple-choice exams that doom certain students, particularly low achievers, to school careers of basic skills worksheets that look just like the exams they are required to pass” (p. 148). He cited research that demonstrates that lower achieving students are more likely “to have their curricular activities determined by a score on an exam than are higher achieving students, who, by contrast, are more likely to have their activities determined by teacher creativity and judgment” (Herman et al. cited in Pearson, p. 148). Thus it appears that urban students, who are frequently lower achievers, are particularly in danger of being denied instruction that will help them transfer their knowledge from the context in which it was learned to broader contexts in which it can be applied and extended.

If, as the NRC (2000) suggested, “a major goal of schooling is to prepare students for flexible adaptation to new problems and settings” (p. 235), then instruction in applying and extending classroom-generated knowledge is in order. The application/extension component of the TW framework is intended to support students as they transfer their knowledge to diverse new contexts. In that manner this lesson component helps each student answer the questions, “How far will my knowledge travel? How robust is it? How far... beyond that initial instructional context can I still apply what I acquired in that classroom?” (Pearson, 2007, p. 13).

**Summary of the TW framework.** In summary, the TW framework is a lesson planning guide that supports teachers in the selection and instruction of research-based comprehension strategies. Each lesson is divided into four components:
1) *The background knowledge component* which helps students build new background knowledge structures and teaches them to activate existing structures. This component is important because comprehension requires actively connecting new information with known information order to construct meaning. The more background knowledge students have about a topic and the more relevant they consider that knowledge to be, the more successful students are at comprehending.

2) *The vocabulary component* which explicitly teaches students the meanings of new words. This component is particularly important in content area subjects which are rife with specialized terminology. Without an understanding of the meanings of individual words students cannot construct an appropriate global understanding of a text or the message.

3) *The comprehension component* which teaches students to apply comprehension strategies to content they are learning. This component is important because the use of strategies increases students’ level of comprehension of the content they are studying and contributes to an improvement in overall comprehension processing.

4) *The application/extension component* which teaches students how to apply and extend learning to new situations and contexts. This component is important because it helps students develop higher-order cognitive processing skills, and it demonstrates to students the relevance of what they are learning to their own lives and the world beyond the classroom.
Although typically the TW framework is applied to literacy events involving either narrative or expository texts (Carr, Aldinger, & Patberg, 2004), it was used as a model in the creation of a series of elementary science lessons known as the TZTW lessons. The particular TZTW lesson examined in this investigation is the Primates lesson which is described in detail in the next section.

The TZTW Primates Lesson

An overview of the TZTW lessons. The Primates lesson was one of 12 TZTW lessons developed by literacy experts at the University of Toledo in cooperation with zoo educators at the Toledo Zoo. These lessons are inquiry-based units of study which combine classroom instruction with visits to zoo exhibits for the purpose of integrating “the development of literacy skills with the development of scientific…content knowledge, dispositions, and critical thinking abilities conducive to life long learning” (Magdich & Carr, 2005, p. 1). Although the lessons were written initially for use in connection with visits to Toledo Zoo exhibits, it is the goal of the Curator of Education at that institution to ensure that the lessons are appropriate for use at related exhibits in zoos across the U.S. and available to teachers nationwide (M. Magdich, personal communication, October 16, 2007).

The NRC (2007) stated that “the processes and methodology that students encounter in the classroom need to reflect the range of investigatory forms in science. The range of methodologies needs to include …observational methods” (p.6). The TZTW lessons provide students with opportunities to engage in authentic observation-based inquiry. Through their interactions in the classroom and at the zoo students “talk and write about their observations of phenomena [and] their emerging understanding of
scientific ideas” (NRC, 2007, p. 6). If teachers and students do not have access to a community zoo, the lessons can be used in connection with educational videos or expository texts that can be read-aloud and discussed.

It should be noted that the TZTW lessons do not require students to read traditional science books or materials. Texts that are generated through the course of the lesson are jointly constructed by the teacher and students; however the focus of the lesson is on the oral literacy practices of teacher-guided observation and class discussion rather than on text-based comprehension. DeTemple and Snow (2001) viewed such “participation in literate conversation…as a very literal context for developing literacy skills, knowledge, and motivation” (p. 56). These oral literary activities are wholly consistent with Snow, Griffin, and Burns’ (2005) conversation-enhanced view of literacy. Further, such practices may be more supportive of elementary students’ comprehension skill development than instruction which requires them to extract meaning from traditional text.

Effective reading comprehension involves the integration of lower order, word level processes (such as decoding and word identification skills) with higher order processes (such as comprehension) which extend to the sentence and paragraph level and beyond. Williams (2003) suggested that although students in the primary grades are still mastering basic word identification and reading fluency skills, they should not be deprived of comprehension instruction. Yet primary students’ limited word identification and fluency skills can, in turn, limit the efficacy of comprehension instruction if instructional texts are too challenging. After all, the more effort that students must
expend in an attempt to identify words, the less cognitive capacity that they have available for comprehension (Pressley, 2002; Sinatra, Brown, & Reynolds, 2002).

Expository texts, such as those used for science instruction, are notoriously challenging for students (Phillips & Norris, 2009). Teachers may be well advised to present science content in a manner that does not place undue demands upon students’ reading abilities. Rather than being burdened with lower order word identification tasks - tasks which many students continue to struggle with even into the third grade and beyond - students who participate in the TZTW lessons are able to focus the bulk of their cognitive resources on higher order comprehension skills as they make observations and participate in class discussions.

The Primates lesson. The Primates lesson, which was used with 3rd grade students in the course of the current investigation, is comprised of instruction in five research-supported comprehension strategies (Carr, Aldinger, & Patberg, 2004). These strategies are:

1. Structured Overview (Vacca & Vacca cited in Carr, Aldinger, & Patberg)
3. Concept of a Definition (Schwartz & Raphael, 1985)
4. Modified Cause/Effect Frame (Carr, Aldinger, & Patberg)
5. About Point Writing Response (Carr cited in Carr, Aldinger, & Patberg)

Instruction in each of these strategies occurs within the one of four components of the TW framework (background knowledge component; vocabulary component; comprehension component; or application/extension component). The following
discussion situates each strategy within the appropriate TW component and explains the instruction and use of the strategy.

**Background knowledge component.** The Background Knowledge component of the TZTW Primates lesson introduces students to the use of two strategies: the Structured Overview; and QCR.

**Structured overview.** The use of graphic organizers in the content area of science is recommended by the National Reading Panel (National Institute of Child Health and Human Development, 2000). The Panel reported that “teaching students to organize the ideas that they are reading about in a systematic, visual graph benefits the ability of the students to remember what they read and may transfer, in general, to better comprehension and achievement in…science” (p. 4-45). Graphic organizers re-present information in a manner that is “visual, concrete, and arguably more memorable” (Duke and Pearson, 2003) than information that is presented verbally.

A Structured Overview is a graphic organizer (Tierney & Readence, 2005) that provides students with a visual representation of the important concepts related to a topic and demonstrates the interrelationships between those concepts. When used at the beginning of a lesson a Structured Overview can help students activate background knowledge and “build a frame of reference…as they approach new material” (Vacca & Vacca, 1999, p. 328). The TZTW Primates lesson provides teachers and students with a Structured Overview which models the hierarchical classification system of primates. This model introduces new terminology and prepares students for the different types of primate species that they will encounter at the zoo exhibits. In this manner the Structured
Overview helps students construct schema that will support their acquisition of new knowledge about the topic of primates.

*Question, Clues, Response.* The QCR strategy is an adaptation of the Inferential Training Technique (Carr, Dewitz, & Patberg, 1989; Dewitz, Carr, & Patberg, 1987): an instructional device that has been demonstrated to increase the inferential comprehension of elementary students through practice with cloze passages (Carr, Dewitz, & Patberg). This technique explicitly demonstrates to students how to make inferences by integrating background knowledge with new information—a cognitive feat that can be particularly challenging for struggling readers.

In cloze tasks students are provided with connected texts from which select words have been omitted. An example of a cloze task is as follows. “The car skidded out of control and crashed through the railing over the _____. ” (Carr, Dewitz, & Patberg, 1989, p. 381). Students are then guided to “act like detectives, searching for clues and information to construct answers” (p. 380). Clues are found in the students’ background knowledge (or schema) as well as in the information presented in the text. By integrating these two sources of information, children are able to infer an appropriate response. Dewitz, Carr, & Patberg (1987) reported that the cloze treatment benefited high-, middle-, and low-ability students in that it increased their inferential comprehension of expository text.

The QCR strategy provides students with a four-column graphic organizer that prompts them to consider and record what they already know about a topic then integrate that knowledge with new information to construct response to a question. In the case of the Primates lesson, the question is, “How are gorillas similar to humans?” During the
background knowledge component of the lesson, students examine the graphic organizer and consider the question that is posed in the first column. Then in the second column, the students record what they already know about the similarities between gorillas and humans. The remaining two columns (titled, “What We Learned at the Zoo,” and “What We Can Tell Others”) are completed during the application/extension component of the lesson.

**Vocabulary component.** The vocabulary component of the TZTW Primates lesson consists of the Concept of a Definition strategy that is described below. This strategy is consistent with Blachowitz and Fisher’s (2000) recommendation that students “be active in developing their understanding of words and ways to learn them” (p. 504).

*Concept of a definition.* Typically teachers teach vocabulary by providing students with definitions of key terms which students are then expected to copy and learn (Phillips, Foote, Harper, 2008). Unfortunately definitions “do not contain the quantity or quality of information that constitutes true word knowledge” (Nagy & Scott, 2000, p. 280). Instead,

Determining the meaning of a new word always poses two problems. The first is specific, tied to the individual word….The second problem requires a decision about what type of information is needed to define any word and how that information can be organized. This problem is general and must be solved repeatedly until the student develops a strong ‘concept of definition. (Schwartz & Raphael, 1985, p. 199)

The Concept of a Definition strategy facilitates the acquisition of both types of word knowledge. First, it promotes an understanding of specific word meanings, and second, it
promotes “metacognitive and metalinguistic ability\textsuperscript{10} in the realm of word learning” (Nagy & Scott, p. 274).

When encountering a new word through the Concept of a Definition strategy students are taught to consider more than a mere definition. First, they categorize the word, responding to the question, “What is it?” Second, students identify the distinguishing characteristics of the word, answering the question, “What is it like?” Third, students record some illustrative examples in response to the question, “What are some examples?” Figure 2.4 depicts the Concept of a Definition strategy applied to the term “primate.”

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{concept_of_definition_primates.png}
\caption{Concept of a Definition: Primates}
\end{figure}

The Concept of a Definition strategy promotes the acquisition of specific vocabulary (in the example above, the term “primate”). In using the strategy, students are prompted to actively contemplate and record multiple dimensions of a word: its categorization, distinguishing characteristics, and illustrative examples. Such an active

\textsuperscript{10}“Metalinguistic ability” can be defined as “the ability to reflect on and manipulate the structural features of language” (Tunmer, Herriman, & Nesdale cited in Nagy & Scott, 2000, p. 274).
word-learning strategy promotes in-depth learning over the mere surface level
memorization that often occurs through the practice of copying definitions. Further, use
of the Concept of a Definition strategy encourages metacognitive and metalinguistic
awareness as students must consciously consider various types of word knowledge.

*Comprehension component.* The comprehension component of the TZTW
Primates lesson introduces students to the use of two strategies: the Modified
Cause/Effect Frame; and the About Point Writing Response Outline and Summary.

*Modified cause/effect frame.* Frames are graphic organizers that present
information in a manner that highlights the relationship between ideas or concepts, and
mirrors the structures found in content area texts. Frames “help students discover
different text patterns, and students use them to understand, organize, and think about
information in a particular way” (Carr, Aldinger, & Patberg, 2004, p. 146). Duke and
Pearson (2003) summarized the research related to text structure by stating “almost any
approach to teaching the structure of informational text improves both comprehension
and recall of key text information” (p. 217). They hypothesized that the structure of the
text (such as cause and effect) reflects the structure of knowledge in a particular domain.
Thus by attending to particular structures, students are able to make sense of subject
content rendering it more meaningful and more memorable. The cause/effect text
structure is among the most commonly used structures in science texts yet it is difficult
for many students to understand (Ciardiello, 2002). Cause/effect frames can be effective
in helping students identify and make sense of causal relationships (Carr, Aldinger, &
Patberg).
In the case of the Primates lesson, a Modified Cause/Effect Frame was created to help students understand the distinguishing physical characteristics of primates, monkeys, and great apes. The distinguishing physical features of various species serve functions in the animals’ survival. The frame directs students to attend to animal features then consider how each feature functions to promote survival. Finally, through inquiry students are directed to provide explicit examples of each cause (feature) and effect (survival function) relationship. For example, monkeys have long arms. This feature enables them to brachiate—swing by their arms—in order to escape from predators.

Students who observe spider monkeys at a zoo exhibit might record that the monkeys moved across the exhibit very quickly by swinging from rope to rope.

Elementary students are often fascinated by primates at zoo exhibits (Kenny, 2009; M. Magdich, personal communication, October 16, 2007). However, merely observing monkeys at a zoo does not necessarily promote an understanding of how the distinguishing physical features of monkeys function to enable the animals to survive in their native habitats. The Modified Cause/Effect Frame included in the Primates lesson helps to focus students’ observations on the most pertinent physical aspects of the various animal species. Further, it enables students to consider the effect that these features have on the survival of the species in the wild. In this manner the Modified Cause/Effect Frame promotes an authentic scientific understanding of the animals under observation.

*About point writing response outline and summary.* Writing-to-learn fosters deep-level comprehension (McKenna & Robinson, 2009) by helping students “focus on information encountered…beyond a level of recall” (Vacca, 2003, p. 199). Through their writing students think deeply about content, exploring and clarifying ideas (Murray cited...
in Vacca & Vacca, 1999), integrating new information with existing schema, and constructing personal understandings. The National Reading Panel (National Institute of Child Health and Human Development, 2000) specifically recommended summary-writing as a practice that helps students integrate ideas and make generalizations about subject content. Further, the Panel reported, “instruction of summarization improves memory for what is read, both in terms of free recall and answering [comprehension] questions” (p. 4-46).

Summarization is a particularly complex cognitive task. Dole, Duffy, Roehler, and Pearson (cited in Duke & Pearson, 2003) described it as follows:

Often confused with determining importance, summarizing is a broader, more synthetic activity for which determining importance is a necessary, but not sufficient, condition. The ability to summarize information requires readers to…differentiate important from unimportant ideas, and then synthesize those ideas and create a new coherent text that stands for, by substantive criteria, the original. This sounds difficult, and the research demonstrates that, in fact, it is. (pp. 220-221)

The About Point Writing Response and Outline Summary (Carr cited in Carr, Aldinger, & Patberg, 2004) included in the Primates lesson provides a supportive structure by which students can practice the skills for effective summary-writing. Carr’s Writing Response strategy is an adaptation of About Point (Martin, Lorton, Blanc, & Evans cited in Carr, Aldinger, & Patberg) which simplifies the task of summarization by directing students to break up a selection of text into discrete segments. For each segment read students are asked to determine what it is “about” and what “point” it makes. Carr’s
writing strategy adapts and extends this process by prompting students to construct a paragraph by identifying their own about-point, providing details which support their point, and creating a closing statement.

In the Primates lesson, students use their observations recorded on the Modified Cause/Effect Frame as a text to be summarized in writing. They begin by identifying what their summary is about and the point that they wish to make in the left-hand column of the graphic organizer. In that same column students record three details that support their point and write a closing sentence that restates the about-point in different words. Finally, students transfer their work (in some cases verbatim) to the “summary” column on the right-hand side. In this manner the complex and difficult task of summary-writing is broken up in smaller, easier tasks that are inherently manageable for elementary students. In addition, since students are explicitly directed to attend to the elements of summary-writing, children develop a metacognitive awareness of the overall process.

**Application/extension component.** During the application/extension component of the Primates lesson students revisit the QCR strategy as described below.

**Question, Clues, Response.** The purpose of the application/extension component is to encourage students to activate critical thinking skills and to apply new-found knowledge to new problems, settings, and contexts. As previously described, the QCR strategy prompts students to construct a response to a question by considering what they already know about a topic and integrating that knowledge with new information. The question addressed in the Primates lesson is, “How are gorillas similar to humans?” During the background knowledge component of the lesson students consider the question in the first column of the graphic organizer and record their background
knowledge in the second column. During the application/extension component students are asked to complete the remaining two columns titled, “What We Learned at the Zoo” and “What We Can Tell Others.”

In recording what they learned at the zoo in the third column, students analyze information presented in the lesson, determining what is relevant and irrelevant to the question at hand. Finally, in the fourth column students synthesize their knowledge about gorillas and humans, taking into account both the question prompt as well as their intended audience as they construct a response. This component prompts students to “create a ‘fresh view’ of the information by integrating elements in a different format” (Carr, Aldinger, & Patberg, 2004, p.14).

**Summary of the TZTW primates lesson.** Many traditional elementary science lessons promote the acquisition of factual and conceptual knowledge through the activation of lower-level cognitive processes such as remembering and understanding (Reiser et al., 2001). The TZTW Primates lesson however emphasizes the acquisition of metacognitive knowledge through the activation of higher-order cognitive processes. Figure 2.5 plots the components of the Primates lesson on Krathwohl’s Taxonomy Table.

The background knowledge component consists of the Structured Overview and QCR. The former strategy assists students in understanding the hierarchical structure of animal classification systems. Such understanding enables students to build new background knowledge structures, while the latter strategy prompts students to activate existing background knowledge structures.\(^\text{11}\) Both of these cognitive activities (creating

\(^{11}\) Although the QCR strategy as employed in the background knowledge component does not require students to create new representations of knowledge, the overall use of the strategy within the lesson does. Thus QCR is plotted at the level of *create* on the Taxonomy Table.
The Cognitive Process Dimension

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<tr>
<td>A. Factual Knowledge</td>
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<td>B. Conceptual Knowledge</td>
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<td>C. Procedural Knowledge</td>
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<tr>
<td>D. Metacognitive Knowledge</td>
<td>Structured Overview</td>
<td>Concept of a Definition</td>
<td>Modified Cause/Effect Frame</td>
<td>QCR / About-Point Writing</td>
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(Adapted from Krathwohl, 2002, p. 216)

Figure 2.5: The Taxonomy Table Applied to the TZTW Primates Lesson

and activating background knowledge structures) support the acquisition of additional knowledge throughout the course of the lesson. The Concept of a Definition strategy, which comprises the vocabulary component, prompts students to analyze elements of word knowledge.

The Modified Cause/Effect Frame and About-Point Writing Response Outline and Summary comprise the comprehension component. The former strategy guides students in evaluating primate features and their corresponding functions, while the latter strategy supports students in creating a written summary of the content that they have learned. Finally, the use of the QCR strategy in the application/extension component prompts students to create a response to the question, “How are gorillas similar to humans?”

The purpose of the Primates lesson is not merely to transmit content to students so that they will remember and understand it. Rather the goal is to promote among students a metacognitive awareness of how they can acquire knowledge then apply the knowledge
that they acquire. Thus the Primates lesson privileges metacognitive knowledge – what Krathwohl (2002) identifies as the most sophisticated dimension of knowledge – over other forms of knowledge. Further the lesson encourages the activation of higher-order cognitive processes such as analyzing, evaluating, and creating which presume mastery of the lower-order cognitive processes of remembering, understanding, and applying. Therefore, unlike many traditional science lessons, the Primates lesson has the potential to promote a form of knowledge (metacognitive knowledge) that will transfer to other settings and contexts. Surely Pearson (2007) would approve.

This discussion related to the theoretical frameworks which undergird this investigation began with a description of the TW framework. It then described and situated the Primates lesson within that framework. In the next section the Primates lesson is examined within the context of a broader sociocultural conception of learning.

**A Sociocultural Conception of Learning**

Sociocultural conceptions of learning posit that learning is a fundamentally social phenomenon. Individual cognition is the result of “internalization,” the process by which children appropriate external cultural behaviors and use them as internal mental tools. Thus cognitive development is the result of participation in social activity. Vygotsky (cited in Wertsch, 1985) explained this phenomenon as follows:

> It is necessary that everything internal in higher forms was external, that is, for others it was what it now is for oneself. Any higher mental function necessarily goes through an external stage in its development because it is initially a social function. This is the center of the whole problem of internal and external
behavior…When we speak of a process, “external” means “social.” Any higher mental function was external because it was social at some point before becoming an internal, truly mental function. (pp. 60-61)

Such social interactions are necessarily mediated by language. Language is the cultural tool by which humans are able to represent thought and thereby communicate about concrete objects and abstract concepts. Units of language (words) act both as identifiers, or “signs” (labeling concrete objects in the immediate environment), as well as signifiers (representing concrete objects that are not present, or abstract concepts). A child’s use of signs and signifiers results in the development of “higher mental functions” which essentially transforms the structure of the child’s cognitive activity (Vygotsky & Kozulin, 1986). Language therefore provides a means by which children can understand, communicate, and build meaning in a social context as well as a mental tool by which they can organize and construct personal knowledge.

**A Vygotskian Perspective**

According to Vygotsky, formal instruction is instrumental in directing children’s cognitive development. “Instruction is one of the principal sources of the schoolchild’s concepts and is also a powerful force in directing their evolution, it determines the fate of his total mental development” (cited in Dixon-Krauss, 1996, p. 12). Vygotsky differentiated between “scientific concepts,” which he believed were the product of formal instruction in academic subject areas, and “everyday concepts” that children spontaneously acquire from daily activities and interactions in informal settings. Scientific concepts also differ from everyday concepts in that they are organized according to formal, often hierarchical, structures. Such is undeniably the case in the
content area of science. To learn academic concepts children must learn to recognize the relationships inherent in those structures. Everyday concepts, in contrast, do not form organized systems. Thus it is the acquisition of scientific concepts, not everyday concepts, which results in the development of higher mental processes (Vygotsky cited in Gredler & Shields, 2008).

**Contemporary Understandings of Learning**

Current conceptualizations of learning as a sociocultural phenomenon expand upon many of the themes evident in Vygotsky’s work. For example, Wenger (1998) described learning as a process of “social participation.” Wenger stated:

Participation here refers not just to local events of engagement in certain activities with certain people, but to a more encompassing process of being active participants in the practices of social communities and constructing identities in relation to those communities. (p. 4)

This concept of “communities of practice” (Lave & Wenger, 1991) is a central aspect of Wenger’s social theory of learning, which presupposes that social engagement is essential to the construction of meaning. Wenger’s viewpoint suggests that children are most successful in acquiring knowledge and constructing meaning when they are actively engaged in authentic, valued practices within a community with which they identify. Gee (2004) and Rogoff (1990) concurred, with the latter suggesting that “children’s cognitive development is an apprenticeship – it occurs through guided participation in social activity with companions who support and stretch children’s understanding of and skill in using the tools of culture” (p. vii).
Science as a culture and a community of practice. A sociocultural perspective of science “means viewing science [and] science education…as human social activities conducted within institutional and cultural frameworks” (Lemke, 2001, p. 296). The scientific community is an established community of practice with its own well-defined cultural and linguistic practices, “rules of argument and means of persuasion” (Wineburg & Grossman, 2001, p. 480). While the construction of scientific knowledge undeniably involves both social and cognitive factors (Reiser et al., 2001, p. 267), Lemke suggested that “what matters to learning and doing science is primarily the socially learned cultural traditions of what kinds of discourses and representations are useful and how to use them” (p. 298).

This assertion is supported by Hogan and Maglienti (2001) who reported that practicing scientists develop scientific ways of knowing about the world by becoming active and contributing members of their community of practice (p. 684). The scientists who participated in that investigation “internalized their sociocultural activity as cognitive tools that enabled them to act in professional contexts in ways that are rational given the objectives and norms of their discipline” (p. 684).

From such a sociocultural perspective, science education is not merely the transmission of scientific knowledge. Rather it is the process of encouraging children to participate in the activities of a legitimate community of practice and enculturating them into the ways of talking and thinking that are characteristic of the discipline (Gee, 2004). For as Snow, Griffin, and Burns (2005) observed, “to some extent the discipline-appropriate use of language functions to define ways of thinking appropriate to those disciplines” and to define the language user as a member of that community (p. 10).
**Issues of identity.** If educators seek to improve urban student achievement in the content area of science, students must be taught the specialist academic variety of language that will enable them to participate fully in the scientific inquiry process and develop the concomitant scientific habits of mind. For in disciplines such as science, modes of discourse are more than a means by which to discuss subject matter (NRC, 2000). Specialist language is the cultural tool with which subject-specific knowledge is constructed. This process of appropriating and internalizing scientific language and ways of thinking is critical to viewing oneself as a member, or potential member, of a scientific community. Through participation in a legitimate scientific community of practice students can “form a projective identity…[When learners] take on a projective identity…the learner comes to know that he or she has the capacity, at some level, to take on the virtual identity as a real-world identity” (Gee, 2004, p. 114).

Gee (2004) cautioned, however, that children’s vernacular language patterns are intimately and inextricably linked to their personal, familial, and cultural identities. Assuming a new identity, even a projective one, requires that the new identity is not at odds with children’s home-based identities. If a new identity is perceived to be alien to or in conflict with their home-based identities, students will choose to disassociate themselves, effectively rejecting the new language patterns and the new identity. According to Gee (2004), children will be motivated to acquire a specialist variety of language only if:

(a) They recognize and understand the sorts of socially situated identities and activities that recruit the specialist language; (b) they value these identities and activities, or at least understand why they are valued; and (c) they believe
they (will) have real access to these identities and activities, or at least (will) have access to meaningful …versions of them. (p. 93)

Examining the TZTW Primates Lesson within a Sociocultural Framework

From a general sociocultural perspective, the TZTW Primates lesson has the potential to be highly supportive of student learning. Through discussion-based guided inquiry students are enculturated into legitimate and authentic (albeit developmentally appropriate) scientific discourse patterns and practices. Hapgood and her colleagues (Hapgood, 2003; Hapgood, Magnusson, & Palinscar, 2004; Hapgood & Palinscar, 2006/2007) have previously demonstrated that through guided inquiry even young children can begin to appropriate and internalize scientific ways of thinking and speaking.

The Primates lesson is also supportive of learning from a variety of more specific sociocultural perspectives. Figure 2.6 summarizes key ideas of the theorists discussed in this section and indicates the manner in which the Primates lesson supports student learning from their perspectives.

According to Vygotsky (cited in Vygotsky & Kozulin, 1986), formal instruction in scientific concepts (Vygotsky’s term for academic concepts) is necessary for students to develop higher mental functions. Unlike everyday concepts, scientific concepts are organized according to formal, hierarchical structures which students must understand in order to make sense of content within the discipline. The Primates lesson provides students with science instruction related to the topic of primates. In addition the Structured Overview strategy introduced in the background knowledge component of the
<table>
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<th>Theorist</th>
<th>Key Ideas</th>
<th>The manner in which the TZTW Primates Lesson supports learning</th>
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<tr>
<td>Vygotsky (Vygotsky &amp; Kozulin, 1986)</td>
<td>Formal instruction in scientific concepts* is necessary for students to develop higher mental functions. Scientific concepts are organized according to formal, hierarchical structures.</td>
<td>The lesson provides students with formal science instruction with respect to the topic of Primates. The Structured Overview strategy in the background knowledge component of the lesson, models the hierarchical classification system of primates.</td>
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<tr>
<td>Wenger (1998)</td>
<td>Learning is a process of social participation. Participation refers to “being active participants in the practices of social communities and constructing identities in relation to those communities” (p. 4).</td>
<td>Students are encouraged to take on identities as scientists as they actively participate in authentic scientific practices (observation-based inquiry) within the context of an authentic scientific community (a community zoo).</td>
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<tr>
<td>Rogoff (1990) Gee (2004)</td>
<td>“Cognitive development is an apprenticeship – it occurs through guided participation in social activity” (p. vii).</td>
<td>The construction of individually held knowledge is supported and encouraged through teacher-guided observation-based inquiry and class discussions.</td>
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<tr>
<td>Gee (2004)</td>
<td>Children can form a projective identities of themselves as scientists, but only if the new identities are not in conflict with their home-based identities.</td>
<td>Students are accompanied to and assisted at the zoo by their teacher, classmates, and possibly parents or other volunteers. Such participation in scientific activity with members of their home-based community has the potential to bridge home-based identities with new, projective identities as scientists.</td>
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*Note. The reader will recall that Vygotsky’s notion of “scientific concepts” refers to academic subjects in general, rather than the content area of science specifically.

Figure 2.6: The TZTW Primates Lesson Examined from Multiple Sociocultural Perspectives
lesson models the hierarchical classification system of the animals and gives students an organizational structure for making sense of the lesson content.

When viewed from the lens of Wenger’s (1998) social theory of learning, learning occurs as a result of active participation in the social practices of a community. Through such participation children begin to construct identities of themselves as members of that community. The TZTW Primates lesson encourages students to take active part in legitimate scientific practices in the form of observation-based inquiry. Further such participation occurs within the context of their classroom community as well as on-site at a community zoo. Thus participation in the lesson encourages children to view themselves not only as classroom-based science learners, but as scientists in a zoo environment.

Rogoff (1990) and Gee (2004) considered cognitive development to be a type of apprenticeship. Children’s learning is promoted through guided participation in culturally valued social practices. In the case of the Primates lesson, the teacher encourages the construction of individually-held knowledge by guiding students in observation-based inquiry and class discussions (social activities which are valued in the scientific community). Finally, Gee (2004) suggested that when participating in social activity, even as apprentices, children can form projective identities of themselves (for example, as scientists). However children are likely to reject these new identities if they are in conflict with children’s home-based identities. Paris and Hapgood (2002) suggested that excursions to ILEs such as zoos can “bolster personal, family, and cultural identity” (p. 40). Through participation in the Primates lesson children are accompanied to the zoo and assisted not only by their teacher, but by their classmates and potentially their parents
and/or other volunteer members of their own community. Thus the Primates lesson has the potential to bridge students’ home-based family and cultural identities with new, projective identities as scientists.

**Summary**

The comprehension and acquisition of scientific concepts can be particularly challenging for less privileged urban students for whom scientific discourse patterns and practices may seem foreign, even alien. The Primates lesson seeks to enculturate students into scientific ways of thinking and knowing. Through their participation in social activity related to the topic of primates (such as teacher-guided observation-based inquiry, and class discussions) children engage in authentic scientific practices, thereby expanding their visions of themselves as scientists and acquiring the specialist language, discourse structures, and concomitant ways of thinking that have the potential to improve their science achievement scores in the short-term and promote long-term engagement with science and scientific thinking. Within such a sociocultural conception of learning however it is important to examine the specific context in which learning occurs. The next section discusses literature related to ILEs in general, and community zoos in particular.

**Learning in ILEs and Zoos**

The NRC (2007) noted that children in contemporary society are more distant from the natural world than those of previous generations:

The increasing sophistication of our everyday tools – cell phones, ipods, computerized vehicles – prohibit the type of hands-on investigations that may
have motivated students to learn science [in the past]. For example, taking apart
radios and putting them back together, rebuilding automobiles. These pursuits are
far less common and less possible. Technology makes it prohibitive. Even as
technology enhances modern life, it may play a role in prohibiting science
inquiry. (NRC, p. 18-19).

Yet researchers have acknowledged that an understanding of phenomena is rooted in the
perceptual world (Dewey, 1934; Lave, 1988; Zull, 2002). As Gee (2004) observed,
“academic language…is not really lucid or meaningful if one has no embodied
experiences within which to situate its meanings in specific ways” (p. 44). Thus children
need first-hand experiences with the natural world in order to make sense of and be
motivated to learn scientific concepts.

For less privileged students first-hand scientific experiences may be especially
critical. For example Westervelt (cited in Dierking, Burtnyk, Buchner, & Falk, 2002)
demonstrated that urban children “lacked much knowledge and experience with wildlife,
which seemed to result in naïve views and behaviors” (p. 1). Back (2003) claimed that
urban students in particular have limited contact with nature, and may consequently
“develop a fear or dislike of animals due to their unfamiliarity with them” (p. 28). Visits
to ILEs such as zoos, aquariums, science centers, and botanical gardens offer
opportunities for urban students to experience first-hand encounters with natural
phenomena in a safe and supportive environment.

Learning in ILEs

Unlike many school-based learning experiences which Gee (2004) characterized
as “disembodied minds learning outside any context of decisions and actions” (p. 39),
ILEs have the advantage of providing children with first-hand experiences with objects and phenomena thus offering the potential for particularly rich engagement with the physical world. ILEs provide opportunities for the active manipulation of objects and the enculturation into discipline-specific social practices (Paris & Hapgood, 2002). Such experiences may well promote learning both in the context of the informal environment (through the active meaning-making that occurs during first-hand investigations) as well as in the school-based environment (through language-mediated reflection) (Braund & Reiss, 2006).

**Advantages of ILEs.** Braund and Reiss (2006) called for “a great deal more thought about the potential for learning science outside the classroom” (p. 1386). These researchers contrasted school-based science learning, which they describe as “all too often boring, irrelevant, and outdated,” with learning in ILEs such as zoos. Learning science in these places “is often seen as exciting, challenging, and uplifting” (p. 1374). For example, in a recent investigation conducted in the United Kingdom students rated “going on a science trip or excursion” as the most enjoyable way of learning science (Cerini, Murray, & Reiss cited in Braund & Reiss, p. 1375). Such enjoyment is likely to lead to increased student interest and intrinsic motivation to learn about science-related topics.

Student interest in a topic has been shown to positively affect learning outcomes (Flowerday, Schraw, & Stevens, 2004, p. 112; Schraw, Flowerday, & Lehman, 2001). Researchers distinguish between situational interest which can be defined as “positive but temporary affective responses to a stimulus or activity” (Guthrie et al., 2006, p. 242) and personal interest which is a “more permanent, strong predisposition for participation in
activities or for pursuit of certain goals” (p. 242). Although teachers cannot control personal interest, they can contribute to its development by exposing students to contexts which are situationally interesting. In that manner teachers can promote student engagement with content and set the stage for deep level processing; “Creating environments that stimulate situational interest is one way for schools to motivate students and help them make cognitive gains” (Hidi & Harackiewicz cited in Guthrie et al., p. 233).

Researchers also have acknowledged the important contribution of motivation to learning. Guthrie and Knowles (2001) suggested that real-world interactions (such as those at ILEs) are highly motivating for students. Kenny (2009) found that to be true after interviewing teachers from urban schools who had participated in the original 2006/2007 TZTW Project. Kenny (2009) reported that the most often-cited student-level benefit of participation in the project was that “students were interested and motivated to learn” (p. 19). Kenny stated,

Teachers used descriptors such as “excited,” “interested,” “fascinated,” and “enthusiastic” to describe students’ responses to the lessons and zoo visits. A teacher observed, “The kids loved it.” Another stated, “It was thoroughly suited to what they were interested in, so they were enthusiastic.” (p. 19)

Another frequently cited benefit of the project was that participating students mastered the content of the lessons and “this learning was characterized as ‘long-lasting’” (p. 19). Teachers directly credited the TZTW lessons with students’ high levels of motivation to learn, and the learning that occurred as a result.
It is evident that out-of-school contexts can enhance science learning. Braund and Reiss (2006) suggested that ILEs do so in the following manner. ILEs:

1. Promote increased knowledge and understanding of science concepts.
2. Encourage extended activity related to authentic scientific practices.
3. Provide students with access to rare and/or unique specimens and artifacts which serve as a “reference point for the accumulation and enhancement of scientific knowledge” (pp. 1378-1379).
4. Expose students to “big” science (interesting and inspiring scientific practices which require sophisticated equipment and/or involve the cooperation of multiple institutions on a large scale).
5. Improve student attitudes towards science.
6. Increase opportunities for student collaboration and socialization.

Other researchers have cited additional benefits of ILEs. Dierking (2002) stated that such environments “enable people to explore…scientific issues perceived as important within a socially supportive, intellectually comprehensible, and contextually appropriate environment” (p. 14). Paris and Hapgood (2002) claimed that ILEs “provide opportunities for significant experiences in the lives of children” (p. 39) and noted that such environments frequently “elicit curiosity and exploration” (p. 45), hence generating situational interest in a particular topic and motivating children to learn more.

**Unique features of ILEs.** Despite the many potential benefits of learning in ILEs, many educators express concerns about the expense of such out-of-school excursions in terms of time and monetary cost (Braund & Reiss, 2006; Kenny, 2009). Leinhardt & Crowley (2002) observed that in contemporary society children need not visit an ILE to
learn about or view a particular topic of investigation. Instead, they and their teachers have multiple sources of information available to them, including books, websites, and videos. However such sources offer only representations of objects – or, in the case of zoos, animals in their environments - not the objects, animals, or environments themselves.

Evans, Mull, & Poling (2002) suggested that “real objects ‘speak’ in ways that representations of those objects do not” (p. 55). Real objects - or in the case of the Primates lesson, real animals in real zoo environments - inspire awe and wonder and elicit an emotional response based upon a singular combination of sensory information such as colors, textures, and spatial relationships (Frost, 2002, p. 80). Leinhardt and Crowley (2002) proposed that there are unique characteristics of original objects that cannot be replicated by mere representations (p. 302). Although the authors discuss the features in terms of their reference to museum objects, these same attributes - which include: (a) the resolution and density of information; and (b) the scale of objects - are characteristic of animal collections housed in zoo environments. The following discussion makes reference to these features in relation to zoo exhibits.

Resolution and density of information refers to the totality of the discernable features of the animals and the overall zoo exhibit. Such features can be perceived through the senses; for example the sights, sounds, textures, and smells that a child encounters when observing a gorilla at a zoo exhibit. “Although many of these features could be described completely and perhaps even represented in close approximations of reality, the holistic collection of features…cannot be efficiently represented in the absence” (Leinhardt & Crowley, 2002, p. 304) of the animals themselves.
Scale is another important feature of animals and their environments that cannot be faithfully represented through books, websites, or videos. It is one thing for children to see an illustration of a gorilla juxtaposed against an illustration of a human. It is another thing entirely for children to view and understand the size of a gorilla in relation to themselves. It is precisely for such reasons that it is important for children to visit ILEs in general and community zoos in particular.

This discussion makes it apparent that ILEs have the distinct advantage of providing students with unique sensory experiences that have the potential to support robust learning. Researchers have acknowledged that learning is in fact rooted in such real-world experiences (Dewey, 1934; Dierking, 2002; Lave, 1988; Zull, 2002). That being said, while sensory experience is an essential condition to learning, it is nevertheless insufficient to ensure that learning occurs.

Dewey (1934) made a distinction between mere sensory “experience” and “an experience” which is educative. As he pointed out, “oftentimes…the experience had is inchoate. Things are experienced but not in such a way that they are composed into an experience. There is distraction.” (p. 36). Zull (2002) concurred:

Experiential learning is often thought of as simply giving people experience. But I stress that little true learning takes place from experience alone. There must be conscious effort to build understanding from the experience, which requires reflection, abstraction, and testing of abstractions. (p. 28)

Such conscious effort requires the allocation of cognitive and attentional resources - resources which may be in short supply in a novel environment in which “auditory and visual distractors compete for sensory and cognitive resources” (Schwerha,
Thus while the novelty of an ILE may enhance learning by providing unique sensory stimulation (Fenker & Schutze, 2008), too much novelty can in fact disrupt learning (Schwerha, Wiker, & Jaraiedi).

**Summary.** This discussion served to highlight the affordances of ILEs and the qualitative differences between classroom-based learning and learning in out-of-school contexts. It is widely agreed that ILEs have tremendous potential to create situational interest and motivate children with respect to learning academic subjects in general (Dierking, 2002; Guthrie and Knowles, 2001; Paris, 2002; Paris & Hapgood, 2002) and science in particular (Braund & Reiss, 2006; Kenny, 2009). Teachers should be cautioned however that visits to ILEs do not always result in the type of learning that can be quantified. As Paris and Hapgood have suggested,

> Sometimes the impact of the experience may be implicit, subtle, and difficult to articulate or assess....Therefore learning (in the traditional sense) may or may not occur and learning does not have to be the goal of a visit to an ILE. (p. 39)

Chong et al. (2008) stated that novel events – or, as in the case of ILEs, novel environments - “can serve as task-irrelevant distracters or as potential sources of engagement” (p. 120).

Zoos are a unique type of ILE that aspire to educational goals. In the next section the discussion turns to what is currently understood about the learning that occurs in zoo environments.

**Learning in Zoos**

Although zoos and aquariums have long been concerned with the impact of their programs, few available studies have actually assessed that impact (Dierking, Burtynk,
An ERIC search revealed several papers and studies that focus on conservation-related knowledge and behaviours (Dierking et al.; Smith, Broad, & Weiler, 2008; Wheater, 1995; Whitehead, 1995) but research related to integrated science and literacy instruction situated within a zoo environment is particularly scarce. The literature that does exist on this topic tends to take the form of practice-based, informative articles rather than reports of research investigations. Nevertheless, the existing literature on learning in zoos and aquariums, and/or with zoo animals informs the current investigation as described below.

**The effect of zoo and aquarium exhibits on visitor knowledge.** A primary goal of zoos is to impart information related to the animal species that they exhibit (Fernandez & Timberlake, 2008, p. 481). Extant literature suggests that zoo exhibits can be effective in increasing visitor knowledge. For example, Lukas & Ross (2005) reported that zoo visitors “performed better on exit than entrance surveys” (p. 33) with respect to knowledge questions related to primate species.

In a review of literature related to visitor learning in zoos and aquariums, Dierking, Burtnyk, Buchner, and Falk (2002) cited several additional investigations which support the conceptualization of zoos as a learning environment. For example, Hayward reported that the Outer Bay Wing exhibition at the Monterey Bay Aquarium “produced a significant increase in visitors’ conservation awareness and knowledge” (p. 9). In a related investigation, visitors of the aquarium reported having “vivid memories…based on powerful visual experiences” (p. 9) after returning home from an exhibit. Bielick and Karns interviewed visitors to an exhibit at the National Zoo and
found that the visitors’ knowledge of animal cognition acquired at the exhibit was maintained thirteen months later.

Dierking and her colleagues (2002) concluded that these results “indicate that long-lasting and robust learning outcomes are possible within a zoo setting” (p. 12). While such a statement is encouraging, it should be noted that participants in the aforementioned studies were likely to have been primarily adults drawn from the general zoo-visiting population rather than urban schoolchildren who are the focus of the current investigation.

Another investigation (which included but did not focus on school-aged children) examined the “educative influence of zoo visits on their visitors at three Indian zoos” (Mallapur, Waran, & Sinha, 2008, p. 214). Researchers interviewed zoo visitors at a primate exhibit and members of the general public in various city centers with respect to their knowledge about a specific primate species. The results of the interviews were compared, and it was determined that “the knowledge base of ‘zoo visitors’ was significantly greater than the ‘general public’ with regard to the…Lion-tailed macaques” (p. 223). These researchers concluded that “zoos are an excellent learning environment…but currently they are an underutilized resource” (p. 214). Mallapur, Waran, & Sinha further stated that “watching live animals in zoos can be an awe-inspiring experience, especially for young children and school students” (p. 221).

The literature related to children’s learning in zoos or with zoo animals is particularly scant. Two studies and several articles were located that relate to children’s encounters with zoo animals - either at the zoo or in students’ home classrooms. Two additional articles describing integrated science and literacy instruction situated at zoos
were found. It should be noted however that the articles do not report formal research. Rather they provide descriptions and anecdotal reports of the success of various programs. Nevertheless these articles, along with the aforementioned research, investigations are described below.

**Student encounters with zoo animals.** In their article, Wickless et al. (2003) described the “Our Zoo to You” program. The program places small zoo animals (such doves, a geckos, horned frogs, and African brown millipedes) in students’ home classrooms during the winter months thus providing access to zoo animals when the local community zoo is closed. The zoo provides participating classrooms with kits which include the information and equipment needed to care for the zoo animals in the classroom. Classes are also able to access and upload web-based information gleaned through classroom-based investigations related to the animals. Wickless et al. reported that through extended contact with the animals, student “observations became more detailed” (p. 38). Further, participating teachers claimed that the “visiting animals provide more opportunity to teach inquiry and develop science-process skills and their students were more excited about doing science” (p. 39).

In a related study, Trainin, Wilson, Wickless, and Brooks (2005) examined the effect of the “Our Zoo to You” program on students in first through fourth grade. The researchers report that the students responded very positively to the zoo animals and that over time the children became “less focused on performance goals…and more on learning goals” (p. 302). Thus it appears that encounters with zoo animals have the potential to promote intrinsic motivation amongst students as well provide opportunities for students to engage in observation-based inquiry.
Through the course of the aforementioned study, student-generated texts were analyzed, and it was found that more unique animals elicited more “mention of science facts” than less unique animals. This finding is bolstered by an investigation by Tunnicliffe (1998) who reported that primary students who visited a zoo made more observations about the unique animals encountered at the exhibits than primary students who visited less unique animals at a farm. These findings suggest that more unique animals found at zoo exhibits may potentially be of greater interest to students than less unique animals. One may speculate that such situational or personal interest, in combination with the intrinsic motivation that appears to result from encounters with zoo animals, will promote increased learning outcomes. Primate species appear to be of particularly high interest to students (M. Magdich, personal communication, October 16, 2007; Stoinski, Ogden, Gold, & Maple cited in Lukas & Ross, 2005).

One additional finding that is of interest to the current investigation is that Tunnicliffe (1998) reported that the comments of both the students who visited the zoo and those of students who visited a farm were frequently focused on features of the animals’ environments. Tunnicliffe suggested that “visitors use phenomena within the environment to set the animals in context and that observing the whole scene is important to them” (pp. 9-10). This finding suggests that it is not merely observing the animals, but rather observing the animals in the context of their environment, that contributes most to the manner in which students make meaning. Teachers may well be advised to ensure that students have access to zoo exhibits rather than merely print-based or digital reproductions of animals in various environments.
**Integrated science and literacy instruction situated at a zoo.** A search of the literature revealed two articles describing integrated science and literacy instruction situated in zoo environments. Henson (2008) described a high school animal behaviour project. Through participation in this project biology students were “challenged to apply their scientific-inquiry skills to the study of animal behaviour” (p. 44). Students collected data at a community zoo for approximately 30 minutes then returned to their home classroom to discuss and represent the data. Henson reported that “the project stimulates student interest” (p. 47).

Back (2003) described a program which shares common elements with the Primates lesson. As was the case with the TZTW lessons, elementary teachers were consulted in developing the “EdZoocation” program, a partnership between a zoo and an elementary school. Participating students were visited at their schools by a zoo educator. During these visits students were encouraged to explore “habitat boxes” containing artefacts and objects related to various animal habitats and encounter live animals. After three subsequent weeks of classroom-based instruction featuring texts about animals in their habitats the students visited the zoo and participated in an interactive tour of exhibits related to animal habitats. The unit of study culminated with students writing and illustrating poems to represent their learning. Although the outcomes of this project were not formally studied, Back described the program as successful in meeting the needs of both the zoo and the school. The program has since been expanded from one school to “more than a dozen” (p. 31).

According to Back (2003), the Edzoocation program successfully combines classroom-based and zoo-based instruction, as do the TZTW lessons. The former
program however is of longer duration and provides some instruction via zoo educators rather than via classroom teachers who direct all phases of instruction in the TZTW lessons. Nevertheless, despite differences in the implementation of the programs, the reported success of integrated science and literacy instruction situated at a community zoo is encouraging.

**Summary.** Although no research (apart from the original TZTW investigation) was found that related specifically to integrated science and literacy instruction situated in a zoo environment, anecdotal evidence suggests that such instruction may be successful in promoting student learning (Back, 2003; Henson, 2008). Extant literature related to learning in zoo environments also offers some support for the potential of the Primates lesson to increase student achievement in the content area of science. The literature suggests that visits to animal exhibits can increase visitor knowledge (Braund & Reiss, 2006; Dierking, Burtynk, Buchner, & Falk, 2002; Lukas & Ross, 2005; Mallapur, Waran, & Sinha, 2008) both in the short-term (Hayward cited in Dierking et al.) and in the long-term (Bielick & Karns cited in Dierking et al.).

Encounters with zoo animals can promote situational interest (Henson, 2008; Mallapur, Waran, & Sinha, 2008; Paris & Hapgood, 2002; Wickless et al., 2003) and intrinsic motivation amongst students (Paris & Hapgood; Trainin, Wilson, Wickless, & Brooks, 2005) which is likely to improve student learning outcomes (Guthrie et al., 2006). Further, the uniqueness of the animals found in zoo exhibits - particularly primate exhibits (M. Magdich, personal communication; Stoinski, Ogden, Gold, & Maple cited in Lukas & Ross, 2005) - promotes greater interest than animals which are less unique.
(Trainin et al.; Tunnicliffe, 1998), and the context in which animals are viewed contributes to students’ meaning-making attempts (Tunnicliffe).

**Chapter Summary**

This chapter traversed numerous bodies of literature. The first section of the chapter provided study-specific definitions for the terms literacy, inquiry-based science instruction, content area literacy, comprehension and comprehension strategies in order to orient the reader to the focal point of the investigation – the intersection of science and literacy. This first section also provided a rationale for integrated instruction, citing the nature of science as a discipline, the manner in which literacy is an integral component of real-world science, and the subject-specific literacy demands of science as compelling reasons for teachers to integrate science and literacy instruction. Finally this section described a number of investigations (including the original 2006/2007 TZTW Project) that have demonstrated the efficacy of such integrated instruction.

The second section of this chapter situated the investigation and the TZTW Primates lesson (the subject of the investigation) within two nested theoretical frameworks: the TW framework, and a broader sociocultural conception of learning. This section examined the manner in which the TW framework supports teachers in the development of expertise related to comprehension strategy instruction and promotes student achievement by encouraging student use of research-based comprehension strategies during literacy events. The four components of the TW framework (background knowledge; vocabulary; comprehension; and application/extension) were examined in light of research that supports their use. The Primates lesson - and the
specific strategies employed therein (including Structure Overview; QCR; Concept of a Definition; Modified Cause/Effect Frame; and About Point Writing Response Outline and Summary) – were situated first within the TW framework, and second within a broader sociocultural conception of learning that posits that individual cognition develops through participation in social activities.

The final section of this chapter examined what is currently known about learning in ILEs in general and zoos in particular. Apart from the original 2006/2007 TZTW Project, no investigations were found that addressed the topic of integrated science and literacy instruction situated within a zoo environment. However, the literature suggests that such environments promote the development of situational interest and motivation, and hence contribute to enhanced learning.

The current investigation is an attempt to add to the existing body of knowledge related to learning within zoo environments. Upon examination of the extant literature it appears that the results of this investigation will be a welcome addition to an as yet underdeveloped body of knowledge. The next chapter describes the current investigation in detail.
Chapter Three

Methods

This chapter delineates the methods used in the current investigation. In the first section the purpose and research question are reviewed. The second section describes characteristics of the participants and research sites. In the third section the materials used are detailed. These materials include: those that were adopted from the original TZTW study (the Primates test and accompanying scoring rubric; the Primates teacher overview; and the TZTW Primates lesson and accompanying lesson materials); those that were created for use in the current investigation (a scavenger hunt and activity key; a teacher questionnaire; and a school demographic information questionnaire); and those that were not used in the original study but were adopted for the purposes of this investigation (three primary-level informational books).

The fourth section discusses the research design and procedures. This research design is evaluated based on the criteria for well-designed controlled trials put forth by the Coalition for Evidence-Based Policy (2003). Study procedures that are detailed include: a sequential account of all research-related activities (training; pre-testing, instruction, post-testing, and delayed post-testing), specific tasks associated with each of the treatment conditions, scoring and the establishment of inter-rater reliability statistics, data sources, and data analysis. The fifth and final section describes the limitations of the investigation with respect to potential threats to the study’s internal and external validity.
Purpose and Research Question

The purpose of this investigation was to compare the science achievement scores of third grade students assigned to the following three treatment conditions:

1. The TWZ group (which received instruction via the TZTW Primates lesson in connection with a visit to related exhibits at the local zoo).
2. The CZ group (which received instruction via a traditional science lesson in connection with a visit to related exhibits at the local zoo).
3. The TWC group (which received classroom-based instruction via the TZTW Primates lesson). This group did not visit the zoo in connection with the investigation.

Thus the research question addressed in this investigation was: How do the science achievement scores of students in the TWZ, CZ, and TWC groups compare at pre-, post-, and delayed post-test?

Participants and Research Sites

Participants

Study participants consisted of 158 third graders and their 10 teachers at 3 elementary schools in an urban school district located in a mid-Atlantic state. Participating schools included: School A (49 students, 3 classroom teachers, and 1 support teacher); School B (47 students and 3 classroom teachers); and School C (62 students and 3 classroom teachers). Cohorts of students were selected for participation based upon two initial criteria: (a) their grade level; and (b) their attendance at one of the

12 For the purpose of this investigation, the terms “science achievement” and “science content knowledge” hereinafter will refer specifically to science achievement and content knowledge related to the topic of primates.
three target schools. The teachers of these groups were then asked to participate based upon their status as third grade teachers at the participating schools. Finally the students who comprised the third grade cohorts were selected for participation based upon their ability to complete the assessment for this study without one-on-one assistance.\textsuperscript{13}

Participating schools were targeted for the study because they were identified by school district administrators as the most similar within the district with respect to key demographic characteristics that are associated with student achievement. Table 3.1 illustrates the school-level features that were considered when matching the schools. Specifically these features were: the number of third grade classes in the school; the total number of students in the school; the percentage of students receiving free or reduced lunch; the racial composition of the student body; the gender composition of the student body; the percentage of students in the school designated as English as a Second Language [ESL]; and the percentage of students in the school eligible for Special Education support.

**Research Sites**

For teachers and students in the TWZ and the CZ groups, research-related activities took place in participants’ home classrooms, as well as on-site at the community zoo (principally at the primates exhibits and in a zoo classroom space). For students in the TWC group, research-related activities took place in students’ home classrooms, with the teachers of the children in this group attending an initial workshop.

\textsuperscript{13} This determination was made by individual classroom teachers. Although teachers were not shown a copy of the test, it was described to them and teachers were asked to provide an alternate activity for any child for whom they believed such a test was inappropriate. This course of action was consistent with the methods used in the original TZTW investigation as any data collected from students who received one-on-one support during the administration of the test were not included in the analysis.
Table 3.1

*Key Demographic Features of Participating Schools*

<table>
<thead>
<tr>
<th>Feature</th>
<th>School A</th>
<th>School B</th>
<th>School C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of third grade classes</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total number of students</td>
<td>500</td>
<td>411</td>
<td>470</td>
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<tr>
<td>% of student receiving free or reduced lunch</td>
<td>88</td>
<td>79</td>
<td>94.9</td>
</tr>
<tr>
<td>Racial composition of the student body</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Caucasian students</td>
<td>48</td>
<td>63</td>
<td>46</td>
</tr>
<tr>
<td>% of African American students</td>
<td>30</td>
<td>28</td>
<td>42</td>
</tr>
<tr>
<td>% of Hispanic students</td>
<td>17</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>% of other minority students</td>
<td>5</td>
<td>2</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Gender composition of the student body</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of female students</td>
<td>48</td>
<td>50</td>
<td>45</td>
</tr>
<tr>
<td>% of male students</td>
<td>52</td>
<td>50</td>
<td>55</td>
</tr>
<tr>
<td>% of students designated as ESL</td>
<td>10</td>
<td>2</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>% of students eligible for Special Education</td>
<td>20</td>
<td>16</td>
<td>22</td>
</tr>
</tbody>
</table>

*Note.* These statistics were provided by school-level administrators at the participating schools.

...held in the zoo classroom space. Neither the teachers nor their students in the TWC group visited the primates exhibits at the zoo in connection with this investigation.
Materials

The current investigation was an attempt to re-examine the effectiveness of the TZTW Primates lesson in promoting the increased science achievement of third grade students. Since the investigation replicated elements of the original TZTW study, when appropriate materials from that study were used or modified so as to meet the needs of the current investigation. These materials are described in the next section. However, unlike the original study, the current investigation took place in a new zoo setting and introduced a second classroom-based control condition (the TWC group). These circumstances necessitated that additional materials be created or adopted. These materials are also described below.

Materials Used in the Original TZTW Investigation

In an attempt to replicate elements of the original TZTW investigation the following materials from that investigation were used or modified for use in the current study: the Primates test, the Primates scoring rubric, the Primates teacher overview, the TZTW Primates lesson, and the TZTW Primates lesson materials.

Primates test. Researchers from the original TZTW investigation created an equal interval appearing measure to test students’ science achievement (see Appendix A). The complete instrument consists of three sections: (a) 9 short-answer questions related to science content intended to measure student’s science content knowledge; (b) a written essay intended to measure students’ writing ability; and (c) 12 vocabulary items intended to measure students’ vocabulary knowledge. This existing instrument was used to measure students’ science content knowledge at pre-, post-, and delayed post-test in the current investigation. However as the current investigation was specifically intended to
examine students’ science content knowledge (rather than writing ability and/or
vocabulary knowledge), only data gleaned from the first section of the test (the 9 short-
answer questions) were analyzed.

The testing instrument used in this investigation was developed for the original
TZTW investigation by Dr. Eileen Carr of the University of Toledo (a content literacy
expert) in cooperation with Mitchell Magdich, Curator of Education at the Toledo Zoo
(an expert in the field of zoo education). In addition to their familiarity with the National
Science Education Standards these experts were well-apprised of the science-based
knowledge and skills that are appropriate for primary students. Although there are “no
precise guidelines to follow in establishing the content of a particular academic subject”
(Crowl, 1996, p. 112), the test can be considered to have content validity based on
Messick’s (cited in Crowl) argument that “content validity is evaluated by showing how
well the content of the test samples the class of situations or subject matter about which
conclusions are to be drawn” (p. 112).

**Primates scoring rubric.** The science content knowledge section of the scoring
rubric (see Appendix B) created for use in the original investigation was employed in the
current study. The number of points assigned to each question ranged from one to seven,
depending upon the number of responses elicited by the question. Only full points were
awarded although students could receive partial credit for multiple-point items. For
example, Question #6 (“Explain why different primate species can all find food in the
same habitat.”), calls for a single response. Correct responses to this item were therefore
awarded a total of one point. In contrast, Question #3 (“Name a primate and identify
three body features that help it survive. Next to each feature, describe how the feature
helps the primate survive.”) calls for a total of seven discrete pieces of information. Each piece of information within students’ responses was examined and scored separately, thus students could be awarded up to seven points for that particular item. A maximum score of 31 points for the entire 9-item section was possible.

The original scoring rubric included a general rationale for scoring responses to each question as well as exemplars and non-exemplars. These exemplars and non-exemplars needed to be expanded for the current investigation. The questions on the Primates test were open-ended response items. Consequently it was expected that the different instructional conditions in the current investigation would result in some different responses that had not appeared in the original data set. Indeed, such was the case.

In expanding the rubric the following procedure was employed. When scorers encountered a new response that was not addressed by the scoring rubric, they informed the researcher who liaised with zoo experts (either at the Toledo Zoo or the participating zoo) to make a determination as to whether the response should be considered correct or incorrect. The researcher then reported back to the scorer(s) who then added that response to the rubric. At no time was the researcher apprised of the treatment conditions of students whose responses were in question. This procedure was adopted so as to minimize researcher-bias.

An illustrative example of how the rubric was expanded occurred in response to Question #7 (“Give one example of why apes are considered intelligent animals.”). Some students responded that primates “chew gum.” Unsure of what to make of this response, the scorers contacted the researcher who in turn contacted the Education Curator and a
The researcher was informed that indeed the orangutans at the participating zoo are given chewing gum as part of their enrichment program or as a “treat” following a visit to the veterinarian. The ability to chew gum is considered to be a sign of intelligence as most animal species would simply ingest the gum. The orangutans, by contrast, understand that gum is not a food source. Instead they enjoy chewing it, playing with it, even blowing bubbles, which they learned to do by observing visitors. Some of the orangutans have been observed to hide the gum so as to have access to it at a later time: a practice which the Education Curator likened to “putting bubblegum on the bedpost.” In this manner, the scoring rubric was expanded based on the data generated by the current investigation.

**Primates teacher overview.** The teacher overview which accompanies the TZTW Primates lesson was created by Toledo Zoo education staff and used in both the original and the current investigations. The teacher overview summarizes pertinent information about animals in the order of Primates and the suborders of Prosimii (Prosimians including lemurs, aye-ayes, and tarsiers) and Anthropoidea (Anthropoids including monkeys, tamarins, great and lesser apes, and humans).

**TZTW Primates lesson.** The TZTW Primates lesson used in the original investigation was also used in the current investigation. Each TZTW lesson combines a series of four research-based learning strategies: (1) a background knowledge strategy; (2) a vocabulary strategy; (3) a comprehension strategy; and (4) an application/extension strategy. The Primates lesson employs the following strategies:
1) Structured Overview (Vacca & Vacca cited in Carr, Aldinger, & Patberg, 2004), a graphic organizer which clearly delineates the hierarchical relationships amongst concepts.

2) Concept of a Definition (Schwartz & Raphael, 1985), a strategy that teaches components of word learning by prompting students to consider the classification, properties, and examples of specific words.

3) Modified Cause/Effect Frame (Carr, Aldinger, & Patberg, 2004), a graphic organizer that prompts students to consider causal relationships.

4) QCR (Carr cited in Carr, Aldinger, & Patberg, 2004), a strategy whereby students consciously and deliberately integrate information from their background knowledge with new information presented in the lesson.

**TZTW Primates lesson materials.** The TZTW Primates lesson materials that were used in the original TZTW investigation consist of packages of student work pages with teacher instructions. Kenny (2009) interviewed teachers who had participated in that investigation. Some teachers observed that “elements of the TW [Thinking Works] materials were not appropriate for primary grades, citing ‘too small of print,’ [and] ‘not kid friendly to reproduce and go over with the students’” (p. 22). For the purposes of the current investigation the researcher adapted the lesson materials by deleting the teacher instructions, using a larger font that was deemed to be more appropriate for primary-age students, and providing more space for written responses. Teachers who participated in the TW conditions of the current investigation were provided with the original version of the lesson for their reference and given the choice of using the original materials or the adapted materials with their students. All teachers opted to use the adapted materials.
Materials Created for Use in the Current Investigation

Materials that were created specifically for use in the current investigation include: a scavenger hunt activity with the accompanying answer key, a teacher questionnaire, and a school demographic information questionnaire. These items are described below.

**Scavenger hunt activity and answer key.** A Primates “scavenger hunt” activity had been used in the original TZTW investigation with students in the comparison condition; however this activity had been specifically designed for use at Toledo Zoo exhibits and was therefore inappropriate for use in the current investigation. To replicate the conditions of the original investigation as closely as possible, the original scavenger hunt activity was provided to the Education Curator at the zoo participating in the current investigation. The Curator created a similar activity (with an accompanying answer key) that was modeled on the original scavenger hunt task.

Like the original, the new version consisted of 20 short answer and fill in the blank items. Whenever possible, items were used verbatim in the new version. Three items are identical. For example, Item 2 on both activities states, “Write your own definition of a vanishing animal.” An additional four items are nearly identical with minor wording changes. For example, Item 4 on the original version states, “Hunting and _________ threaten wild populations of *monkeys* [emphasis added] in every country where they are found.” In the new version, the item reads, “Hunting and _________ threaten wild populations of *primates* [emphasis added] in every country where they are found.” Since different species are exhibited and different signage is displayed at each of the zoos, the remaining items are necessarily zoo-specific. These items highlight
information observable at the participating zoo’s exhibits. As per the original study, the scavenger hunt activity was used with students in the CZ group in the current investigation.

**Teacher questionnaire.** A questionnaire was developed to collect information relating to participating teachers so as to enable the researcher to understand contextual factors and better interpret the results of the investigation. The 8-item questionnaire included 2 items related to teachers’ level of experience (at the elementary level in general and at the 3rd grade in particular). This information is reported in Table 3.2. Questionnaire items also allowed for collecting data related to teachers’ participation in science training. All teachers reported that they had participated in the same district-level training related to rocks and minerals and plant growth and development. None of the teachers reported receiving any additional training in teaching science.

**School demographic information questionnaire.** A school demographic information questionnaire was created to collect information to help the researcher understand contextual factors and better interpret the results of the investigation. Data from these questionnaires are reported in Table 3.1.

**Additional Materials Adopted for Use in the Current Investigation**

The inclusion of a classroom-based comparison group (the TWC group) in the current investigation necessitated the adoption of additional materials that had not been used in the original study. Students assigned to the new condition did not visit the zoo
Table 3.2

Teacher characteristics

<table>
<thead>
<tr>
<th></th>
<th>TWZ</th>
<th>CZ</th>
<th>TWC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n</strong></td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Range of elementary teaching experience*</td>
<td>4 - 20</td>
<td>15 – 35</td>
<td>8 - 11</td>
</tr>
<tr>
<td>Average elementary teaching experience*</td>
<td>10</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>Range of 3rd grade teaching experience</td>
<td>2 - 4</td>
<td>8 - 18</td>
<td>1 - 10</td>
</tr>
<tr>
<td>Average 3rd grade teaching experience</td>
<td>3</td>
<td>14</td>
<td>5</td>
</tr>
</tbody>
</table>

* Ranges and averages are reported in years rounded to the nearest whole number.

during the course of the investigation, and therefore had no opportunity to directly observe Primates species or encounter information relayed via signage at zoo exhibits. Instead the teachers of these students were provided with the three primary-friendly books relating to primates for use during research-related instruction. Teachers were instructed to read the books aloud to the students as part of the lesson and use them as a basis for class discussions. Teachers were also asked to provide students with access to the books throughout the duration of the lesson.

The researcher selected the books from the children’s collection at the local public library. Because multiple copies were available, each classroom received its own copy of each book. In general the books addressed the same basic topics; however, as would be expected, there were slight variations among the texts. The topics addressed include: the
classification and distinguishing characteristics of apes and monkeys; similarities between humans and other primates; general and species-specific body features and their functions; behavior; predators; habitats; food sources and food gathering behaviors; indicators of intelligence; family groupings; communication; locomotion; threats to species caused by humans; and conservation efforts. Distinguishing features of the individual books are described below.

**Book 1. Apes and Monkeys,** by Barbara Taylor (2004), is a 48-page book that is estimated to be at a fourth grade reading level. What is most striking about the book is the large, bright color photographs which dominate each 8 x 10 inch page. The book is organized according to 18 headings. Each topic is summarized on two pages and is supported by appropriate photographs. Definitions of key terms are provided on the corresponding pages and an index is included at the back of the book. The text is printed in a large, primary-friendly font. Even larger, bolded font indicates headings and subheadings while the size and placement of the text are further used to organize the text according to subtopics.

One additional, very appealing aspect of this book is that it includes primary-friendly craft activities that support active engagement with concepts presented in the book. For example children are instructed as to how to make a “termite tower” using common household craft supplies. Once constructed, the children can place small candies in the tower to represent termites then use a straw to suck them up, mimicking how a chimpanzee would use sticks or grass stems to collect termites for a snack. Although the

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14 All readability approximations are based on “The Raygor Readability Estimate” (Raygor cited in McKenna & Robinson, 2009). To obtain this estimate, three 100-word passages are counted out and the average number sentences and words containing six or more letters are calculated. These figures are then plotted onto a matrix which indicates the approximate readability level.
participating teachers did not direct their students in these activities, had they chosen to, the students themselves could easily have created such crafts at home.

**Book 2.** *Monkeys and Apes of the World* by Rita Golden Gelman (1990) is a 62-page book that is estimated to be at a fourth grade reading level. Each page measures 8 ½ x 7 inches, and the book includes both photographs and colored illustrations of varying sizes. Rather than being divided into topics and subtopics, the text is connected and supplemented by extended captions that describe the photographs and illustrations. The amount of text on each page varies: some pages include several paragraphs of text, while others only a few lines. Pages of text alternate with pages of photographs or illustrations. The style and size of the font is generally appropriate to third grade students however the amount of text on the pages may be off-putting to some children. Further the captions are printed in all capital letters which may prove challenging for some students. Additional features of the book include a glossary and an index.

The book includes several interesting and memorable anecdotes about specific apes and monkeys. For example it describes how scientists threw potatoes onto a beach to observe the behavior of macaques. The monkeys liked the potatoes but not the sand that would cling to them. While the other monkeys were crunching sand along with their potatoes, one young female monkey, named Imo, decided to wash the sand off in the water. She quickly taught her playmates and their mothers to do the same. The adult males however, who paid little attention to either the young monkeys or the females, continued to crunch sand even weeks later.

**Book 3.** The third and final text used in this investigation was *Monkeys and Apes* by Mary Varilla (1999). It is the smallest of the books both in terms of its size (the pages
are a mere 7 x 6 inches) and the number of pages (36). The text is roughly organized according to topic, although no headings or subheadings are used. Instead information is presented in short snippets. For example one segment of text placed opposite a large illustration of a gorilla reads, “The gorilla is the largest ape.” (no page number). Beneath the text is an illustration of a small monkey sitting in what appears to be a child’s tennis shoe. The text below the illustration reads, “The dwarf marmoset is the smallest monkey. It can fit in a child’s shoe.”

According to the readability estimate, the book is approximately at a fourth grade reading level. However, specific features of the book and the text would tend to make it more supportive and appealing for students below that reading level. Text-based information is presented in small, manageable segments – often only one to two short sentences in length. The text is interspersed with bright, interesting illustrations that vary in size and perspective. Some of these illustrations are printed onto transparent pages, providing a front and back view of the same animal or habitat, or representing different aspects of an animal. For example, the front and back of one transparent page depict different facial expressions of the same chimpanzee. The illustrations and the transparent pages in this book are likely to be particularly appealing to young readers.

Teachers in the TWC group reported that they found the books to be both interesting and engaging for students. The teachers reported that their students frequently sought out the books to peruse during free-choice time and the teachers even requested that the test administrator leave the books in the classrooms after completion of the lesson. (This request was denied so as not to bias the results of the investigation.)
Research Design and Procedures

Research Design

This investigation employed a between-group, quasi-experimental, repeated measures design. Figure 3.1 depicts a diagram of the research design. The independent variable being manipulated was “type of instructional condition” with intact school groups being assigned (as will be described) to one of three treatment conditions:

1. School A was assigned to the TWZ group (the members of which participated in the TZTW Primates lesson, and visited the zoo in connection with that lesson).
2. School B was assigned to the CZ group (the members of which participated in a traditional science lesson focusing on Primates, and visited the zoo in connection with that lesson).
3. School C was assigned to the TWC group (the members of which participated in the TZTW Primates lesson, but did not visit the zoo in connection with that lesson).\(^\text{15}\)

<table>
<thead>
<tr>
<th>G1</th>
<th>O1</th>
<th>X1</th>
<th>O4</th>
<th>O7</th>
</tr>
</thead>
<tbody>
<tr>
<td>G2</td>
<td>O2</td>
<td>X2</td>
<td>O5</td>
<td>O8</td>
</tr>
<tr>
<td>G3</td>
<td>O3</td>
<td>X3</td>
<td>O6</td>
<td>O9</td>
</tr>
</tbody>
</table>

\textit{Note.} \(G = \text{group, } O = \text{observation, } X = \text{treatment}\)

Figure 3.1: Diagram of the Research Design

\(^{15}\text{The first two conditions replicate those in the original Thinking Works investigation. The third condition was added in this study for the express purpose of examining the effect of science instruction situated at a community zoo. So as not to disadvantage students in the third group, the participating school district scheduled a zoo visit for this group shortly after data collection was concluded.}\)
Although the U.S. Department of Education cautioned that such comparison group study designs may lead to erroneous conclusions (Coalition for Evidence-Based Policy, 2003), it acknowledged that “well-designed and implemented randomized controlled trials are not very common in education” (p. 11). Creswell (2008) posited that the nature of the educational setting frequently “prohibits forming artificial groups” (p. 313). The U.S. Department of Education contended however that comparison group studies can constitute “possible” evidence of effectiveness (Coalition for Evidence-Based Policy) if the following criteria are met:

1) The study’s intervention and comparison groups should be very closely matched in academic achievement levels, demographics, and other characteristics prior to the intervention….

2) The comparison group should not be comprised of individuals who had the option to participate in the intervention but declined….

3) The study should preferably choose the intervention/comparison groups and outcome measures ‘prospectively’ – that is, before the intervention is administered….

4) The study should…use valid outcome measures, have low attrition, [and] report tests for statistical significance. (pp. 11-12)

It can be argued that with the exception of the study’s attrition rate (which is unlikely to be related to any treatment intervention in the current study), this investigation meets all of the aforementioned criteria as explained below.

**Intervention and comparison groups are very closely matched.** According to the U.S. Department of Education, intervention and comparison groups are considered
closely matched if: the groups are comparable with respect to pre-test scores and other measures of academic achievement (ideally these same measures are then used to evaluate the outcome variable); the groups are similar with respect to demographic characteristics; the groups are studied in the same time period; and the data collection methods are consistent among groups (Coalition for Evidence-Based Policy, 2003).

Based upon these criteria, the intervention and comparison groups in the current investigation appear to be very closely matched. First, the pre-test equated the groups on measures of the dependent variable prior to treatment. This pre-test was the same measure that was administered to participating students to evaluate the outcomes of the interventions. Second, participating schools were selected based on their similar demographic profiles (see Table 3.1). Third, participants were studied during the same time period. And fourth, the same methods were used to collect outcome data from all three groups.

**Comparison group did not consist of students who declined to participate.** Permission for students to participate was granted by district administrators. All students in participating classrooms received the intervention assigned to their condition.

**Groups were assigned and outcome measure was determined prior to treatment.** Prior to the onset of treatment, participating schools groups were assigned to their conditions and the outcome measure was determined. Due to practical considerations on the part of the participating school district schools could not be assigned randomly to their respective conditions. However care was taken to assign schools to conditions in manner that would not favor the TWZ condition (the group hypothesized to outperform the other groups at post-, and/or delayed post-test) over either...
of the comparison conditions. Figure 3.2 depicts the researcher’s decisions related to the assignment of schools to conditions.

Since School C is located furthest from the zoo, scheduling and transportation issues prohibited the students and teachers at this school from visiting the zoo in connection with this investigation. These circumstances dictated that the two remaining schools (A and B) be assigned to the two remaining conditions (TWZ and CZ). Although all of the schools were initially matched according to demographic features, of the two remaining schools, the students at School B could be considered slightly more privileged. Administrators at this school reported the smallest percentages of students: receiving free or reduced lunch; designated as minority; designated as ESL; and eligible for Special Education services (factors associated with academic achievement). The location of School B also gives students at that school an advantage since the school is located a mere 0.39 miles from the zoo. According to the participating teachers, such propinquity enables the teachers and students at School B to visit the zoo more frequently than their peers at other schools in the district. In addition students at School B may be more likely to visit the zoo outside of school hours since they live in such close proximity to the attraction.

**Outcome measures, attrition rates, and statistical tests.** Guidelines for a well-designed controlled trial include: the use of valid outcome measures; the report of tests for statistical significance; and a low rate of attrition (Coalition for Evidence-Based Policy, 2003). The investigation employed a test of science achievement as the outcome
Figure 3.2: Researcher Decisions Related to the Assignment of Schools to Conditions

School A is located 2.14 miles from the zoo.

District-level administrators picked the three schools for participation that they believed to be the most similar within the district according to key demographic features (See Table 3.1).

School B is located 0.39 miles from the zoo. The students and teachers can walk to the zoo, and do not require bussing. Because of their proximity, these students may visit the zoo more often than their peers at School A.

School B was assigned to the CZ group, as the school’s demographic features and proximity to the zoo may privilege the students at this school over their peers at School A with respect to the dependent variable.

School C is the furthest school from the zoo (3.2 miles). District administrators decided that due to scheduling and transportation issues, the students and teachers at this school would not visit the zoo as part of the study.

School C was assigned to the TWC condition (the only group which did not visit the zoo during the course of the study.) This decision necessitated that the 2 remaining schools be assigned to zoo groups.

School A (the only remaining school) was assigned to the TWZ group (the only remaining condition).

measure. As this instrument and its accompanying scoring rubric were created and vetted by subject area experts, the test can be considered to have content validity. Appropriate
statistical tests were used to analyze the data. These tests are described in a subsequent section and the results reported in Chapter Four. Thus the investigation meets two of the three criteria; however the variability of attrition rates among groups is the cause for some concern. Rates of attrition varied considerably among the groups as depicted in Table 3.3. The attrition rate for the CZ group was a mere 2%, while the TWZ and TWC groups achieved rates of 10% and 16% respectively.

Absentee rates were not available at the school or district level. However an official with 34 years of experience in the district confirmed that the attrition rates reported above roughly correspond to what he estimated to be the rates of mobility\textsuperscript{16} at the participating schools. Although the participating district does not formally track or report school mobility rates, the official stated that the school assigned to the CZ group has a highly stable school population (which could, in part, account for the group’s low attrition rate) while the school assigned to the TWZ group has a higher mobility rate. The school assigned to the TWC group has a higher rate still as that school draws students from numerous housing projects which are typically associated with high mobility rates.

**Procedures**

Data collection took place in the fall of 2008 and spanned a total of seven weeks. Table 3.4 identifies the research-related activities that took place during the data collection phase.

\textsuperscript{16} “Mobility rate” is a measure of the number of students that transfer in and out of a school within a given time period.
Table 3.3

Rates of Attrition among Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th># of students pretested</th>
<th># of complete data sets</th>
<th>% of attrition*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWZ</td>
<td>49</td>
<td>41</td>
<td>37</td>
<td>10</td>
</tr>
<tr>
<td>CZ</td>
<td>47</td>
<td>43</td>
<td>42</td>
<td>2</td>
</tr>
<tr>
<td>TWC</td>
<td>62</td>
<td>56</td>
<td>47</td>
<td>16</td>
</tr>
</tbody>
</table>

Note. *Percentage of attrition was based upon the number of students who completed the pre-test, not the total number of students in each group.

Training sessions. During Week 1 two separate three-hour training sessions were held at the zoo for participating teachers: the first session was held for teachers in the CZ group; and the second for teachers in the two TW groups (TWZ and TWC). These latter two groups attended a joint training session as they were to teach the same lesson albeit in different locations and relying on different instructional “texts” (TWZ texts were the animals and signage at the zoo exhibits; TWC texts were non-fiction books on primates).

Teacher training sessions were held to:

1. Obtain informed consent and collect teacher-level data in the form of questionnaires which were filled out by the teachers at the session.
2. Discuss and demonstrate the research protocol.
3. Provide teachers with copies of the appropriate lesson plans and supporting materials (see Appendix C).
### Table 3.4

*Research-Related Activities*

<table>
<thead>
<tr>
<th>Week</th>
<th>Activity</th>
<th>Time on Task</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher-training session</td>
<td>3 hours</td>
<td>Zoo</td>
</tr>
<tr>
<td></td>
<td>Test administrator training</td>
<td>2 hours</td>
<td>Home of one of the test administrators</td>
</tr>
<tr>
<td></td>
<td>session</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Monday: Pre-testing</td>
<td>As needed</td>
<td>Home classrooms</td>
</tr>
<tr>
<td></td>
<td>Tuesday: Instruction</td>
<td>50 minutes</td>
<td>Home classrooms</td>
</tr>
<tr>
<td></td>
<td>Wednesday: Instruction</td>
<td>80 minutes</td>
<td>TWZ &amp; CZ: Zoo</td>
</tr>
<tr>
<td></td>
<td>Thursday: Instruction</td>
<td>60 minutes</td>
<td>Home classrooms</td>
</tr>
<tr>
<td></td>
<td>Friday: Post-testing</td>
<td>As needed</td>
<td>Home classrooms</td>
</tr>
<tr>
<td>3–6</td>
<td>None</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>7</td>
<td>Delayed post-testing</td>
<td>As needed</td>
<td>Home classrooms</td>
</tr>
</tbody>
</table>

4. Give teachers a tour of the related exhibits, or, in the case of the TWC group, allow teachers time to examine the non-fiction books that they would be using in connection with their lesson.

5. Respond to teacher questions.

Although teachers were aware of their assigned treatment conditions, they were asked not to discuss those conditions with their students.
During Week 1 a two-hour training session was held for three test administrators. The test administrators were employed to ensure fidelity to the testing protocol and to minimize the amount of effort required on the part of participating teachers. One test administrator was assigned to each of the three participating schools. All three test administrators were certified or retired teachers with a minimum of 15 years of primary teaching experience.

Prior to being assigned to their respective schools test administrators were surveyed to ascertain whether or not they had close connections to any of the participating teachers, students, or schools. “Close connections” were defined as friendships, family relationships, and/or previous long-term or frequent teaching experiences at the participating schools. None of the test administrators had a close connection to any person or school participating in the investigation; neither had they ever served as a substitute teacher for any of the participating classes. Given these circumstances, test administrators were assigned to their schools based upon the geographic proximity of their homes to the participating schools. School assignment based upon this criterion effectively served the same purpose as random assignment. During the data collection phase of the investigation test administrators refrained from accepting any substitute teaching positions in their assigned classrooms.

The test administrator training session was held to:

1. Describe the investigation to the test administrators.
2. Provide test administrators with directions to their respective schools and testing schedules.
3. Review the testing procedures. (See Appendices A & D).
4. Respond to questions.

**Pre-testing and instruction.** The research protocol required that the students and teachers in each of the three groups devote the same amount of time daily to the investigation during Week 2. On Monday test administrators arrived at each of the schools to administer the pre-test to the students in their home classrooms. Text administrators were asked to follow the same prescribed protocol (See Appendix D). Field notebooks were provided for each of the test administrators so that they could record information and observations related to the testing session and context.

Students were given as much time as needed to complete the tests. If they did not know the answer to a question, students were asked to record a question mark (by asking students to record a question mark for each unknown item the test scorers could ensure that the student had, indeed, read and considered each question). Students were also advised that they had the option of writing “stop” and discontinuing the test if they became overly frustrated or discouraged. In total five students availed themselves of this option at pre-test, writing “stop” before they had completed the 9-item content knowledge section of the test.17 (Four of the five students were assigned to the TWZ group, while the other student was assigned to the TWC group.) These data were not included in the analysis.

Two other students wrote “stop” in response to multiple items in the content knowledge section; however, as both of these students had obviously given consideration to each item, these data were included. When the test administrator remarked about this behavior to the classroom teacher, the latter speculated that the students had likely been

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17 Data provided by students who completed the content knowledge section but wrote “stop” in a subsequent section of the test (either the writing section or the vocabulary section) were included in the analysis.
confused by the standardized tests that they had recently taken. Those tests had the word “stop” printed at the bottom of each section.

When students completed their tests, they raised their hands and remained seated so as not to disturb others who were still taking the test. Test administrators collected the completed tests and provided students with an activity package (consisting of tasks such as drawing, mazes, crossword puzzles, and word searches) which students were given the option of working on. For legal purposes teachers were asked to remain in the classrooms during the testing session. The teachers complied, busying themselves with other tasks while the test administrators explained the instructions to students and supervised the administration of the tests.

On Tuesday teachers were asked to spend a total of 50 minutes instructing their students in two lesson components: 20 minutes were spent on a background knowledge component and an additional 30 minutes were spent on a vocabulary component. On Wednesday students received a total of 80 minutes of comprehension instruction: teachers and students in the two zoo groups visited the related zoo exhibits and observed the animals for 40 minutes; immediately after their time at the exhibits they spent an additional 40 minutes discussing their observations in a zoo classroom.18 In contrast students in the TWC group received their 80 minutes of instruction in their classroom. Rather than observing animals first-hand, these students explored the three researcher-selected non-fiction books.

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18 As per the protocol used in the original investigation, the researcher was on-site at the zoo on the day of students’ zoo visit. The researcher did not instruct students; rather she assisted teachers with admission procedures, liaised with zoo staff, ensured that teachers had all of the necessary materials and information, and observed teachers and students during the course of their visit. The researcher also took field notes for the purpose of better understanding the learning context.
On Thursday participating classes spent a total of 60 minutes on research-related instruction. Students spent 20 minutes writing and completing the comprehension component (if they had not had sufficient time to complete it on the previous day). They spent an additional 20 minutes on an application/extension component, while a final 20 minutes was spent revisiting the background knowledge and vocabulary tasks.

**Post-testing and delayed post-testing.** When administering the post-, and delayed post-test (on Friday of Week 2, and in Week 7, respectively) the test administrators followed the same basic testing protocol as the pre-test with two minor exceptions. First, instead of reading the introductory script, test administrators merely reviewed the testing instructions. Second, in response to concerns expressed by the teachers regarding students feeling discouraged by having to write question marks when they did not know the correct responses, test administrators were instructed to advise students that if they wished, they could merely leave an item blank. When collecting the tests the test administrators scanned the completed pages for blank items and verified with individual students that the students had, in fact, intended to leave certain items blank. Once again students were given as much time as needed to complete the tests.

**Tasks associated with treatment conditions.** Although all three groups spent the same amount of time on each component of their respective lessons, the lesson plan assigned to the TW groups differed qualitatively from the lesson plan assigned to the CZ group. Table 3.5 identifies the specific tasks associated with the treatment conditions, highlighting the differences between those tasks. The two TW groups engaged in strategy-based instruction per the TW framework (Carr, Aldinger, & Patberg, 2004).
Table 3.5

Tasks Associated with Treatment Conditions

<table>
<thead>
<tr>
<th>Lesson Component</th>
<th>TWZ/TWC</th>
<th>CZ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Background Knowledge</strong></td>
<td>Structured Overview (Vacca &amp; Vacca cited in Carr, Aldinger, &amp; Patberg, 2004) and QCR (Carr, Aldinger, &amp; Patberg, 2004)</td>
<td>Students participate in a teacher-led class discussion relating to zoo animals.</td>
</tr>
<tr>
<td><strong>Vocabulary</strong></td>
<td>Concept of a Definition (Schwartz and Raphael, 1985)</td>
<td>Teacher introduces vocabulary words; students write words in sentences.</td>
</tr>
<tr>
<td><strong>Comprehension</strong></td>
<td>Modified Cause/Effect Frame and About Point Writing Response (Carr, Aldinger, &amp; Patberg, 2004)</td>
<td>Students observe animals at the zoo exhibit. After their observation students discuss, draw, and write about what they observed. Students write individual thank-you notes to the Educator Curator of the participating zoo.</td>
</tr>
<tr>
<td><strong>Application/Extension</strong></td>
<td>QCR (Carr, Aldinger, &amp; Patberg, 2004)</td>
<td>Students draw and write about what they found interesting about the zoo exhibits.</td>
</tr>
</tbody>
</table>

Each lesson component featured an evidence-based strategy that was designed to teach students protocols for engaging the cognitive processes that support comprehension. In contrast, instruction for the CZ group was activity-based, which is more reflective of the type of instruction the typical elementary student receives in connection with a field trip to a zoo (M. Magdich, personal communication, October 16, 2007).

**Scoring procedures and inter-rater reliability.** To minimize researcher-related bias, two scorers were employed to score all the tests. The scorers were not informed as to the conditions to which various schools were assigned therefore it is unlikely that there was any bias on their part. Although both scorers worked on the original TZTW study in
the same capacity (scoring tests) and were therefore familiar with the basic scoring procedures, additional measures were taken to train them before they began examining the data set related to the current investigation. The scorers attended a one-hour training session during which completed tests from the original investigation were examined in connection with the scoring rubric. To ensure an acceptable level of agreement between the scorers, 100 post-tests from the original investigation were divided between the two scorers. Each scorer scored her own set of tests independently then re-scored the tests initially provided to the other scorer. Once completed, the entire set of tests was examined on an item-by-item basis and the inter-rater reliability coefficient was calculated for each item. All items achieved an inter-rater reliability coefficient of greater than +.95 on this training round of scoring.

The tests from the current investigation were then divided between the two scorers. As with the data set that was used for training, each scorer scored her set of tests independently before providing them to her partner who re-scored the tests. One hundred percent of the tests were double-scored. Inter-rater reliability coefficients were calculated on each item for the entire data set and are reported in Table 3.6. All items achieved a minimum inter-rater reliability coefficient of +.99.

Data Analysis

Data sources included the pre-, post-, and delayed post-tests taken by students (see Appendix A). Test scores were analyzed using SPSS 16.0 statistical software. As this investigation was concerned with comparing three conditions (TWZ, CZ, and TWC

---

19 The Curator of Education at the Toledo Zoo granted permission for tests in the original study to be used for the purpose of training scorers in the current investigation.
Table 3.6

*Inter-Rater Reliability Coefficients for Testing Items*

<table>
<thead>
<tr>
<th>Item #</th>
<th>Inter-rater reliability coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+ 1.0*</td>
</tr>
<tr>
<td>2</td>
<td>+ .99</td>
</tr>
<tr>
<td>3</td>
<td>+ .98</td>
</tr>
<tr>
<td>4</td>
<td>+ .99</td>
</tr>
<tr>
<td>5</td>
<td>+ 1.0*</td>
</tr>
<tr>
<td>6</td>
<td>+ 1.0</td>
</tr>
<tr>
<td>7</td>
<td>+ 1.0*</td>
</tr>
<tr>
<td>8</td>
<td>+ 1.0*</td>
</tr>
<tr>
<td>9</td>
<td>+ 1.0</td>
</tr>
</tbody>
</table>

*Note.* *All statistics are rounded to two decimal points. Items indicated with an asterisk round to +1.0, however, these items did not achieve perfect inter-rater reliability scores.*

Over time, a repeated measures factorial analysis of variance [RM-ANOVA] was implemented. A mixed RM-ANOVA is based upon four assumptions: (1) data are measured on an interval scale; (2) the data are normally distributed; (3) homogeneity of variance; and (4) sphericity, which can be described as “the equality of variances of the differences between treatment levels” (Field, 2009, p. 459).

In this investigation only complete data sets were analyzed. Thus if a student did not complete all three tests (pre-, post-, and delayed post-), the data for that student were deleted from the analysis. The independent variable, “science achievement,” was measured on an equal interval appearing scale as described in a previous section.
In order to test for the assumption of normality, the values of skewness (a measure of the symmetry of a distribution) and kurtosis (a measure of the peakedness of a distribution) were examined (Field, 2009). Since the sample size in the current investigation was relatively small (126 complete data sets), Tabachnick and Fidell (cited in Meyers, Gamst, & Guarino, 2006) recommended “detecting normality violations by dividing a skewness or kurtosis value by its respective standard effort and evaluating this coefficient with a standard normal table of values (z-scores)” (p. 50). Such scores were calculated for skewness and kurtosis at pre-, post-, and delayed post-test. These z-scores were then compared against “known values for the normal distribution” (Field, p. 139) using the following guidelines: if the absolute value of any z-score exceeded 1.96, then the assumption of normality was deemed violated. It should be noted however that as the students had had no previous instruction related to the science content being tested it was expected that the data would be positively skewed at pre-test only. This situation would be conceptually appropriate for the reason cited above.

Field (2009) further stated that “in terms of violations of the assumption of homogeneity of variance, ANOVA is fairly robust in terms of the error rate when sample sizes are equal” (p. 360). However the sample sizes in this investigation were unequal, therefore the design was unbalanced. As a result it was particularly important to test for the assumption of homogeneity. When conducting a RM-ANOVA, SPSS automatically runs Levene’s Test of Equality of Error Variance which tests the null hypothesis that the error variance of the dependent variable is equal across groups.

The final assumption of sphericity, unique to a RM-ANOVA, was relevant to test because there were more than two points of data from the same participant (Field, 2009).
Since the study design incorporated more than two levels, SPSS automatically ran
Mauchley’s test of sphericity. Mauchley’s test was used to test the hypothesis that the
variances of the differences between conditions are equal. If Mauchley’s test was non-
significant, then it was presumed that the assumption of sphericity was met.

After the assumptions of the RM-ANOVA were tested, an omnibus test was run
for an overall experimental effect (Field, 2009). If significant, the RM-ANOVA statistic
\((F)\) does not indicate which of the groups differ. Consequently, in addition to conducting
an RM-ANOVA, further analysis would be needed to determine wherein lies the
difference. In this investigation, if the overall experimental effect was found to be
statistically significant, pairwise comparisons, with a Sidak adjustment for multiple
comparisons were used to further examine the specific differences in the mean scores of
students in the CZ group with students in the two TW groups.

Limitations

According to Onwuegbuzie (2000), “every single study in the field of education
has threats to internal and external validity” (p. 9). The following discussion identifies
potential threats (and therefore limitations), and describes the researcher’s attempts to
minimize them.

Threats to Internal Validity

“Threats to internal validity are problems that threaten our ability to draw correct
cause-and-effect inferences” (Creswell, 2008, p. 308). These threats can be classified into
three categories: participant-related threats (including history, maturation, regression,
selection bias, and mortality); treatment-related threats (including diffusion of treatments,
compensatory rivalry, and resentful demoralization); and procedural threats (including testing and instrumentation).

**Participant-related threats.** Participant-related threats include: history, maturation, regression, selection bias, mortality, and evaluation anxiety. (Creswell, 2008; Onwuegbuzie, 2000). History refers to phenomena unrelated to the treatment intervention which occur during the course of the investigation and account for changes in the outcome measure. Maturation refers to changes that naturally occur in participants over time and therefore are not the result of the treatment intervention. Neither threat is of major concern with respect to this investigation as the time elapsed between the pre- and post-test was a mere four days and the time elapsed between post- and delayed post-test longer was approximately four weeks. Further, the focus of school-based science instruction during that four-week period was unrelated to the living sciences.

Regression, which is the tendency of participants with extreme scores on initial tests to score closer to the mean on subsequent measures, does not pose a concern since participants were not selected based on extreme scores. Selection bias refers to “substantive differences between two or more of the comparison groups prior to the implementation of the intervention” (Onwuegbuzie, 2000, p. 18). Unfortunately it is a common threat in educational research since intact groups are often assigned to treatment conditions as was the case in this investigation. Although selection bias is of some concern, it was minimized in this investigation by matching the three cohorts of students according to school demographic characteristics, assigning each cohort to a condition in a manner that was weighted against the TWZ group (the group that was hypothesized to outperform the other two groups on the post-, and/or delayed post-test) then pre-testing
students to ensure equivalency between the groups’ mean scores on a measure of the dependent variable.

Mortality, also referred to as “attrition” (Onwuegbuzie, 2000), is a situation that occurs when participants have been selected for an investigation but they fail to take part in all or any of the related activities. Mortality is of some concern to this investigation. Although the data collection phase was kept intentionally short (a mere five weeks from pre-, to delayed post-test), two of the three groups (TWZ and TWC) achieved unexpectedly high mortality (attrition) rates. However, as Onwuegbuzie (2000) observed, “a loss of participants, per se, does not necessarily produce a bias. This bias occurs when participant attrition leads to differences between the groups that cannot be attributed to the intervention” (p. 19). From this perspective mortality was controlled for by the statistical analysis. The mixed RM-ANOVA only analyzed data points from those students who completed all three tests.

Evaluation anxiety refers to anxiety that participants may experience under testing conditions, resulting in poor performance. Evaluation anxiety was minimized as the test administrators made concerted efforts to ensure that the students were made to feel as relaxed and as comfortable as possible during the administration of the tests. (As described in a previous section, students were given the option of writing “stop” and discontinuing the test if they became overly anxious.)

**Treatment-related threats.** Treatment-related threats include: diffusion of treatment, compensatory rivalry, resentful demoralization, and implementation bias. Diffusion of treatments occurs when participants in the control condition learn about the experimental invention from members of the experimental group. This threat is not of
concern since the three groups of students were at different schools and any communication between the groups regarding the treatment during the data collection phase was extremely unlikely. Compensatory rivalry, also known as “the John Henry Effect”, occurs when participants assigned to the control group are aware of their condition and exert extra effort as a result of that knowledge. Resentful demoralization is the reverse. Participants assigned to a control group become discouraged and consequently exert little effort. Neither compensatory rivalry nor resentful demoralization were likely to have occurred in this investigation since participating students were unaware of their assigned treatment conditions.

Implementation bias is a further potential threat to internal validity. Implementation bias occurs when teachers do not follow the prescribed protocol. In this investigation implementation bias was minimized since the researcher provided explicit lesson plans for the teachers to follow and provided all materials required for the implementation of the lessons.

**Procedural threats.** Procedural threats include testing and instrumentation. Testing is a potential threat when the same test is administered multiple times (as was the case in this investigation). Although this threat is of some concern to the internal validity of this study, the pre-, post-, delayed post-test design adopted was deemed preferable to a design which introduced multiple versions of a test and consequently introduced additional threats to internal validity (such as instrumentation). Instrumentation occurs if: different testing instruments are used at pre- and post-test and these instruments are not parallel; scoring procedures change over time; the testing measure(s) “does not generate reliable scores” (Onwuegbuzie, 2000, p. 17); or scoring is inconsistent. This threat is not
of major concern as: the same instrument was used for all three tests; test administrators administered the tests using the same protocol so as to ensure standardized testing procedures between and among the groups; a standardized scoring rubric was used by scorers; and 100% of the tests were double-scored, achieving the very high levels of inter-rater reliability that were reported in a previous section.

**Researcher bias.** One additional threat to the internal validity of any investigation is that of researcher bias. Researchers, either consciously or subconsciously, can influence participant behavior (Onwuegbuzie, 2000). In this investigation deliberate steps were taken to ensure that any researcher bias was minimized or negated. First, researcher contact with participants was limited intentionally during the data collection phase of the investigation as the researcher did not wish to subconsciously transfer a personal bias to the participants in a manner that could have affected their behavior (p. 21). As a result, the researcher only came into direct contact with students during zoo visits. This contact was very limited since the researcher’s purpose during these visits was to assist with admission and observe teacher-student interactions. Second, test administrators were hired to collect the data. Third, the data were scored by trained scorers. Neither the test administrators nor the scorers were aware of the conditions to which students had been assigned. Although the researcher designed and closely monitored the testing and scoring protocols, she intentionally did not directly participate in data collection or scoring so as not to “contaminate data collection techniques” (p. 21).

**Threats to External Validity**

Threats to external validity may affect a researcher’s ability to generalize the findings of an investigation “to other persons, settings, and past and future situations”
Potential threats to external validity include: population validity; ecological validity; and temporal validity (Onwuegbuzie, 2000).

Population validity refers to “the extent to which findings are generalizable from the sample of individuals on which a study was conducted to the larger target population of individuals, as well as across different subpopulations within the larger target population” (Onwuegbuzie, 2000, p. 31). Ecological validity refers to “the extent to which findings from a study can be generalized across settings, conditions, variables, and contexts” (p.31). These threats are of little concern to the current investigation as the researcher does not intend to generalize beyond the schools in which data were collected. Temporal validity however is relevant to this investigation. Temporal validity “refers to the extent to which research findings can be generalized across time” (p. 32). It is hoped that this study will be replicated and that replications will lend weight to the generalizability of the original findings, or shed new light on the topic under investigation.

According to Onwuegbuzie (2000), threats to internal and external validity can occur at any of three stages in the research process. Specifically threats can occur at the research design and data collection stage, at the data analysis stage, and at the data interpretation stage (pp. 13-14). Although the researcher attempted to minimize such threats at all stages of the investigation (as described above), it is suspected that the results of the investigation were, to some degree, influenced by contextual factors. These factors are discussed in Chapter Five.
Chapter Four

Results

The purpose of this investigation was to compare the science achievement scores of students in three treatment conditions over time. Specifically the study was intended to address the following research question: How do the science achievement scores of students in the TWZ, CZ, and TWC groups compare at pre-, post-, and delayed post-test? This chapter reports the results of the statistical analysis - a mixed RM-ANOVA – that was conducted to answer the research question. First, results of the data screening are reported, followed by the results of the RM-ANOVA.

Tests of Assumptions

Data screening revealed that in this investigation the assumptions of normality, homogeneity of variance, and sphericity were met. Details pertaining to each assumption are discussed next.

Normality

SPSS was used to run descriptive statistics for the data at three points in time: pre-test [1]; post-test [2]; and delayed post-test [3]. Skewness and kurtosis statistics and their respective standard errors were used to compute z-scores, which were compared against known values of the normal distribution. Table 4.1 reports these scores.
Table 4.1

*Skewness and Kurtosis z-scores*

<table>
<thead>
<tr>
<th>Time</th>
<th>S</th>
<th>SE_S</th>
<th>K</th>
<th>SE_K</th>
<th>Z_S</th>
<th>Z_K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.697</td>
<td>0.216</td>
<td>-0.002</td>
<td>0.428</td>
<td>3.227*</td>
<td>-0.005</td>
</tr>
<tr>
<td>2</td>
<td>0.268</td>
<td>0.216</td>
<td>-0.815</td>
<td>0.428</td>
<td>1.241</td>
<td>-1.904</td>
</tr>
<tr>
<td>3</td>
<td>0.024</td>
<td>0.216</td>
<td>-0.522</td>
<td>0.428</td>
<td>0.111</td>
<td>-1.220</td>
</tr>
</tbody>
</table>

*Note.* S = skewness, K = kurtosis, * = p < .01

As seen in Table 4.1, at Time 2 both skewness (Z_S = 1.241, p > .05) and kurtosis (Z_k = -1.904, p > .05) were non-significant. The same held true at Time 3 (Z_S = 0.111, Z_k = -1.220, p > .05), indicating that the data were normally distributed at both Time 2 and Time 3.

At Time 1 kurtosis was non-significant (Z_k = -0.005, p > .05) however skewness was significant at the .01 level as the absolute value of the z-score exceeded 2.58 (Z_S = 3.227, p < .01). Thus at Time 1 the data were not normally distributed, but positively skewed as predicted.

**Homogeneity of Variance**

The Levene’s Test of Equality of Error Variance to test for the assumption of homogeneity of variance was not significant at Times 1 (F = 0.178, p = 0.837), 2 (F = 0.02, p = 0.98), and 3 (F = 0.147, p = 0.863). Thus the assumption of homogeneity of variance was met at all points in time, meaning that observed non-normality at Time 1 was not serious.
Sphericity

Mauchley’s Test of Sphericity was not significant (Mauchley’s W = .986, 
p=.418), indicating that sphericity could be assumed.

Repeated Measures Analysis of Variance Results

Omnibus Results

The significant effect of interest was the Time x Group interaction effect. If found 
significant it would mean that the TWZ (n = 37), CZ (n = 42), and TWC (n = 47) school 
groups performed differently across the three time periods. Table 4.2 reports the means 
and standard deviations for each group at Times 1, 2, and 3. Table 4.3 reports the 
omnibus results from the mixed RM-ANOVA.

As seen in Table 4.3, there was a statistically significant Time x Group interaction 
effect, \( F(4, 246) = 3.47, (p=.009) \). These statistics indicate that students in the three 
groups performed statistically significantly differently over time. Approximately 3% of 
the change in science achievement scores can be attributed to the interaction between 
time and group (\( \eta^2 = .03 \)).

Post Hoc Analysis

Pairwise comparisons (with a Sidak adjustment for multiple comparisons) were 
used to further examine specific differences among the mean scores of students in the 
three groups over time. Table 4.4 reports the results of the pairwise comparisons, while 
Figure 4.1 is a graphic representation of the data over time.
Table 4.2

*Means and Standard Deviations of School Groups over Time*

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>TWZ</td>
<td>4.57</td>
<td>8.35</td>
<td>11.16</td>
<td>4.33</td>
<td>6.03</td>
<td>5.10</td>
</tr>
<tr>
<td>CZ</td>
<td>5.36</td>
<td>8.38</td>
<td>11.74</td>
<td>4.41</td>
<td>5.86</td>
<td>4.89</td>
</tr>
<tr>
<td>TWC</td>
<td>6.45</td>
<td>12.94</td>
<td>14.13</td>
<td>4.64</td>
<td>6.15</td>
<td>4.94</td>
</tr>
</tbody>
</table>

Table 4.3

*Repeated Measures Analysis of Variance for Science Achievement Scores over Time*

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time x Group</td>
<td>150.99</td>
<td>4</td>
<td>37.75</td>
<td>3.47*</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note. * = p < .01
Table 4.4

*Pairwise Comparisons between Groups over Time*

<table>
<thead>
<tr>
<th>Time</th>
<th>(I) Group</th>
<th>(J) Group</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TWZ</td>
<td>TWC</td>
<td>-1.88</td>
<td>.98</td>
</tr>
<tr>
<td></td>
<td>TWZ</td>
<td>CZ</td>
<td>-0.79</td>
<td>.82</td>
</tr>
<tr>
<td></td>
<td>TWC</td>
<td>CZ</td>
<td>1.09</td>
<td>.58</td>
</tr>
<tr>
<td>2</td>
<td>TWZ</td>
<td>TWC</td>
<td>-4.59**</td>
<td>1.32</td>
</tr>
<tr>
<td></td>
<td>TWZ</td>
<td>CZ</td>
<td>-0.03</td>
<td>1.36</td>
</tr>
<tr>
<td></td>
<td>TWC</td>
<td>CZ</td>
<td>4.56**</td>
<td>1.28</td>
</tr>
<tr>
<td>3</td>
<td>TWZ</td>
<td>TWC</td>
<td>-2.97*</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>TWZ</td>
<td>CZ</td>
<td>-0.58</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>TWC</td>
<td>CZ</td>
<td>2.39</td>
<td>1.06</td>
</tr>
</tbody>
</table>

*Note.* * = p < .05, ** = p < .01. Sidak adjustment made for multiple comparisons

All groups were statistically similar at Time 1 (p> .05) with respect to science achievement. However at Time 2 the TWC group’s mean science achievement score was significantly higher than the mean scores of students in the CZ group (p = .002) and the TWZ group (p = .002). The scores of these latter two groups did not differ (p = 1.0).

The TWC group also outperformed the TWZ group at Time 3 (p = .023). However the mean score of the CZ group, which fell between the mean scores of the other two groups at Time 3, did not statistically significantly differ from the scores of either of the other two groups.
Figure 4.1: Estimated Marginal Means

**Conclusion**

Although these results reflect seemingly modest changes in scores over time, they are nonetheless both statistically significant and practically important. Instructional time is a limited and precious commodity. Educators should be alert to any instructional practices that have the potential to improve student achievement. In the next chapter these results are compared to the findings of the original TZTW investigation and interpreted in light of contextual factors which may have contributed to the outcome.
Chapter Five
Summary, Conclusions, Implications, and Recommendations

Summary of the Study

At present students in the U.S. are failing to meet national standards for scientific proficiency (National Assessment for Educational Progress, n.d.) and lag behind their global counterparts with respect to scientific literacy skills (OECD, 2007). Urban students in particular struggle with science. These children - many of whom are members of cultural and/or linguistic minority groups (Hannaway, 2005) - can be considered less privileged than their suburban peers as early language experiences often do not prepare urban students for success in content area school subjects (Chall, Jacobs, & Baldwin, 1990; Gee, 2004). This situation poses a potential threat to the nation as the security and prosperity of the U.S. depend, to a great degree, upon the scientific proficiency of its populace (NRC, 2005).

In an effort to increase U.S. students’ proficiency in the area of science, recent reform documents (see National Academy of Sciences, 1996; NRC, 2005, 2007) have stressed the need for inquiry-based science instruction, which emphasizes active engagement with scientific concepts over the mere transmission of knowledge. One particularly powerful way to promote the scientific literacy skills of students is to integrate inquiry-based science instruction with literacy instruction (Hapgood & Palinscar, 2006/2007). Such integrated instruction is consistent with the nature of
authentic scientific practices which rely heavily on reading and writing as tools for the construction and dissemination of scientific knowledge (Palinscar & Magnusson, 2001; Phillips & Norris, 2009). Further, this type of integrated instruction has the potential to substantially increase the amount of time that is currently devoted to science in U.S. elementary classrooms.

A number of researchers have reported the success of integrated science and literacy instructional models in increasing the science achievement of urban students (Hapgood & Palinscar, 2006/2007; Kenny, Carr, & Magdich, 2009; Palinscar & Magnusson, 2001; Rosebery, Warren, & Conant, 1992). The TZTW lessons are one such model. These lessons combine instruction related to the use of reading comprehension strategies with inquiry-based observation situated at the Toledo Zoo. Such partnerships, between schools and ILEs, are endorsed by the National Academy of Sciences (1996).

In the 2006/2007 TZTW Project reported by Kenny, Carr, & Magdich (2009), the effect of the TZTW lessons on elementary student achievement in the content area of science was examined. As described in previous chapters, the science achievement scores of students in a TW condition were compared against the scores of students in a comparison condition. Children in the former group statistically significantly outperformed their peers in the latter group for five of the six lessons examined. The Primates lesson however failed to produce statistically significant results. Further, the original TZTW investigation did not attempt to tease out the effects of the zoo environment on student learning.

The current study was in part a replication of the original TZTW Project as well as an extension of it. This investigation was undertaken to compare the science
achievement scores of third grade students in three treatment conditions (TWZ, CZ, and TWC) at three points in time (pre-, post-, and delayed post-test). These treatment conditions were thoughtfully engineered so as to generate results that would better inform current understandings of integrated, inquiry-based instructional models and the educative role of zoo environments in science education. Not only does the current investigation compare the science achievement scores of students in the TWZ group with those of students in the CZ group as per the original TZTW study, but the scores of both of the aforementioned groups are also compared with the scores of students in the TWC group.

The results of the current investigation were reported succinctly in the previous chapter. An informed interpretation of those findings however requires a far more nuanced scrutiny of both the results and the contextual factors which likely contributed to the outcome. This chapter includes such an examination as well as a discussion of the study’s implications for classroom instruction and future research.

**Discussion of the Findings and Directions for Future Research**

This section summarizes the findings of the current investigation with respect to the research hypothesis, which was informed by the results of the original TZTW study. These findings are subsequently examined in light of contextual factors that likely contributed to the outcome of the current investigation. The performance of each group is then examined in relation to the performance of the other two groups so as to discern how to most appropriately interpret the results and how these results can contribute to extant bodies of knowledge related to science and literacy instruction, and learning in zoo
environments. Embedded within this discussion are recommended directions for future research.

**Research Hypothesis and Summary of Results**

Table 5.1 summarizes the rationale for the research hypothesis, the anticipated results, and the actual results of the current investigation. As indicated the statistical analysis revealed that students in all three conditions (TWZ, CZ, and TWC) performed the same at pre-test, and improved from pre- to post-test. These findings are consistent with the research hypothesis. However, additional findings are both unexpected and enlightening.

It should be noted that researchers in the original TZTW investigation conjectured that the results of the Primates lesson may have been confounded by contextual factors. Specifically Kenny (2009) reported that some students in the TW condition had been unable to access the primates exhibit due to weather conditions. Further, Kenny, Carr, & Magdich (2009) speculated that students may have been suffering from testing fatigue. As a result of these speculations, the results of the Primates lesson (which were inconsistent with the results of the remaining TZTW lessons) were discounted in forming the research hypothesis. Instead, the researcher primarily took into account the results generated by the remaining five TZTW lessons, which did in fact produce statistically significant results and demonstrated similar patterns over time.

It was hypothesized that students in the two TW groups would maintain gains from post- to delayed post-test, while the scores of the CZ group would decrease from post- to delayed post-test. These trends were observed with respect to the majority of the
### Table 5.1

*Research Hypothesis and Results*

<table>
<thead>
<tr>
<th>Rationale for Research Hypothesis</th>
<th>Anticipated Results</th>
<th>Actual Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups are comparable, and students had not yet received instruction related to primates.</td>
<td>$H_0: \mu_{twz} = \mu_{cz} = \mu_{twc}$ Students in the three groups scored the same at pre-test.</td>
<td>As anticipated.</td>
</tr>
<tr>
<td>Traditional and inquiry-based instruction will increase student achievement.</td>
<td>All groups significantly improved over time from pre- to post-test.</td>
<td>As anticipated.</td>
</tr>
<tr>
<td>In the original TZTW Project, the mean score of the TW group remained the same from post- to delayed post-test for 3 of the 5 lessons that produced significant results. The mean scores of the comparison group decreased for 3 of the 5 lessons (Kenny, Carr, &amp; Magdich, 2009).</td>
<td>Scores of students in the two TW groups maintained gains from post- to delayed post-test. Scores of students in the CZ group decreased from post- to delayed post-test.</td>
<td>Scores of students in all three groups increased from post- to delayed post-test.</td>
</tr>
<tr>
<td>For 5 of the 6 lessons in the TZTW Project, students in the TW group outperformed students in the comparison group at post- and delayed post-test. The situational interest and motivation generated by observations of primates at zoo exhibits resulted in increased science achievement scores for the TWZ group over the TWC group.</td>
<td>At post- and delayed post-test, students in the TWZ group outperformed students in the TWC group, who in turn outperformed students in the CZ group.</td>
<td>The TWC group outperformed the CZ group at post-test. However the TWC and CZ groups performed the same at delayed post-test. The TWZ and CZ groups performed the same at post- and delayed post-test. The TWC group outperformed the TWZ group at post- and delayed post-test.</td>
</tr>
</tbody>
</table>
TZTW lessons that produced statistically significant results in the original investigation. Surprisingly in the current investigation the scores of all three groups increased from post- to delayed post-test.

Since five of the six TZTW lessons produced statistically significant results in favor of the TW group at post- and delayed post-test in the original investigation, it was anticipated that both TW groups in the current investigation would outperform the CZ group in a similar manner. However while the TWC group did outperform the CZ group at post-test, these two groups scored the same at delayed post-test. Further, the TWZ and CZ groups performed the same at both points in time.

Another unexpected result was that students in the TWC group outperformed the TWZ group at post-test, and delayed post-test. It had been anticipated that the situational interest and motivation generated by visiting primates at the zoo exhibits would result in higher science achievement scores for students in the TWZ group. Yet in actual fact the TWC group significantly outperformed the TWZ group at both points in time.

As discussed, many of the aforementioned results were unanticipated. On the surface these results may appear to discount any contribution of a zoo environment to student learning. Such an interpretation however would be misguided given the contextual factors which likely contributed to the outcome of the current investigation. In the next section these factors are examined in detail.

**Relevant contextual factors**

Upon close examination a number of relevant contextual factors emerge which must be taken into account when interpreting the results of this investigation. These
factors can be grouped into two major categories: (1) differences in groups; and (2) level of familiarity of the learning environment.

**Differences in groups.** Although the three school groups selected for participation in this investigation were matched as closely as possible, they nevertheless were intact groups which differed with respect to demographic characteristics, level of teacher experience, and familiarity with the zoo environment.

**Demographic characteristics.** Based on socioeconomic factors associated with student achievement, the students assigned to the TWZ group (School A) and the TWC group (School C) were less privileged than the students assigned to the CZ group (School B) (see Table 3.1). Administrators at the CZ school reported the lowest percentage of: students receiving free or reduced lunch, minority students, and students eligible for Special Education services. Thus the students at the CZ group can be considered the most privileged with respect to these factors. Of the two TW groups, the TWC group would be considered the least privileged. Administrators at this school reported the highest percentages of students: eligible for free or reduced lunch, of minority status, and eligible for Special Education support.

The within-study attrition rates of the three participating school groups provide further evidence of demographic variability among the groups. As reported in Chapter Three, an official at the participating district affirmed that the within-study attrition rates roughly correspond to the participating schools’ rates of mobility. Just as higher percentages of minority students, students eligible for free or reduced lunch and/or Special Education services correspond with lower student achievement, so too are higher rates of mobility associated with lower student achievement. The within-study attrition
rates of the groups directly correspond to the school demographic information reported above. The attrition rate for the CZ group was a mere 2% (providing further evidence that the students in this group are the most privileged), while the TWZ and TWC groups achieved rates of 10% and 16% respectively (suggesting that the students in the latter group are the least privileged).

**Level of teacher experience.** In addition to being more privileged with respect to socioeconomic factors, students in the CZ group were the most privileged with respect to their teachers’ level of experience. As indicated by Table 3.2, the teachers assigned to the CZ group averaged 23 years of elementary school teaching experience and 14 years of experience at the third grade level. In comparison, the teachers of students in the TWZ group averaged only 10 years of elementary teaching experience and a mere 3 years of third grade teaching experience. The teachers assigned to the TWC group averaged only 9 years of total elementary teaching experience and 5 years of experience at the third grade level. The level of teacher experience was not taken into account when assigning groups however this factor may have had profound effects on the results of the study.

According to Snow (2002), the expertise of teachers “consistently and accurately” predicts student achievement (p. 48). This assertion is supported by Vanderhaar, Munoz, and Rodosky (2006) who reported that “the more average teaching experience of the staff [in urban schools]…the higher the academic achievement test scores” (p. 30). Huang and Moon (2009) however cautioned that total years of teaching experience is not a significant predictor of student reading achievement (p. 209) although they found that “years of teaching experience at a particular grade level was significantly associated with increased student reading achievement” (p. 209).
Through the course of this investigation, no data were collected for the purpose of determining teacher expertise therefore no judgments can be made about the quality of instruction provided to the various groups of students. Nevertheless it is reasonable to speculate that the more experienced teachers in the CZ group would have developed more expertise related to teaching third grade students. Such expertise is likely to have mediated student learning and consequently may have contributed to the CZ group’s higher-than-expected achievement at post- and delayed post-test.

**Familiarity of the zoo environment.** Another important factor to consider when comparing the achievement of students in the CZ and TWZ groups at post- and delayed post-test is the students’ level of familiarity with the zoo environment. As mentioned in Chapter Three, when being assigned to a treatment condition the students in School B (who were subsequently assigned to the CZ group) were considered to be more advantaged with respect to their proximity to the zoo. These students attended a school that was located a mere 0.39 miles from the zoo, much closer than either of the other two schools. This factor was taken into account during school assignment as it was considered probable that the children at School B would have had more exposure to the zoo environment than students at the remaining two schools (see Figure 3.2).

Upon discussion with participating teachers it was found that this situation was indeed the case, however to a much greater degree than had been anticipated. The teachers of students assigned to the CZ group reported that the children at their school were able to walk to the zoo on field trips, and that they did so several times a year every academic year. In addition, the zoo is a feature of the neighborhood. Students likely pass by it on a daily basis and use the adjacent picnic grounds and playground area with
family members and friends. In contrast, the teachers of students assigned to the TWZ group reported that for some of their students this project marked their first ever visit to a zoo. For these students the zoo was a truly novel environment.

According to Lubow, Rifkin, and Alek (1976), “enhancement of learning is achieved when a new stimulus is presented in an old environment or an old stimulus [is presented] in a new environment” (p. 38). Learning is less effective “with conditions of no contrast between stimulus and environmental novelty” (p. 41). For students in two of the three treatment conditions (TWC and CZ) new information was presented in an old environment, providing the contrast that Lubow, Rifkin, and Alek claim is necessary for enhanced learning.

The students in the TWC group received all of their instruction in their home classrooms, a learning environment that is highly familiar to them. Students in the CZ group also received instruction in familiar environments: their home classrooms, and the community zoo. Students in the TWZ group received some instruction in their familiar classroom environment, but new information was also imparted in a new environment – the community zoo. Since many of the children in this group had never visited the zoo before, it is likely that the novelty of the learning environment detracted from their ability to concentrate on the new information that was being taught (Chong et al., 2008; Schwerha, Wiker, & Jaraiedi, 2007).

**Summary.** Quasi-experimental investigations do not generate conclusive results as they are prone to selection bias. Prior to any treatment intervention pre-existing groups may differ in a manner that influences the outcome measure. This situation appears to be

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20 TWC students’ familiarity with the zoo environment is not relevant to this investigation as these students did not visit the zoo in connection with their treatment condition.
the case in the current investigation. Despite the best efforts of the participating school
district and the researcher, the intact school groups that were assigned to the treatment
conditions differed in the following ways with respect to three important factors
(demographic characteristics, level of teacher experience, and level of familiarity with the
zoo environment):

- Students in the CZ group are the most privileged with respect to all three factors.
- Students in the TWZ group are less privileged than those in the CZ group with
  respect to all three factors.
- Students in the TWC group are the least privileged with respect to demographic
  characteristics and level of teacher experience.

Consequently the results of this investigation cannot be interpreted in terms of an
“apples to apples” comparison. Instead the results must be examined in light of the
aforementioned contextual factors which likely mediated the outcome. In the next
section, pairwise comparisons are examined and summarized in light of these contextual
factors for the purpose of discerning what the findings of this investigation can contribute
to extant bodies of knowledge.

**Pairwise Comparisons**

**TWZ and CZ groups.** The inclusion of the TWZ and CZ groups was an attempt
to replicate the treatment conditions in the original 2006/2007 TZTW study. In that study
the Primates lesson was the only one of the six lessons which failed to detect a
statistically significant difference between the science achievement scores of the two
groups at post- or delayed post-test. Researchers speculated that this outcome was
confounded by contextual factors including weather-related problems and testing fatigue
on the part of the students. Consequently the validity of the results related to the Primates lesson was called into question.

It was anticipated that in the current investigation students in the TWZ group would outperform students in the CZ group at post- and delayed post-test: a pattern that was consistent in the five TZTW lessons that produced statistically significant results in the original study. Unexpectedly, in the current investigation there was no statistically significant difference between the TWZ and the CZ groups at post- or delayed post-test. Although a surface-level examination of these findings may discount the effectiveness of the Primates lesson in promoting increased science achievement, a more nuanced examination of the results suggests otherwise.

As stated in a previous section, students in the CZ group were more privileged with respect to three factors that likely mediated the outcome measure. These factors include: differences in the groups, level of teacher experience, and familiarity with the zoo environment. Students in the CZ group were more privileged with respect to socioeconomic factors that are associated with student achievement. Further, their teachers were substantially more experienced at the 3rd grade level and the students themselves were highly familiar with the zoo as a learning environment. When viewed together these factors appear to privilege this group over the TWZ group with respect to this investigation.

The current study was intended to examine the effectiveness of the Primates lesson in promoting the increased science achievement of elementary students. If that lesson was equally or less effective than the comparison group lesson then it would be presumed that the CZ group would have statistically significantly outperformed students
in the TWZ group. After all, the former group was more advantaged than the latter with respect to all factors identified as relevant to this investigation. Yet such was not the case. Despite being less privileged socioeconomically, having less experienced teachers, and being unfamiliar with the zoo environment, the students in the TWZ group performed on a level that was on par with their more advantaged peers both at post- and delayed post-test. This situation argues for the efficacy of the Primates lesson in promoting increased science achievement as compared to a more traditional science lesson. A comparison of the scores of the TWC and CZ groups also argues for such an interpretation as is described below.

**TWC and CZ groups.** As discussed in a previous section, the TWC group was the least privileged of the three groups with respect to socioeconomic characteristics. The teachers assigned to this group were also less experienced than the teachers of the students in the CZ group. In addition, unlike the students in the CZ group, the students in the TWC group did not have the advantage of visiting the animals in the zoo environment – an event that likely would have increased their situational interest in the topic (Henson, 2008; Mallapur, Waran, & Sinha, 2008; Paris & Hapgood, 2002; Wickless et al., 2003), potentially leading to increased motivation to learn (Guthrie & Knowles, 2001; Kenny, 2009) and contributing to their increased science achievement (Guthrie & Wigfield, 2000).

Like the TWZ group, the TWC group can be considered less privileged than the CZ group with respect to important factors that are likely to have contributed to science achievement scores. Yet despite being disadvantaged with respect to these factors, the students in the TWC group statistically significantly outperformed their peers in the CZ
at post-test. (The two groups performed the same at delayed post-test.) These findings are further evidence to suggest that the Primates lesson in conjunction with a visit to a community zoo is effective in promoting the increased science achievement of elementary students.

**TWZ and TWC groups.** Perhaps most surprising of all of the pairwise comparisons were the scores of the TWZ group as compared to the TWC group. As discussed previously, it was anticipated that the TWZ group would statistically significantly outperform the TWC group at post- and delayed post-test. Both of these groups received instruction via the TZTW Primates lesson however only the TWZ group had the opportunity to observe animals in the zoo environment - an event which was expected to generate situational interest, which would increase students’ motivation to learn, which would in turn promote increased science achievement scores. The TWC group had opportunities to engage in text-based observations, which were presumed to be both interesting and motivating (though not to the same degree as an actual visit to the zoo).

These two treatment conditions were included in the current investigation in an attempt to sift out the effect of a zoo environment on learning in the content area of science. Unexpectedly the TWC group statistically significantly outperformed the TWZ group at post-test. (The groups performed the same at delayed post-test.) While a surface-level interpretation of these results may suggest that science instruction in a classroom environment is equally, if not more effective than instruction in a zoo environment, such an interpretation is overly simplistic and likely to be erroneous given the contextual factors noted above.
*Learning in zoo environments.* As previously discussed, many of the students in the TWZ group had never visited a zoo before. In such a highly unique environment with uncommon and distinctive sights, sounds, and smells, it is unlikely that the students in the TWZ group would have opted - or even been able - to focus on the lesson content to the same extent as the students in the TWC group who received instruction in their home classrooms. With respect to the study-specific outcome measure the zoo environment likely served to distract student attention from the content of the lesson. This statement is not intended to suggest however that the visit to the zoo was not a valuable and productive learning experience for these children.

According to a participating teacher, the TWZ students’ visit to the zoo was perhaps the highlight of their academic year. Rather than being an isolated event, this experience became a focal point for class discussions throughout the entire year. Children in the TWZ group frequently revisited concepts they had learned in connection with the Primates lesson. In addition the children often framed new knowledge within the context of experiences that they had had during their zoo visit. According to the teacher, “All we heard about all year long was opposable thumbs!” This teacher’s comments suggest that the zoo visit made an important contribution to children’s background knowledge, enabling them to expand existing schema and build new knowledge structures, structures which will serve to support future learning.

*Examining learning outcomes.* Dierking (2002) criticized studies that “rely on paper and pencil instruments, administered to individual children, in a test-like context” (p. 15). She argued that:
Because learning is a series of overlapping and reinforcing experiences over time and place, a meaningful research design includes opportunities to investigate children using the wealth of knowledge and experience they have constructed in all parts of their life. Such research should also provide opportunities for researchers to explore the connections children have constructed among and between these experiences. (pp. 15-16)

Given constraints upon the researcher’s time and resources, this investigation did not examine student learning in the manner Dierking described. Instead, the researcher opted to frame the investigation in the “linguistic currency of public policy discourse, that of inferential statistics” which has been found “to be invaluable in persuading school district administrators and other policymakers of the potential value of the instructional sequences developed during design experiments” (Cobb, 2001, p. 462). While the results of this investigation demonstrate that the Primates lesson was effective in increasing students’ content knowledge over time, the outcome measure was not designed to detect other effects of learning in a zoo environment. Yet as Rowe (2002) observed, “we would expect from a sociocultural perspective that what “counts” as learning in any given museum [or zoo] would be quite different from what “counts” as learning in school” (p. 20).

The test used to measure student achievement in this investigation was constructed from a distinctly school-based perspective. It was not intended to discern learning outcomes such as interest and motivation – factors which ultimately may be more important and more predictive of long-term academic and real-world achievement than isolated science achievement scores.
While situational interest and motivation appear to have contributed to the outcome in this investigation as described above, these factors cannot be fully understood given the method of analysis employed in this investigation. Other methods of inquiry would provide different lenses through which to view the contribution of zoos to student learning. Qualitative investigations could tease out and identify relevant learning outcomes other than science achievement, while additional quantitative studies could measure factors such as situational and personal interest and motivation.

Longitudinal studies are also in order to examine the long-term effects of experiences in zoo environments. Two questions that come to mind are as follows: Are early experiences in zoo environments likely to increase urban students’ participation the sciences? Do such experiences affect urban students’ concepts of identity with respect to science? Rennie and McClafferty (cited in Braund & Reiss, 2006) claimed that “the key question is not: do people learn science from a visit to a science centre [or, as in this case, a zoo]? But do science centres [or zoos] help people develop a more positive relationship with science?” (p. 1379). Future investigations will hopefully tackle some of these important and compelling questions.

*Novelty in learning environments.* Another important aspect of the zoo as a learning environment is the degree of novelty that it presents to students. For some children the zoo is an interesting yet not entirely novel learning environment. Many children in the mainstream culture have frequent opportunities to visit zoos as do urban children such as those in the CZ group who live within close proximity to such an attraction. For other urban children however a zoo is a completely unfamiliar and therefore highly novel learning environment (Kenny, 2009). As the literature suggests,
novelty has the potential to stimulate interest and enhance learning, however too much novelty can become a distraction which interferes with learning goals (Chong et al., 2008; Schwerha, Wiker, & Jaraiedi, 2007).

In the original 2006/2007 TZTW Project many of the participating urban students had never visited a zoo before (Kenny, 2009). With multiple visits, however, the students became very focused on the content of the lessons. One teacher observed, “The kids were more focused that they knew that they were looking for certain things….And they were really looking for that, rather than just, ‘Aaaaah, we’re at the zoo!’” (p. 20).

The children in the TWZ group did not have a similar opportunity to acclimate to the zoo environment before being expected to attend to the content of the lesson. Thus the novelty of the learning environment - which may well have contributed substantially to children’s long-term learning by helping them build new schema – likely served as a distracter in the short-term with respect to learning the lesson content. In visiting ILEs such as zoos, teachers should consider the degree to which an environment is familiar to students and adjust learning goals accordingly. Perhaps the most appropriate goal for an initial visit to a zoo is for students to simply investigate the question: What is a zoo?

Learning from texts. While students in the TWZ group engaged in inquiry-based observations at zoo exhibits, students in the TWC group engaged in text-based observations in their classrooms. As this latter group outperformed the other two groups at post-test, it is important to consider the contribution of texts to student learning. Palinscar and Magnusson (2001) reported that some teachers view traditional, non-refutational, expository text as having the potential to stifle instead of promote inquiry as “children might defer to the authority of the text, seeking answers from the text, when, in
fact, the children themselves had a key role to play in working toward explanations” (p. 160). However Kenny (2009) reported that teachers who participated in the 2006/2007 TZTW Project recommended the inclusion of texts in the TZTW lessons, “not to supplant children’s inquiry and discourse, but rather to extend it” (Palinscar & Magnusson, p. 160).

Texts have the advantage of helping children organize knowledge. According to Varelas and Pappas (2006),

Information books offer prototypical explanations and paradigmatic ways of talking about ideas and phenomena. As children are encouraged to interact with these texts, they are offered opportunities to develop both new conceptual entities and ways of seeing a concept, along with wording to express these entities and new ways of talking about them. (p. 214)

Further, as these researchers suggested, “information books may facilitate children’s engagement with the theory level of scientific activity that is needed to complement the data level” (p. 213).

A question that should be considered in the future is not which type of inquiry is more effective (observation-based or text-based), but rather how and to what extent traditional and non-traditional texts can be used to support first-hand learning experiences. Palinscar and Magnusson (2001) reported that their “preliminary data suggest that strategically experienced second-hand [text-based] investigations can have a productive influence on the way children enact and learn from first-hand investigations” (p. 184), yet as Varelas and Pappas (2006) observed, “research on the intersection between learning from text and learning from activity-based, guided-inquiry experiences
in science instruction, in general, is still quite limited” (p. 212). As the results of this investigation highlight, texts can play an important role in supporting student learning in the content area of science. Yet one can speculate that students in both TW conditions would have performed better had they been exposed to multiple forms of inquiry (observation-based and test-based) through the course of the lesson. Hopefully future investigations will examine the degree to which the “integration of text with other modes of experiencing and learning science” (Palinscar & Magnusson, p. 152) can contribute to student learning.

**Summary of pairwise comparisons.** The results of this investigation can be as misleading as they are interesting. Although a superficial review of the findings suggests that the TZTW Primates lesson is not effective in promoting increased science achievement as compared to a traditional lesson, a careful scrutiny of both the data and contextual factors suggests otherwise. Despite being less privileged, the two TW groups performed as well as, or better than, the comparison group at post-test and delayed post-test.

On the surface the results also appear to suggest that classrooms are more effective learning environments than community zoos. However this assertion is at least called into question (if not contradicted) by a participating teacher’s statements as well as the fact that the TWZ students performed well over time despite being tested on information which was taught to them in a new and novel environment - a condition which is associated with decreased learning (Lubow, Rifkin, & Alek, 1976). It is likely that the treatment provided to students in the TWZ condition did not effectively utilize the full potential of the zoo as a learning environment. Students were not given sufficient
time to acclimate to that new environment, hence in the short-term, the sights, sounds, and smells of the zoo likely served to distract students from the content of the lessons. In the long-run however it may be these stimuli which promote the greatest learning over time by providing students with sensory information with which to construct new knowledge structures, promoting situational interest in science (which could in turn become personal interest) and increasing student motivation. Such effects are not measured in this investigation but future studies will hopefully examine the contribution of zoo visits to these and other learning outcomes.

It was also found that science texts were effective in promoting increased science achievement however it is unknown if combining such text-based inquiry with observation-based inquiry would produce additional gains. Future research should also consider the manner in which non-fiction and hybrid texts can be used in combination with other forms of inquiry to support student science learning.

**Student Learning over Time**

Another trend that is worth noting is that the scores of the students in all three treatment conditions increased from post- to delayed post-test. This trend was unexpected since it was not observed in any of the five lessons which produced statistically significant results in the original TZTW investigation. As it appeared across all three groups it is unlikely that this effect was the result of the combination of strategies used in the Primates lesson. It seems more likely that this phenomenon resulted from students’ enhanced interest in the topic of primates.

The lessons that students experienced in the first year of the 2006/2007 TZTW Project concentrated on categories of animals (birds, amphibians, and fish) that were
likely to be familiar to students even if the specific species were uncommon and exotic.

The animals that students encountered in the second year of the project were more unique (exotic cats, primates, and animals of the Savanna). Such uniqueness appears to generate increased student interest (Trainin, Wilson, Wickless, & Brooks, 2005; Tunnicliffe, 1998) – as in the case of the TWZ students who were fascinated by opposable thumbs – which can in turn lead to increased academic achievement over time. Increased interest in primates was noted by participating teachers in the original TZTW investigation as well as by the education curators at the Toledo and the participating zoo. Teachers in the current investigation also commented that their students were particularly fascinated with primate species. Such interest, whether fostered through observation-based inquiry at zoo exhibits or through text-based inquiry in the classroom, may have led to increased motivation amongst the students, which in turn resulted in improved science achievement scores over time.

This assertion may be called into question since the observed trend (an increase from post- to delayed post-test) was not observed in the original TZTW investigation with respect to any of the animals that students encountered in their second year of participation. By that time however the children were beginning to experience testing fatigue (Kenny, Carr, & Magdich, 2009). It appears likely that their interest in these unique animals was tempered by their distaste for the tests that accompanied the units.

Traditionally humans have been fascinated with apes and monkeys, in part because of their human-like features and behavioral patterns as well as their remarkable intelligence. Primates species housed in zoos are often the most active and entertaining of all zoo animals, attracting a great deal of attention, particularly from children (M.
Magdich, personal communication, October 16, 2007). Future research is needed, however, to determine the extent of that interest, and how such interest can be capitalized on to plan for instruction that best supports student learning.

**Supporting student learning with technology**

A final consideration with respect to this investigation is the role of technology in supporting student learning. Many children in the U.S. do not have a zoo in their community and consequently would not have opportunities to engage in observation-based inquiry at zoo exhibits. Although two-dimensional representations of animals cannot speak to students in the same way that a first-hand experience at a zoo would, videos and webcams nevertheless have the potential to enrich instruction by providing students with opportunities for classroom-based animal observation.

At the outset of this investigation alternate means of animal viewing (via video and/or webcam) were explored for the classroom-based group for the purpose of supplementing the texts that were used. It was found that existing resources offered little to support student learning. The researcher contacted the participating school district, the local public library system, the Ohio Link University Library system, and the educational library at the Toledo Zoo. The participating zoo did not have a library per se; however the education department did have a substantial collection of educational videos that were also available for use in this investigation. From these sources, nine videos were identified as being relevant to primates and were previewed. Of the nine, only one was deemed appropriate for primary students viewing in that is was (a) primary grade friendly; and (b) provided extended viewing of primates. Unfortunately even this video lacked a public performance license, and when shown to the Education Curator at the
participating zoo, the researcher was informed that that particular series was not highly regarded in the zoo community as the commentator was known to disseminate inaccurate information. The paucity of appropriate video materials is disappointing as teachers tend to be comfortable and familiar with the related technology and likely would avail themselves of such resources were they obtainable and appropriate to the grade level.

Web-cams of primates were also researched and information related to two sites were provided to the teachers in the TWC group, but none of the teachers reported making use of them during the course of the investigation. Although such technologies have tremendous potential for extending the reach of the classroom, when the researcher visited these sites several times during the course of the investigation, they afforded poor viewing for primary-age students. The animals were typically not active (or not active within the range of the camera), and camera positions often made it difficult even to detect the animals in their zoo habitat. It is highly unlikely that using these sites would have contributed in a meaningful way to the classroom discourse. In fact the opposite is true. Had teachers and students invested time and effort attempting to view the animals in this manner, it is likely that the experience would have led to frustration and disappointment.

Like many cultural institutions, zoos are investing in current technologies to extend their reach and generate interest in their institutions and the animals which they house. Such practices are laudable; however merely making videos and/or webcams available to the public is an unsatisfactory goal. Zoos should be thoughtful and deliberate with respect to the manner in which they invest their time and resources. Given the educational mission at such institutions, zoos should consider creating resources
specifically for the school-age audience. Children are particularly interested in animals, and this interest could be fostered with appropriate resources that make classroom-based animal viewing possible and meaningful.

**Conclusion**

Like many investigations, this study yielded as many questions as answers. Happily, all three treatment conditions were effective in promoting increased science achievement. It was initially surprising however that the Primates lesson situated in a zoo environment did not produce statistically significant gains as compared to a comparison group, nor did zoo-based instruction promote increased gains over classroom-based instruction. Yet when viewed in light of relevant contextual factors these results appear to support the efficacy of both the Primates lesson and learning in zoo environments as argued above.

Current ideas about science instruction and goals for science achievement are different from those in the past. Unlike the students of previous generations, today’s students are required to do more than memorize content. They are expected to understand the nature of scientific knowledge and apply that knowledge within the context of authentic scientific practices. This investigation began as an attempt to examine the THTW Primates lesson as a viable means of promoting increased science achievement of urban, primary-age students. Given the current emphasis on inquiry-based science instruction, the Primates lesson provides a vehicle through which teachers can increase instructional time devoted to science by engaging students in authentic observation-based inquiry. This lesson (in combination with the remainder of the THTW lessons) represents
an integrated model of science and literacy instruction that capitalizes on the educative potential of community zoos. In addition to supporting student learning, the TZTW lessons support teacher learning by equipping educators with the background knowledge they need to effectively teach lesson content to primary-age students. Further, the model provides a supportive framework (the TW framework) through which teachers can develop their own expertise related to comprehension strategy instruction.

The comprehension of scientific concepts and texts in the content area of science is particularly challenging for less privileged urban students who often have not had the benefit of the types of life and language experiences that support academic success. This situation is untenable, both for the students themselves and for the nation as a whole. Today’s students face a world in which science is becoming increasingly important to their daily lives. Full and informed participation in modern society requires a much higher level of scientific literacy than in the past, and to be scientifically illiterate is to risk being marginalized by that society (Bereiter, Scardamalia, Cassells, & Hewitt, 1997). As Goldenberg (2004) observed, education is, in essence, a matter of social justice. It is a moral imperative for teachers to strive to provide the best possible science instruction to less privileged urban children so as to enable them to gain access to the benefits of full participation in modern society. Society also benefits from maximally-effective instruction as these students have the potential to make substantial contributions to future scientific knowledge. Such knowledge may well contribute to the safety and prosperity of the nation.

Children make meaning from personal life experiences. Rich environments such as community zoos and other ILEs provide a host of sensory information that can expand
and enrich children’s schema, enabling them to construct more complete and accurate understandings of academic vocabulary and concepts. As evidenced by a participating teacher’s comments, for students in the TWZ group their visit to the zoo was not an isolated episode. It was an important, meaningful event that promoted students’ short-term learning, but more importantly provided a shared experience for the children to visit and re-visit in the classroom, offering repeated opportunities from which to construct additional meanings.

As this investigation demonstrates, however, learning is a highly complex phenomenon that is influenced by many factors including the lesson materials, the level of teacher expertise, and the familiarity of a given learning environment as well as students’ situational interest and level of motivation. While the current study serves to highlight the fact that zoos and school districts can effectively partner to provide enhanced science instruction for elementary students, a wide variety of variables must be considered when implementing such instruction. For example in novel environments, educators would be wise to adjust their curricular goals so as to afford students with opportunities to make sense of and acclimate to that environment.

The sights, sounds, and smells of a zoo provide excellent fodder for educative experiences provided children have ample time and opportunity to process the information and reflect upon it. Attempts to construct meaning from an experience are not confined to the experience itself. As Dierking (2002) observed, "all learning is a cumulative, long-term process, a process of making meaning and finding connections among a variety of learning experiences. What we know about any particular topic is the accumulated understanding constructed from a wide variety of sources" (p. 13).
Post-event classroom discussions and experiences (both formal and informal) may provide excellent forums for exploring information and concepts and continuing to construct meaning from a unique experience. It is unreasonable and undesirable to expect children encountering new stimuli in a novel environment to be able to block out the interesting and stimulating sights, sounds, and smells, and to focus exclusively on teacher-directed content.

In planning for instruction teachers should also carefully consider how student interest can promote learning. Visits to zoos and other ILEs have enormous potential to generate situational interest and consequently promote personal interest in a topic. It appears that the children in the TWZ group developed a personal interest in the specific topic of opposable digits, if not in the general topic of primates. That interest likely served to promote increased learning in the long-term.

Another important consideration for planning science instruction is the integration of first-hand experiences with texts. Although both TW conditions were effective in promoting student learning over time, the students in the TWC group outperformed the students in the TWZ group at post-test (although by delayed post-test there was no difference between the groups). It is possible that the texts that were used helped students to better organize their knowledge. If such texts were used in combination with zoo visits, the results may be very powerful indeed.

Siegler (2001) claimed that “the [current] emphasis on hands-on learning is appealing and the results are promising…however we need evidence that hands-on learning is worth the extra time and effort that would be required for teachers in the
classroom to adopt the approach” (pp. 198-199). Although the results of this investigation do not constitute hard evidence which indisputably proves the educative value of field trips to zoos, this investigation demonstrates that additional research in this area is greatly needed. According to Falk (2002), "when museums [or zoos] succeed…it is because of the contributions they make to deepening, expanding and enhancing children's understanding and appreciation of the world; but these outcomes are cumulative, long term, and not easily teased out of the fabric of children's lives" (p. xii). Nevertheless, it is hoped that future research will attempt to do exactly that.
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Appendix A

“How to Rate a Primate”
Differences between Apes and Monkeys

Student Number: __________   School: __________________________________________

1. Apes and monkeys are higher order primates. Name two species of apes and two species of monkeys.

<table>
<thead>
<tr>
<th>Apes</th>
<th>Monkeys</th>
</tr>
</thead>
<tbody>
<tr>
<td>__________________________</td>
<td>____________________________</td>
</tr>
<tr>
<td>__________________________</td>
<td>____________________________</td>
</tr>
</tbody>
</table>

2. Name three ways primates communicate with each other.

   • ________________________________
   • ________________________________
   • ________________________________

3. Name a primate and identify three body features that help it survive. Next to each feature, describe how the feature helps the primate survive.

<table>
<thead>
<tr>
<th>Primate</th>
<th>Body feature</th>
<th>How feature helps survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>________</td>
<td>--------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>________</td>
<td>--------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>________</td>
<td>--------------</td>
<td>----------------------------</td>
</tr>
</tbody>
</table>
4. Compare two body features that are **different** in an ape and monkey.

<table>
<thead>
<tr>
<th>Ape body feature</th>
<th>Monkey body feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apes have ________, but monkeys have __________.</td>
<td>Apes have ________, but monkeys have __________.</td>
</tr>
</tbody>
</table>

5. Primates move in different ways that are suitable to its habitat. Name a primate that moves in each of the ways listed below. Then describe the special features of its arms and legs that allow it to move that way.

<table>
<thead>
<tr>
<th>Ways of moving</th>
<th>Primate</th>
<th>Special features of arms and legs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadrapedalism</td>
<td>________</td>
<td>→ ______________________________</td>
</tr>
<tr>
<td>Bipedalism</td>
<td>________</td>
<td>→ ______________________________</td>
</tr>
<tr>
<td>Brachiation</td>
<td>________</td>
<td>→ ______________________________</td>
</tr>
</tbody>
</table>

6. Explain why different primate species can all find food in the same habitat.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

7. Give one example of why apes are considered intelligent animals.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
8. Describe three ways in which apes are similar to humans.

Apes and humans both ______________________________________________________.

Apes and humans both ______________________________________________________.

Apes and humans both ______________________________________________________.

9. Most primates live in the Rain Forest but some are becoming endangered because of human actions. Describe one human action that endangers primates and tell what humans can do to solve that problem.

<table>
<thead>
<tr>
<th>Human action that endangers primates</th>
<th>How humans can solve that problem</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

_________________________ → __________________________________________________________
10. Write a paragraph about an ape or a monkey describing how interesting body features help it survive in its habitat.
Define the following words:

Mammals - ________________________________________________________________
________________________________________________________________________

Primates - ________________________________________________________________
________________________________________________________________________

Frugivore - ________________________________________________________________
________________________________________________________________________

Habitat - __________________________________________________________________
________________________________________________________________________

Opposable thumbs - __________________________________________________________________
________________________________________________________________________

Bipedalism - __________________________________________________________________
________________________________________________________________________

Knucklewalk - __________________________________________________________________
________________________________________________________________________
Brachiating - 


Prehensile - 


Quadrapedalism - 


Prosimians - 


Anthropoidea - 


Appendix B

Primates Scoring Guide

1. Apes and monkeys are higher order primates. Name two species of apes and two species of monkeys. (4 points)
   - One point for each of two correctly identified species of apes. (Apes include: gibbons; gorillas; chimpanzees; bonobos; and orangutans.)
   - One point for each of two correctly identified species of monkeys. (Monkeys include: Diana monkey; De brazza’s monkey; swamp monkey; colobus monkey; Francois monkey; golden-headed tamarin; and marmosets.)
Simang & silver back gorilla are acceptable under Apes.
Accepted for monkeys: baboon, squirrel, lemur, old world, owl, african, lion, spider, ringtail, yellowtail, whitetail, white bellied, snow, spring, & howler. No willow monkey. Gibbons are apes, not monkeys, and cannot be accepted as monkeys.

2. Name three ways primates communicate with each other. (3 pts.)
   - One point for each of three correctly identified means of communication. (ie. Sounds, gestures, body language, facial expressions, touch)
   *Acceptable: one word answers, voice, hand signals, noises, back slapping, grooming, beating the chest, stomping, hugging, eyes, screeching, “say ooh”, yell, yelling, scream, screaming, howl, howling & hoot or hooting (as these are all types of vocalizations). All other non-verbal vocalizations are acceptable.
   *Incorrect: moving, play, wrestle, fists, tails, sign language, mating, , talk the same way, talk a different way, speak language to communicate, talking in different languages, just hands or just feet (the children must indicate an action, ie. Hand gestures, hand movements, stomping feet) to receive one point. “talk in their own way” is NOT acceptable (talk implies language), nor is “the way they act”.

3. Name a primate and identify three body features that help it survive. Next to each feature, describe how the feature helps the primate survive. (7 pts.)
   - One point for primate species.
   - One point for each of three correctly identified body features.
   - One point for each of three correctly identified function which correspond to the stated features.
Acceptable: (Students can get points for a feature and function without listing a primate, if the feature listed is a body feature that is common to all primates.) Thumbs, mouth, hands, feet, fur, knuckles, brain. “Eyes to see” is awarded two points (eyes is the feature, the function of which is “to see”; “legs to walk” is also acceptable, since walking is necessary for primates to find food)
Incorrect: skin to blend in from predators, body or bodies. hard chest so it doesn’t get hurt easily. “Claws”

Reminder: Gibbons are apes, not monkeys, therefore do not have tails.

4. Compare two body features that are different in an ape and monkey. (4 pts.)
   ➢ One point for each of two body features of apes.
   ➢ One point for each of two body features of monkeys that differ from the ape features identified.
*The key concept here is “different.” If children respond with items like “brains” and “no brains”, no points would be given. If a child were to respond with “tails” for monkeys and leave the apes column blank or an item unrelated to tails (ie. “brains”), then the child would only receive one point since they identified a monkey feature that was different from an ape feature. Therefore, responses such as “big nails/small nails”, “big teeth/small teeth”, and “thick fur/thin fur are not acceptable.

“Claws” is not acceptable as a monkey feature.

*In general, we will categorize “apes” as the great apes, and will consider them to be “bigger” than monkeys. So responses such as “bigger bodies/smaller bodies”, or “bigger muscles/smaller muscles” would be acceptable.

* Characteristics of apes: knuckle walk, arms far apart, larger bodies, heavier bodies, no cheek pouches, & no tail.
* Characteristics of monkeys: have tails, cheek pouches, smaller bodies, lighter bodies, arms close together, hands flat while walking. Fatter vs. skinnier not accepted.

If a child states that “apes knucklewalk, but monkeys don’t”, give a point for the “don’t”.

5. Primates move in different ways that are suitable to its habitat. Name a primate that moves in each of the ways listed below. Then describe the special features of its arms and legs that allow it to move that way. (6 pt.)
   ➢ One point for each of three correctly identified primates that move in a given way. (Quadrapedalism: Colubus monkey, Dianna monkey, lori; Bipedalism: humans; Brachiation: gibbon)
   ➢ One point for each of three correctly identified body features that help the primate move. (Quadrapedalism: arms and legs of similar length; Bipedalism: long legs; Brachiation: long arms)

• Quadrapedalism: Apes, gorillas or any primate other than humans acceptable. “four legs” “legs and arms” “walking on four legs” “on all fours” are all acceptable. Not just “walking” or “running”. 

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• Bipedalism: Humans only. Legs help them move accepted. “Run” & “jumping” are not accepted. “Two feet” or “two legs” are acceptable.

Brachiation: Monkeys. NOT gorillas but orangutans are acceptable. Arms that help move is acceptable. Not just swinging from branches or trees (children must indicate that arms are used).

6. Explain why different primate species can all find food in the same habitat. (1 pt.)
   ➢ One point for a reasonable response. (ie. Different primates eat different foods, they eat at different times, get food from different sources)

7. Give one example of why apes are considered intelligent animals. (1 pt.)
   ➢ One point for a reasonable response. (ie. They have a large brain, they communicate, they use tools, they can solve problems)
* Can learn sign language is also acceptable.

8. Describe three ways in which apes are similar to humans. (3 pts.)
   ➢ One point for each of three correctly identified similarities. For example: neither apes nor humans have a tail; they both have forward-facing eyes, opposable thumbs, flat nails, body covered in hair, large brains; they both are able to communicate, use of tools, and solve problems.
Can be liberal in what is accepted, provided they are legitimate similarities. Primarily any body feature: eyes, hands, feet, legs, etc.
Also accepted: give LIVE birth (“give birth” alone is not acceptable), are mammals, intelligent, smart, eat fruits & vegetables, can grasp, have thumbs, warm blooded, have forward-facing eyes.

“Walk on two feet” is not acceptable since only humans use bipedalism as a form of movement.

9. Most primates live in the Rain Forest, but some are becoming endangered because of human actions. Describe one human action that endangers primates and tell what humans can do to solve that problem. (2 pts.)
   ➢ One point for a harmful action (ie. destruction of habitat)
   ➢ One point for a solution to the problem (ie. Stop cutting down the Rain Forest.)
Acceptable:
Hunt, hunting, hunters, shooting, killing, shoot, hunting and killing. Don’t have wild animals as pets. Poaching, pollution, cutting down trees.
For action that can solve the problem: recycling is acceptable, planting trees, etc.

Not acceptable: stop buying guns Things like “guns” are not acceptable and do not imply an “action.” “Stop littering” is not acceptable.
Appendix C

Comparison Group Lesson

**Background Knowledge Strategy:**
Teacher leads the students in a general discussion about apes and monkeys:

- What do students like about apes and monkeys?
- What do students find interesting about apes and monkeys?

(Teachers record student responses on chart paper.)

Students will be informed that they will be observing apes and monkeys on their upcoming visit to the zoo.

**Vocabulary Strategy:**
Teacher introduces the meaning of the vocabulary words. Students use the new words in sentences which they write on their own papers.

**Comprehension Strategy:**
Teacher leads the students in making general observations about the animals at the zoo primate exhibits. In addition, teachers lead the students in completing an informational scavenger hunt related to primates. (The scavenger hunt activity will be created by education staff members at the zoo and designed for third grade students.) Teachers will lead students in a discussion about the items on the scavenger hunt activity.

**Application/Extension Activity**
Students will draw pictures of a primate and write about their picture.

**Writing Activity**
Students will write thank you letters directed to the Curator of Education at the zoo describing what they learned about primates.
Appendix D

Testing Procedures

Instructions to Research Associates

To introduce the testing procedures prior to the pre-test:

1. After you are introduced by the classroom teacher, explain to the students that you are a researcher. Explain that this means that you are trying to figure out the best way to teach children in third grade about animals.

2. Invite students to help you. Explain that they can help by writing down what they know about animals.

3. Demonstrate several sample test questions taken from another unit of study. Model how to think about and respond to a question that is likely to be familiar to most students, then a question that is likely to be unfamiliar to most students.

4. Explain to students that if they have thought about a question, but do not know the answer, they can respond by writing a “?”.

5. Explain that what is important is not how many questions the students answer, but whether or not they thought about their answers and responded to the best of their abilities. Highlight the fact that no one will know how many questions they answered correctly, since they are not even putting their names on the papers.

6. Acknowledge that some of the questions are difficult, but emphasize that students should feel proud of themselves if they do their best. Also, if students are willing to write down what they know now, after their lesson on animals, and once more a few weeks later, you will have a special treat for them to say “thank you” to them for helping with your research.

7. Explain that if any students feel upset or do not want to finish, they do not have to. They can write “STOP” on their paper and turn it in to you. Nothing bad will happen, and no one will be upset with them if they choose to do so.
To administer all tests (pre, post, and delayed-post):

1. Review the instructions noted above.

2. Explain to students that if they are having trouble reading a question, they can raise their hands and you will read the question to them. (You can read a question as many times as students wish, but you must do so verbatim. You cannot elaborate or paraphrase. If students are unsure as to how to respond to any given item, encourage them to think about it and give their best response. Remind students that they can respond with a “?”.

3. Ask the classroom teacher to read out the numbers assigned to the students (for example, “Number 1, John Smith”).

4. Pass out the numbered tests to the correct students as their names are called. If a student is absent, please note that on the appropriately numbered test.

5. Once all students have their tests, read all of the items aloud to them. Instruct students to hand the packages in to you as they are completed.

6. Provide students with as much time as they need to complete the test.

7. When students are finished, they can start work on a self-directed, quiet activity to be provided by the classroom teacher or the researcher.