FACTORS THAT INFLUENCE STUDENT LEARNING DURING A WEEK-LONG ZOO EDUCATION PROGRAM

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ABSTRACT

Zoos have been under attack by animal rights groups for decades. Despite significant reforms to improve animal welfare in accredited zoos and aquariums across North America, and significant participation in animal conservation efforts globally, these attacks persist. If zoos are to continue long-term, they need to establish themselves as community resources. One way that zoos can act as community resources are as resources for science education.

For zoos to establish themselves as educational resources, there first must be evidence that zoos are positively impacting the education of their visitors. To date, however, the published research is limited and the most prominent research claiming to verify the educational impact of zoos has been highly criticized. Most research on zoo education to date has focused on the education of visitors during informal zoo visits. There is even less research regarding formal zoo education programming that typically occurs during school field trips.

Research investigating how current programming designed to help elementary school students learn science through a five-day school field trip would help both zoos and elementary educators understand how students learned, and what impacted learning during participation in this program. The research outlined in this dissertation helps to answer these questions through an investigation of the BIG Zoo Lesson (BZL).

A case study design was used for this research because it provided an appropriate approach to understand a complex situation with several different sets of data. A total of 9 teachers and their 48 students were interviewed both before and after their participation in the BZL and observed during the five school days they spent using a zoo as their classroom. These observations included scripted observations of lessons and activities, and direct observations of selected students during their daily one-hour animal observations. Additionally, students' BZL journals

were digitally scanned, producing 2628 images of student artifacts. From the cross-referenced analysis of this data, several conclusions were made.

First, the BZL facilitated active STEM learning by upper elementary students. Students appeared highly engaged during these learning experiences and appeared to both gain and retain some understanding of the science concepts in these lessons. Second, learning recorded by students through student artifacts during the BZL was retained at greater rates than learning not recorded for upper elementary students. Lastly, proximity to and observation of live animals during the BZL facilitated engagement in learning for upper elementary students. It appeared that this engagement led to greater understanding and retention of conceptual knowledge.

Parent chaperone behavior during daily one-hour observation periods appeared to impact student learning by impacting engagement and on-task behavior during daily one-hour animal observations. The use of activities during daily one-hour animal observations not designed to task students with conducting independent investigations utilizing science practices may have impacted student identification of their own observations as learning. Overall, the design of the BZL provided learning experiences for upper elementary students utilizing live animals and animal artifacts not available to typical elementary teachers. The use of these resources facilitated engaging active learning experiences that positively impacted student learning. The insights from this research can help to improve learning experiences for all BZL participants and inform program design for zoo educational field trips, thereby helping zoos establish themselves as community educational resources.

To My Family

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CHAPTER 1: INTRODUCTION

Overview

Ethical concerns regarding keeping and displaying exotic animals are forcing zoos and aquariums to establish themselves as a resource for the community (Falk *et al.*, 2007; Marino *et al.* 2010; Moss & Esson, 2013; Ballantyne & Packer, 2016). Education is a prominent theme in the mission statements of most zoos (Patrick, 2007). On the other hand, with the implementation of Next Generation Science Standards (NGSS), elementary teachers who typically have very little training in science education find themselves in need of science resources and expertise that their local zoos and aquariums can provide (Collins, 2020). Some educational programs that help zoos accomplish their missions while simultaneously meeting the needs of elementary teachers and students already exist. Recent research has shown their overall potential for benefiting student learning (Jensen, 2014; Jensen *et al.*, 2017; Collins *et al.*, 2020a; Collins *et al.*, 2020b). However, most of the specific factors that underlie their success have yet to be identified and analyzed.

Statement of the Problem

The AZA reported that 5.5 million K-12 students were reached through zoo and aquarium fieldtrips, outreach programs, and educational resources in 2019 (AZA, 2021). This demonstrates a powerful opportunity for zoos to impact the learning of K-12 students. Unfortunately, a severe shortage of research on zoo educational programming provides little understanding of the focus, structure, or effectiveness of these programs. By not understanding the focus, structure, or effectiveness of zoo education programs we cannot build upon our successes or learn from our failures. This research aimed at addressing the problem of this lack of understanding in hopes that zoo education can use what was learned to improve the effectiveness of zoo education.

The lack of evidence that zoos have an educational benefit does little to justify their existence considering ongoing criticism of keeping exotic animals in captivity. Critics of zoos point to a lack of clear evidence that zoos impact on education outweighs welfare concerns of keeping animals in captivity (Jamieson, 2006). The educational impact of zoos on school-age visitors is even more poorly researched, although the few studies that do exist have reported educational benefits in their research (Jensen, 2014; Jensen *et al.*, 2017; Collins *et al.*, 2020a; Collins *et al.*, 2020b). The largest investigation of zoo educational impact on school-age children found that 91% of participants demonstrated a positive change in at least one education, conservation, satisfaction, or enjoyment variable (Jensen, 2014). The author also reported that when zoo visits were supplemented by an educational presentation, scientific learning doubled over that achieved by self-guided visits. Other research, however, has identified even more effective instructional methods.

Collins *et al.* (2020a) found that instructional methods used in zoo education programming significantly affected learning in elementary students. Students who participated in a one-hour educational intervention (EI) program that included hands-on learning prior to their zoo visit demonstrated increased learning compared to student groups that did not receive EI. Students who received EI also were more likely to maintain a constant level of learning compared to control group students, who may have become bored with the traditional zoo curriculum (Collins *et al.*, 2020a). Collins *et al.* (2020b) expanded the use of EI with school groups attending a one-day aquarium visit. Compared to control group students, students who received the EI demonstrated increased knowledge following the aquarium visit as much as six-months after their visit. While these two studies suggest that hands-on learning prior to a zoo visit benefits potential learning and retention, many other factors still need to be investigated.

Research has demonstrated that many factors such as student preparedness, attitudes, and expectations (Davidson *et al.*, 2009; Patrick *et al.*, 2013), teacher preparedness, attitudes, and expectations (Davidson *et al.*, 2009; Scott & Matthews, 2011; Behrendt & Franklin, 2014), program curriculum (Tran, 2007; Randler et al, 2007; Jensen, 2014; Collins *et al.*, 2020a; Collins *et al.*, 2020b), and chaperone attitudes and behavior (Burtnyk & Combs, 2005; Wood, 2010) can influence the educational value of zoo field trips.

While previous research sheds light on potential impacts of the educational value of zoo field trips, significant differences between the programs studied limit the applicability of that previous research with respect to understanding the factors that impact student learning during the BIG Zoo Lesson. Most of that research was conducted both outside of the United States (Davidson *et al.*, 2009; Randler et al, 2007; Patrick *et al.*, 2013; Wood, 2010; Jensen, 2014; Collins *et al.*, 2020a; Collins *et al.*, 2020b) and prior to the development of NGSS (Burtnyk & Combs, 2005; Tran, 2007), which significantly influenced both learning objectives and pedagogy employed in the programs studied. Prior research focused on traditional zoo education activities, including guided tours and presentations by zoo staff, with no evidence of students conducting scientific investigations or using science practices during these programs (Burtnyk & Combs, 2005; Davidson *et al.*, 2009; Tran, 2007; Randler et al, 2007; Patrick *et al.*, 2013; Wood, 2010; Jensen, 2014; Collins *et al.*, 2020a; Collins *et al.*, 2020b). Collins *et al.* (2020b) conducted the only research not focused on traditional single-day school fieldtrips; however, they studied a voluntary five-day summer camp program with participants who both chose to attend and likely had significant interest prior to attending.

The present study aimed to address the problem of existing knowledge gaps in zoo education by observing participants in the BIG Zoo Lesson (BZL), a complex and unique educational program

(BIG Zoo Lesson, 2018) offered to classroom students who may or may not have had prior interest.

Statement of Purpose

The BZL is widely perceived to be a highly effective educational tool by teachers, students, zoo staff, and the zoo industry. However, analyses of the factors that underlie its success are mainly anecdotal, limited in scope, and not available in peer-reviewed format. Despite its dynamic design and industry recognition of its excellence (AZA, 2018), the BZL has never been formally investigated during its more than 20-year existence.

As described in its website (BIG Zoo Lesson, 2018), the primary characteristics of the BZL that set it apart from other programs and make it the ideal choice for the present investigation are as follows:

1. It is designed specifically for middle and upper elementary classes.
2. Student participation is mandatory during five consecutive school days.
3. Its methodology is diverse, including teacher-, student-, and docent-led lessons.
4. Students are "doing science" through daily animal observation and data interpretation.
5. Students, teachers, and parent chaperones all learn together, in sharp contrast to the "recreational" focus of traditional zoo field trips.

The uniqueness of the BZL and the limited applicability of existing research for understanding why the BZL is perceived to be highly successful necessitated a proof-of-concept focus for this research. The improvement of zoo education across the industry begins with understanding how students learn and what factors impact learning in programs like the BZL.

Research Questions

The BIG Zoo Lesson is a unique program having numerous differences compared to traditional zoo education programs. These differences and the general lack of zoo education program research (Jensen 2017; Collins *et al.*, 2019; Collins, 2020) provide justification for the primary investigable research questions:

- How do students learn through participation in the BIG Zoo Lesson?
- What factors may be impacting student learning during their participation in the BIG Zoo Lesson?

Significance of the Study

While zoos desire to make an educational impact on visitors, research is lacking in both the educational impacts of zoos and the factors that impact zoo education. Research investigating the impacts of zoos on formal education is even less well studied than education of non-school-based zoo visitors. To help zoos meet the needs of formal education, we first need to understand the factors that impact student learning during zoo education programs. The BIG Zoo Lesson was chosen as the subject of this research because of its complexity and perceived effectiveness by its stakeholders.

By better understanding the BIG Zoo Lesson and the factors that impact its effectiveness in promoting learning in upper elementary students, we can better understand the elements necessary to design and implement effective educational programming that meets the needs of students and allows zoos to accomplish their educational goals. The complexity of the BIG Zoo Lesson (BZL) and the potential factors that could influence student learning necessitated a research design using diverse methods to better understand this complex process. With knowledge obtained in this research, new zoo education programs that maximize elementary science learning could be developed, and existing programs could be improved.

Delimitations

This study did not address how the BZL affected students' understanding of specific learning objectives. The design of the BZL allowed teachers to build their curriculum for their week at the zoo to meet the needs of their students. While many of the concepts addressed during the BZL were similar between classes, how teachers chose to address these concepts in the design and implementation of the curriculum created too much variation for a pre-test/post-test design to produce meaningful results.

Organization of the Study

In Chapter One, the context of this research has been introduced. The problem and purpose have been stated, and the value of this research has been argued. Delimitations guiding the research design and focus have been identified.

In Chapter Two, relevant literature related to the scope of this research has been reviewed. The interdisciplinary nature of this research necessitated that the review included relevant research in informal education, education, science education, and zoo sciences.

In Chapter Three, the theoretical framework has been presented and the adoption of the mixed-methods case study approach is justified. How each element of the research design was chosen to address specific components key to answering the research questions is presented and justified.

In Chapter Four, the results of this research are presented. These results were organized by the data collection type (student observations, student and teacher interviews, student artifacts, and participant observation journals).

In Chapter Five, the results from different data collection types are discussed to argue how these data relate to each other in the context of the BZL. The implications of how these findings demonstrated student learning through participation in the BZL and how these findings can inform changes to the BZL and other zoo educational programs were also discussed.

CHAPTER 2: LITERATURE REVIEW

Introduction

Zoo education is an understudied field that has, until recently, focused primarily on the education of adult recreational visitors (Collins 2018; Collins *et al.* 2020). There is less research regarding education of elementary age students, and less involving formal elementary science education (Jensen 2014; Jensen 2017; Collins 2018). While recent research has demonstrated the potential for significant learning due to the participation in structured elementary science programs in zoos, we are far from understanding the factors that impact this learning (Jensen 2014; Jensen 2017; Collins 2018). The implications of curriculum and methodology shifts in response to *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC 2012) also contribute to the need for research to better understand zoo education.

Zoos and aquariums are a prominent part of the informal education sector in the United States, with over 175 million visitors annually (AZA 2015). Zoos typically are found in or near large urban communities, where exposure to wildlife is limited (Andersen 2003). Firsthand access to wildlife is especially important to children in urban environments and has been shown to promote positive attitudes toward nature and conservation (Andersen 2003). Despite their proximity to large populations, zoos remain underutilized for their educational potential (Coe 1987; Tunnicliffe 1996; Zareva-Simeonova 2009, Moss and Esson 2013). Adoption of Next Generation Science Standards (NGSS) is causing the informal science education sector to rethink its educational approaches and develop new education programming aligned with these curriculum changes (Falk *et al.* 2014). Rethinking educational programming in response to NGSS provides an opportunity for zoos to redefine their relationship with formal education (Falk *et al.* 2014). However, no evidence was found in published literature that indicated zoos had utilized this opportunity to redefine their relationship with formal education.

Science Education Reform

Science education reform is moving science teaching from textbook-oriented direct instruction to hands-on science inquiry and application (National Research Council, 2012; Mulkerrin & Hill, 2013). Leaders in science education insist that the best way to understand science is for students to spend more time "doing" science (National Research Council, 2012). Calls for reforming science teaching have focused on inquiry-based instruction for decades, yet science teaching has remained largely teacher-driven and textbook-oriented, with little attention given to inquiry (Andersen, 1993; Sappington, 1995; Crawford, 2007; Jones and Eick, 2007; Fifolt & Morgan, 2019). This is especially evident in urban schools in which most of the students are economically disadvantaged and persons of color (Buxton, 2006; Seiler, 2001, Fifolt and Morgan, 2019). Lack of equipment, funding, and inadequate teacher professional development often are blamed for adherence to traditional teaching methods in urban classrooms (Leonard *et al.*, 2011). The stakeholders in these urban schools must recognize that inquiry-based science instruction establishes habits of evidence-based reasoning that can transform schools by teaching students how to think and reason rather than memorize a collection of facts (Leonard *et al.*, 2011; National Research Council, 2012; Fifolt & Morgan, 2019).

In addition to inquiry-based methods, new science standards place more emphasis on integration of math and technology (Rhoton, 2001, NGSS, 2013). This integration is often referred to as STEM (science, technology, engineering, and mathematics) and forms the basis for the most recent reform in science education standards (NGSS, 2013). Integration of math, technology, and engineering into science teaching calls for teachers to serve as facilitators, creating learning environments in which students can engage in problem solving and higher order thinking while both integrating fundamental information and building transformative understanding (Andersen, 1998, NGSS, 2013). Effective STEM learning activities create an environment in which students can develop and demonstrate skills in leadership, collaboration, and communication (Hugh *et al.*, 2006). This change in roles for teachers, combined with the perceived barriers of high stakes testing and accountability, makes implementation of STEM difficult (Johnson, 2012, Berlin and White, 2012). Successful implementation of STEM curriculum and teaching methodology requires a sustained education reform effort (Johnson, 2012). Community and stakeholder involvement are essential for the formation and sustainment of education reform (Zmuda *et al.*, 2004). Past education reform efforts lacking infrastructure and community involvement generally have failed to produce a sustained change (Anderson, 2002). With successful implementation of STEM-based curricula, student skills in problem solving and inquiry, achievement on standardized tests increase significantly, and attitudes towards science improve (Morrison *et al.*, 2015).

Learning Theory of Constructivism

Constructivism has its foundation in the philosophy of John Dewey, who argued that the root of all true learning lies in experiences by learners (Dewey 1938; 1986). Piaget (1952) expanded upon the ideas of Dewey, arguing that individuals learn by reconciling new knowledge gained through experiences with their existing knowledge. As Piaget (1952) described, there are two primary processes for learning, assimilation and accommodation. When first introduced to new knowledge or skills, students assimilate them into their preexisting mental framework (schema). As students apply these newly learned skills while attempting to build connections between concepts over time, they experience both successes and failures, causing them to readdress these conflicts between new and old knowledge. These experiences continue to add information to the preexisting schema, which the student continue to assimilate. The new information may conflict with what the student already "knows" and what their experiences have taught them. They must then reconcile this new knowledge with their existing schema. This process of reconciling newly acquired experiential knowledge with the previous schema causes a new schema to develop in a process referred to as accommodation (Piaget, 1952).

Vygotsky (1978) further expanded upon the ideas of Piaget (1952) and constructivism by accounting for the impact that social interactions have on learning. Vygotsky's theory of social constructivism focuses on the social interactions of learners and how they contribute to the process of learning. Within the theory of social constructivism, Vygotsky (1978) explained how the interaction between the learner and more knowledgeable others can increase the potential learning beyond what the learner could attain on their own. This difference in learning potential is the zone of proximal development. Vygotsky (1978) explained that in any group of learners there will be varying levels of knowledge and proficiency for a given concept or skill. As learners work together to solve problems, they can overcome their own deficiencies by gaining insight or learning from peers who are slightly more advanced in that specific aspect at that time (Eastwell, 2000). This pushes what they can do on their own in the next similar circumstance, increasing their individual abilities incrementally through learning from others (Vygotsky, 1978; Eastwell, 2000).

Scaffolding in Learning

In formal learning, scaffolding is used to move students incrementally through this learning process (Bruner, 1961). Instructors first must understand the students' current level of knowledge and skills, and then design instructional activities to move students through their zone of proximal development (Vygotsky, 1978; Rhodes & Bellamy, 1999). As students assimilate and accommodate this new learning into their existing schema, both their potential for self-attained learning and their new zone of proximal development continue to expand. Proper scaffolding allows instructors to guide students through their zone of proximal development, slowly relinquishing control over learning to the learner (Bruner, 1961; Rhodes & Bellamy, 1999). As learners move through the instructional process and attain greater autonomy, the instructor acts as a facilitator, providing feedback and assistance when necessary to help the learner continue to progress in their understanding of the concept or skill being addressed (Bruner, 1961; Rhodes & Bellamy 1999). Application of the social constructivist theory into teaching in this way still allows learners to construct their own knowledge through their experiences (Piaget, 1952); however, facilitation of these experiences through strategically designed instruction helps learners increase their understanding and skill application much faster than they could do alone (Bruner, 1961; Vygotsky, 1978).

Experiential Learning

Experiential learning is based upon the philosophy of Dewey (1938; 1986), who believed that all genuine education occurs through experiences. Dewey (1938; 1986) argued that not all experiences are equal in their educational impact, and that this needs to be understood so educators facilitate experiences that maximize the learning potential for students. Experiential learning theory developed by Fry & Kolb (1979) expanded upon the philosophy of Dewey, arguing that learning is done through a cycle of experiences and reflections. Learning in the experiential learning model requires a cyclical relationship between concrete experience, reflective observation, abstract conceptualization, and active experimentation (Fry & Kolb, 1979). Removing any one of these components of the cycle will impact the learning impact of the experience and the knowledge and understanding that the learner can gain (Fry & Kolb, 1979).

Active Learning

Active learning is an instructional process that engages students in their own learning (Prince, 2004). During active learning students acquire knowledge by developing skills in analytical thinking and problem solving (Johnson & Malinowski, 2001; Demirci, 2017). These skills are acquired through small group learning activities through which students collect and analyze data to solve authentic problems (Chen & Cheng, 2016). Active learning lessons often are referred to as "hands-on" activities because students can physically touch and examine objects using multiple senses (Johnson & Malinowski, 2001; Miller & Metz, 2014). Active learning requires time for students to think, ask questions, collect, and analyze data, and form their own conclusions. While this learning process is often more time-consuming than passive learning approaches, through which students are the recipients of knowledge rather than the creators of knowledge, when students are given sufficient time active learning often leads to highly engaged students who feel empowered in their own learning (Cochran-Smith & Stern, 2014).

Active learning can take on numerous forms, but the essence of active learning is that the students are thinking critically and purposefully to explore relationships and solve problems creatively (Teixeria-Dias *et al.*, 2005). One method often used in active learning is drawing. Descriptive drawings help students capture information and collect data that helps their conceptual understanding of science concepts (Lin *et al.*, 2017). Lin *et al.* (2017) found that student's comprehension of science concepts improved far more when generating descriptive drawings than through repeated reading, a passive learning strategy. The increased comprehension of science concepts through descriptive drawing is likely due to the complexity of thought and action that occur during the drawing process (Van Meter & Garner, 2005). During the process of developing a descriptive drawing, students are accessing prior knowledge, summarizing new ideas, making strategic decisions while forming their drawings, and self-questioning as they are drawing regarding how well their drawing represents what they are trying to communicate (Van Meter, 2001; Van Meter & Gardner, 2005).

Active learning is a student-centered strategy that has been a focus of recent science education reform (AAAS, 2010). While research has demonstrated that active learning can be an effective strategy for improving both student engagement and comprehension (Freeman *et al.*, 2014), it appears that the actions of teachers can have a significant impact on this student-centered learning. Knight *et al.* (2013) found that higher order learning increased when teachers prompted students to explain their reasoning and peer group discussions. Student learning during student-centered active learning lessons can also be impacted by the actions of learning assistants. Knight *et al.* (2015) found that higher order learning occurred when learning assistants used questioning techniques to assist students during active learning lessons rather than directly answering student questions. While research indicates that student-centered active learning is an effective learning strategy, teachers and learning assistants must understand how their behaviors both prior to and during instruction can influence both student engagement and comprehension (Cooper *et al.*, 2017).

Inquiry Learning

Inquiry learning is a form of active learning that begins with a question that the learner seeks to answer through investigation (NRC, 2000; AAAS, 2009). These investigations include many of the same components as formal scientific investigations. When inquiry learning is used in science learning, it provides both an opportunity to learn science content and to improve the student's scientific literacy (knowledge and understanding of scientific concepts and processes) (Levy *et al.*, 2013; McCormick-Smith & Trundle, 2014; AAAS, 2009; NRC, 2000). By improving their scientific literacy, students understand that science is a way of knowing rather than a collection of facts that have been discovered by "scientists" (AAAS, 2009; NRC, 2012; NGSS, 2013).

Barriers to inquiry-based learning that must be overcome for it to be successfully implemented. Inquiry-based instruction in science requires that teachers have a deep conceptual understanding of the use of scientific practices (NRC, 2012; NGSS, 2013). However, research has demonstrated that this is an issue for many elementary teachers, who have been found to have significant deficits in the conceptual understanding of both science learning and science practices (Smith & Anderson, 1999). Professional development for teachers at both the pre-service and in-service levels is critical to provide teachers with the understanding of science practices and science instruction necessary to design and implement successful inquiry-based lessons (NRC, 2012; Krajcik *et al.*, 2014; Lewis *et al.*, 2014).

Inquiry-based science instruction requires considerable training and practice for students as well. This is particularly important for elementary students, who should not be expected to develop an entire investigation independently (Banchi & Bell, 2008). A strategy for implementing inquiry-based instruction for elementary students would be to use scaffolding to transition students from highly structured and guided inquiry to inquiry that is developed and implemented by students (Bell *et al.*, 2005; Banchi & Bell, 2008, van der Valk & Jong, 2009).

Banchi & Bell (2008) outline the levels of inquiry and how they should be utilized to build student efficacy in inquiry-based learning. The first level of inquiry is *confirmation inquiry*. In confirmation inquiry students are provided with the question and data collection procedure, and the results are known in advance. Confirmation inquiry is useful for teaching students skills used in scientific inquiry (science practices) and for providing practice to promote proficiency with the skills. This form of inquiry is often used in "cookbook" laboratory investigations used to confirm previously learned concepts (Benedis-Grab *et al.*, 2009). This method of inquiry is helpful for reinforcing previously learned concepts and building efficacy with science practices; however, the lack of student involvement in components of the inquiry process is not ideal for developing confident self-guided science learners (NRC, 2012).

Structured inquiry is the next step in the scaffolding of inquiry-based science education (Banchi & Bell, 2008). In structured inquiry students are provided with the question and the data collection procedure; however, the results are unknown, and the conclusions are based upon student analysis of their results. Structured inquiry helps students build data analysis skills while ensuring that the collected data aligns with the research question. Elementary science students often use structured inquiry to build science skills and confidence in science (Banchi & Bell, 2008).

Guided inquiry utilizes a teacher-developed research question to focus the investigation; however, students design and implement their data collection methods, analyze their data, and form conclusions based upon this analysis. Successful use of guided inquiry requires significant student understanding of science practices, including data collection methods appropriate for answering research questions. Guided inquiry promotes student motivation in science investigation because it provides students with the opportunity to use their creativity in designing and conducting their own investigations (Benedis-Grab *et al.*, 2009). Both efficacy in appropriate science practices and sufficient background knowledge are required for successful use of guided inquiry to prevent frustration and disengagement in the inquiry process (Snodgrass *et al.*, 2011). *Open inquiry* is the least guided form of inquiry-based instruction in science (Banchi & Bell, 2008). Successful open inquiry requires efficacy in the development of research questions answerable through scientific investigations. Open inquiry is often frustrating to both students and teachers. Students can become frustrated with the autonomy of their own learning process, particularly when significant effort is put forth with little perceived results by the students (Snodgrass *et al.*, 2011). Teachers also can be frustrated by the open inquiry process, which changes their role in students' learning (van der Valk & Jong, 2009). Teachers must resist becoming overly involved in the students' learning process and allow students to have the intellectual space and autonomy that open inquiry requires (Tomkins & Tunnicliffe, 2001; van der Valk & Jong, 2009).

Next Generation Science Standards

The Next Generation Science Standards (NGSS) are based upon *A Framework for K-12 Science Education: Practices, Cross Cutting Concepts, and Core Ideas* (NRC, 2012). The NGSS is rooted in the concept of three-dimensional learning. Three-dimensional learning refers to the process of science teaching through which the three dimensions - (1) Science and Engineering Practices, (2) Crosscutting Concepts, and (3) Disciplinary Core Ideas - are combined to teach science (NRC, 2012). Each of the dimensions describes foundational ideas about how science curricula should be designed to foster student engagement in developing their understanding of science content. The fundamental shift in the focus of teaching science through three-dimensional learning is that students learn science by doing science rather than by memorizing factual scientific data. To understand how each of these dimensions work together, it is important to understand each of the dimensions on its own.

Science and Engineering Practices

Science and Engineering practices are the behaviors that scientists and engineers engage as professional practice (NRC, 2012). The term practice is emphasized here, because rather than simply being a skill that the students can learn, a practice emphasizes that there is specific knowledge necessary to accomplish the practices of science and engineering. Science practices differ from engineering practices based upon their fundamental goals. The goal of science is to develop a question which can be answered through a well-developed investigation while the goal of engineering is to find a solution for a problem (NRC, 2012). The practices outlined in *A Framework* are as follows:

1. asking questions (for science) and defining problems (for engineering);
2. developing and using models;
3. planning and carrying out investigations;
4. analyzing and interpreting data;
5. using mathematics and computational thinking;
6. constructing explanations (for science) and designing solutions (for engineering);
7. engaging in argument from evidence; and
8. obtaining, evaluating, and communicating information.

In three-dimensional learning, students use these practices in their learning process to develop and build their understanding of natural phenomena. The rationale for engaging students in these practices is multifaceted. First, this approach allows students to construct their own knowledge through experiential learning, combining their background knowledge with new information they gather using science and engineering practices. Second, by developing their own understanding through this process, students gain an appreciation for how scientific knowledge is generated, and an understanding of the rigorous processes involved in the validation of scientific findings. By improving their understanding of science, students' trust in science and scientific findings will increase. Third, building students proficiency and experience with science and engineering practices will better prepare students for careers in STEM fields, an area in which the U.S. workforce is already experiencing a shortage that is only projected to worsen over time (NSB, 2018).

Crosscutting Concepts

Crosscutting concepts are concepts that are common to the four disciplines of science taught in K-12 education: (1) physical sciences, (2) earth and space sciences, (3) life sciences, and (4) engineering, technology, and the applications of science (NRC, 2012). These concepts also provide links between the science disciplines, allowing students to link their understanding of these concepts, further reinforcing their schema into an overall scientific understanding across disciplines. The crosscutting concepts are:

- patterns, similarity, and diversity;
- cause and effect;
- scale, proportion, and quantity;
- systems and system models;
- energy and matter;
- structure and function; and
- stability and change.

Disciplinary Core Ideas

Disciplinary core ideas are the foundational ideas of each of the four scientific disciplines (NRC, 2012). Each idea must meet at least two of the following criteria to be considered as disciplinary core idea:

- have broad importance across multiple sciences or engineering disciplines or be a key organizing concept of a single discipline;
- provide a key tool for understanding or investigating more complex ideas and solving problems;
- relate to interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge; and
- be teachable and learnable over multiple grades at increasing levels of depth and sophistication.

Examples of disciplinary core ideas for life science include:

- LS1: From Molecules to Organisms: Structures and Processes
    - LS1.A: Structure and Function
    - LS1.B: Growth and Development of Organisms
    - LS1.C: Organization for Matter and Energy Flow in Organisms
    - LS1.D: Information Processing
- LS2: Ecosystems: Interactions, Energy, and Dynamics
    - LS2.A: Interdependent Relationships in Ecosystems
    - LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
    - LS2.C: Ecosystem Dynamics, Functioning, and Resilience
    - LS2.D: Social Interactions and Group Behavior

- LS3: Heredity: Inheritance and Variation of Traits
    - LS3.A: Inheritance of Traits
    - LS3.B: Variation of Traits
- LS4: Biological Evolution: Unity and Diversity
    - LS4.A: Evidence of Common Ancestry and Diversity
    - LS4.B: Natural Selection
    - LS4.C: Adaptation
    - LS4.D: Biodiversity and Humans

These core ideas are further subdivided into the sub-ideas to better facilitate the development of performance standards set forth by the Next Generation Science Standards (NGSS) that resulted from *A Framework* (NGSS Lead States, 2013).

Now that there is a clear idea of what the three dimensions are in three-dimensional learning, we need to understand how they are utilized together. The use of scientific and engineering practices is how students obtain knowledge in three-dimensional learning (NRC, 2012). Students use scientific practices to develop and construct their own knowledge on selected core ideas. Core ideas are scaffolded vertically across grade levels as are the use of scientific and engineering practices. As students progress through successive grades, the level at which they are expected to use scientific and engineering practices increases. The expectation is that the proficiency of using scientific practices will increase over time as students build their understanding of the processes and experience utilizing them as tools for their learning. The core ideas increase in both the complexity of information and the depth of content over time as well. The combination of both the expected proficiency for using science and engineering practices and the depth of understanding of core ideas (and sub-core ideas) is combined into what is known as performance expectations. Performance expectations are functionally objectives, tasks that students should be able to demonstrate a proficient understanding of scientific content at the level of Bloom's taxonomy expected for that grade level (NRC, 2012).

Crosscutting concepts are the final piece of integration for three-dimensional learning (NRC, 2012). Crosscutting concepts are the basis for connections between content within and across the different fields of science. This is important because of the foundational learning theory upon which three-dimensional learning is based, constructivism. As students construct their own knowledge through their learning experiences, the knowledge is organized within their existing schema or new schema, depending on how it agrees with their existing understanding (Piaget, 1952). Within this context, the connections between the schemas are important for reinforcing and strengthening the understanding of knowledge. Crosscutting concepts are used to make these connections more explicit to students, strengthening their connections between core ideas of different fields of science and demonstrating how fundamental principles apply to all areas of science (NRC, 2012).

A Framework and the NGSS that followed allowed for a fundamental change in teaching science by paring down the amount of science content at each grade level, allowing students to learn through inquiry-based methods by providing them with the time to do so (NRC, 2012; NGSS, 2013). This method of science teaching requires a change in role for teachers as well, from that of disseminators of knowledge to facilitators or learning environments (NRC, 2012). In three-dimensional learning, teachers create learning environments in which students can engage in problem solving and higher order thinking, while both integrating fundamental information and building transformative understanding (NGSS, 2013). When effectively designed, these learning activities create an environment in which students can develop and demonstrate skills in leadership, collaboration, and communication (Hugh *et al.* 2006). Successful implementation of this type of curriculum improves student skills in problem solving and inquiry, develops positive attitudes toward science, and increases achievement on standardized tests significantly (Morrison *et al.* 2015).

Properly scaffolded instruction may also help students improve their use of science skills by improving their use of metacognitive strategies used in problem solving (Schunk, 2012). As guidance is slowly withdrawn by the instructor, students are required to think about how they will attempt to design and conduct their own scientific investigations. The process of designing and conducting scientific investigations is a strategic process whereby students must develop a testable question and a strategy to gather data appropriate for answering that question. The understanding of strategic knowledge and its application to accomplish task goals is described as metastrategic competence (Kuhn & Pearsall, 1998). Properly scaffolded instruction helps students improve their metastrategic competence for using science practices (Kuhn & Dean, 2005). Prior instruction and practice with instructional support appear to be crucial in helping students develop and hone skills necessary to generate scientific evidence and develop their own explanations (Kuhn & Dean, 2005; Metz, 2004).

Contextual Model of Learning

Understanding developed through museum studies often is applied to learning at informal learning centers such as nature centers, science centers, aquaria, and zoos (Falk and Dierking 1992). One of these models is the *Contextual Model of Learning* (Falk and Dierking 2000), which describes how the *Personal Context*, *Sociocultural Context*, and *Physical Context* influence potential learning at informal learning centers. Situated within these contexts are eight key factors Falk and Dierking (2000) believe are key to museum learning experiences.

- Personal Context
    - Motivation and expectations
    - Prior knowledge, interests, and beliefs
    - Choice and control
- Sociocultural Context
    - Within-group sociocultural mediation
    - Facilitated mediation by others
- Physical Context
    - Advance organizers and orientation
    - Design
    - Reinforcing events and experiences outside the museum

These factors are all important and contribute to the construction of meaning during learning experiences in informal settings. The absence of any one of these factors impacts the potential learning resulting from these experiences, making construction of meaning difficult (Falk and Dierking 2000).

Personal Context

The Personal Context in Falk and Dierking's *Contextual Model of Learning* (2000) refers to the conditions within each individual that impact learning. These conditions are specific to each individual learner and must be accounted for during learning experiences. Falk & Dierking (2000) divide the Personal Context for each learner into three parts.

The first of these parts is the learner's *motivations and expectations.* The motivations and expectations of learners can be determined through two questions. 1) Why is the learner engaging in the learning experience? 2) What do they expect to gain from this experience? The motivations and expectations of typical zoo visitors can vary widely and often include recreation as a significant component (Tunnicliffe, 1997; Davidson *et al.*, 2009; Randler *et al.*, 2012). The recreational focus of zoo visits appears to be retained even when the zoo visits are a part of formal educational field trips. Most traditional zoo field trips, especially at the elementary level, are recreationally focused rather than educationally focused (Tunnicliffe, 1997; Davidson, *et al.,* 2009; Randler *et al.*, 2012). Zoos would like field trips to focus more heavily on education rather than recreation, to position themselves as educational resources in their respective communities. Zoo educational programming is moving toward more heavily educationally focused learning experiences, requiring that traditional motivations and expectations of students for zoo field trips be modified. It is ideal that the motivations of learners and facilitators of learning experiences have motivations and expectations that are aligned (Falk & Dierking, 2000; Behrendt & Franklin, 2014). Aligning these motivations and expectations involves significant planning and communication, and proper implementation of lessons and activities in advance of the field trip (Behrendt & Franklin, 2014).

The second key factor of Personal Context is *prior knowledge, interests, and beliefs* of learners. Prior knowledge is the foundation of new learning and necessary for the construction of greater understanding through informal learning experiences. A lack of key prior knowledge can impede potential learning during visits to informal learning centers (Falk and Dierking 2000). Interests are key because they are pathway to authentic learning. Authentic learning is learning activities that represent "the types of complex tasks performed by professionals in the field, rather than decontextualized or contrived activities. Students have access to supporting resources and engage in collaboration, articulation, and reflection as they produce outcomes typical of quality performance." (McKenzie, *et al.*, 2002). When learners' interests relate to learning experiences, the natural inquisitive nature of learners facilitates engagement (Falk & Dierking, 2000). Beliefs prior to a learning experience can shape how learners perceive the experience they are having (Falk & Dierking, 2000). It is important to account for prior beliefs held by learners that may impede the learning potential of these learning experiences.

The final components of the Personal Context are *choice and control*. Choice is an important factor in learning because it allows students to align new learning experiences with their interests (Dobrow *et al.*, 2011). Such alignment increases engagement in learning and provides ownership by students in their own learning (Owusu-Ansah, 2016). Control over their learning experience is also important for learner motivation and engagement. Learners are more open to learning experiences when participation in the learning experience is perceived to be under their control rather than imposed upon them by an authority figure (Dewey, 2004). Ultimately, when learners are provided choice and control of their learning, their intrinsic motivation, interest, and engagement increase, all of which improve the learning potential of any learning experience (Schraw *et al.,* 2001).

Sociocultural Context

The Sociocultural Context refers to the social interactions that influence learning during learning experiences. These social interactions are divided into two sets, *within-group sociocultural mediation* and *facilitated mediation by others*.

Within-group social mediation refers to the interactions between learners within their peer group (Falk & Dierking, 2000). For formal learning groups such as those used in school field trips, these are the interactions that occur between students. Student collaboration during group activities is one such social interaction that impacts learning and has been shown to result in increased learning compared to when students work independently (Azmitia, 1996, Falk &

Dierking, 2000). There is also considerable evidence that both student learning and learning retention are increased when students present their learning or discuss what they have learned with their peers (Falk & Dierking, 2000). Within peer groups students often observe the behavior of their peers and use this information to influence their own behavior during learning experiences. This process, referred to as modeling through social learning, also appears to impact student learning during learning experiences (Falk & Dierking, 2000).

Facilitated mediation by others refers to social interactions between learners and those outside of their peer group, and it also appears to have a significant impact on learning (Falk & Dierking, 2000). For school groups, these others include teachers, docents, and parent volunteers. These individuals are all adults who are perceived by students to be more knowledgeable that they. When these interactions help students move through their zone of proximal development, the learning potential for the experience increases (Vygotsky, 1978). Conversely, if these interactions contrast with the motivation and expectations of learners, the learning potential of these experiences can be impacted negatively.

Physical Context

The Physical Context of learning refers to how both the physical infrastructure and design of the informal learning environment and the educational infrastructure of the program impacts learning. Falk & Dierking (2000) divide the Physical Context into three components: *advance organizers and orientation, design,* and *reinforcing events and experiences*.

Advance organizers are tools used to illustrate to learners what they are about to learn and how it connects to what they already know (Shihusa, & Keraro, 2009). The use of advance organizers helps students access related prior knowledge, focus on important upcoming concepts in the lesson, and make connections between concepts (Gurlitt *et al.*, 2012; Jafari, 2012). Examples of advance organizers used in education are text organizers, graphic organizers, and narrative organizers (Shihusa, & Keraro, 2009). While the methods may differ, advance organizers fundamentally orient students within their learning process; however, learners also need orientation within the physical space where learning is to take place.

Falk and Dierking (2000) explain how the learner's *orientation* within the physical space of learning also impacts learning. When learning environments are extremely novel, learning is depressed because the learner is uncomfortable and focuses on orienting themselves within the environment. Alternatively, when the learning environment is extremely familiar, there is little to explore, and the natural curiosity of learners is depressed. The ideal learning environment is therefore one with moderate novelty, where the learner is both comfortable and familiar with their surroundings while surrounded by novelty that stimulates their curiosity (Falk & Dierking, 2000). Students' lack of orientation in their learning environment is the cause of the novel field trip phenomenon, an important factor influencing learning during field trips (Falk, 1978). The novel field trip phenomenon describes how the learning potential of field trips is often depressed due to the novel environment and the time and focus that students use to orient themselves within the space rather than using their experiences to gain new knowledge and build connections with prior knowledge (Falk, 1978).

Zoo Education

The concept of education at United States zoos began with the opening of the Bronx Zoo education department in 1929 (Schwammer, 2001). Early zoo education focused on the communication of natural history and taxonomic information about the exhibited animals through signage to visitors. Zoo education began to take shape in the 1980's, by incorporating conservation education as a part of the education mission and by building connections with formal education through field trips (Schwammer, 2001). Education is now a prominent theme in the mission statements of zoos, surpassing even conservation, with 131/136 including the theme of education vs. only 118/136 including the theme of conservation (Patrick *et al.,* 2007). Field trips remain a popular choice for teachers looking to provide experiences for their students beyond what is possible in their classroom (Cox-Petersen *et al.*, 2003), with over 12 million students annually participating in field trips at zoos and aquariums in the U.S. (AZA, 2018). These field trips are typically single-day events for students in elementary grades (Patrick, 2006). Despite changes in formal science education that utilize inquiry-based methods to promote active learning, zoo educational programming often uses traditional classroom models of science teaching (Coe, 1987, Andersen, 2003, Moss & Esson, 2013). Students often use worksheets to guide their learning during scavenger hunts and guided tours through the zoo (Andersen, 2003; Kisiel, 2007; Moss & Esson 2013) and attend direct-instruction-oriented presentations conducted by zoo staff and volunteers (Moss & Esson, 2013).

Incorporation of evidence-based science teaching methods is beginning to appear in zoo education programming as zoos increasingly understand that they must make changes to meet the needs of public-school students and teachers (Phipps, 2010; Mulkerrin & Hill, 2013, Jensen, 2017; Collins *et al.*, 2019; Collins, *et al.*, 2020). These new educational programs incorporating inquiry-based, STEM-oriented, hands-on methods help zoos accomplish their own educational missions (Mulkerrin & Hill, 2013) while providing resources and scientific expertise rarely available in traditional classroom environments (Seiler, 2001; Buxton, 2006; Leonard *et al.,* 2010, Heimlich, 2010).

BIG Zoo Lesson

One example of a zoo education program in which students learn science through inquiry-based and STEM-oriented lessons at their local zoo is the BIG Zoo Lesson (BIG Zoo Lesson, 2018). The BIG Zoo Lesson is modeled after the "Beyond the Classroom" model first implemented by Gillian Kydd in 1993 at the Calgary Zoo (Kydd, 2004; Holtschlag, pers. comm., 2017). The BIG Zoo Lesson (BZL) uses this model to create learning experiences in which students use the zoo and its exhibits as their classroom, and using science processes to conduct their own investigations (Holtschlag, pers. comm.; BIG Zoo Lesson, 2018). This program was developed by a former Michigan Teacher of the year, Margaret Holtschlag, and first implemented in the 2000-01 school year. Since its inception more than 20,000 students have participated in this program at Potter Park Zoo (PPZ) (Holtschlag pers. comm., 2017; Laidler, pers. comm., 2017). The program has expanded several times to meet demand; however, it is consistently fully booked, even at the current rate of 65 participating classes per year (Holtschlag pers. comm., 2017; Laidler, pers. comm., 2017). Teachers take their students to the zoo for five consecutive days, where students conduct daily animal observations, participate in lessons with docents and zookeepers, and engage in labs and activities designed to promote active and engaging learning experiences at the zoo (Holtschlag pers. comm., 2017; Laidler, pers. comm., 2017; BIG Zoo Lesson, 2018).

These foundational components of the BIG Zoo Lesson are perceived to be instrumental in the program's success impacting student learning (Holtschlag pers. comm., 2017; Laidler, pers. comm., 2017; BIG Zoo Lesson, 2018). The BZL Teacher Training Manual (2016) and BIG Zoo Lesson website (2018) outline these critical program components.

Critical Program Components

The five critical components of the BZL program as outlined by the BZL Training Manual and BIG Zoo Lesson website.

- Each teacher must participate in a mandatory teacher development program, including a two-day training workshop and additional small group planning meetings for each teacher's BZL week.
- Students must attend the site for five consecutive days.
- Students must conduct a minimum of daily one-hour observations of zoo animals on exhibit.
- Parents must fill the role of co-teachers and co-learners rather than chaperones.
- All major lessons are followed immediately by debriefing sessions to help students process what they have just observed/learned.

The interdisciplinary design of the program allows teachers to design their own BZL week based upon their chosen curriculum focus and objectives (Holtschlag pers. comm., 2017; Laidler, pers. comm., 2017). Teachers are free to choose from existing lessons and activities as well as work with zoo staff members and other teachers to develop new lessons and activities to meet their objectives and curriculum goals. While teachers are given flexibility to design their BZL week, they must adhere to the foundational components outlined above. Despite BZL curriculum variation, students are told to "act like scientists" during their BZL week. The daily observations of zoo animals on exhibit are key to this behavior, but typically are not the only activities in which students are asked to be scientists. Most BZL participating students are in 3rd-5th grade and are in the early stages of applying the concepts of STEM education. Daily observations and other STEM-oriented activities are designed to develop and strengthen the use of science practices by students in a real-world environment (Holtschlag pers. comm., 2017; Laidler, pers. comm., 2017; BIG Zoo Lesson, 2018).

Participation in the BZL at PPZ is limited by the available space to accommodate groups, with demand exceeding available slots despite the $30 per student participation fee (Holtschlag pers. comm., 2017; Laidler, pers. comm., 2017). Demand for participation in the program is fueled by the perception of zoo education staff, teachers, and parents that the BZL positively impacts student learning (Holtschlag pers. comm., 2017; Laidler, pers. comm., 2017; BIG Zoo Lesson, 2018). Despite the widespread perception that the BZL positively impacts student learning, all evidence collected to date has been anecdotal, and there is no published research studying if, how, and/or why the BZL impacts student learning in STEM. Neither has there been any study published in a peer-reviewed journal documenting the impacts on student learning of the BIG Lesson model, in general.

Research on BIG Lesson model

An exhaustive search using both library resources and discussions with Kydd and Holtschlag for published research involving the Beyond the Classroom/Open Minds/BIG Lesson models uncovered three studies, none of which were published in peer-reviewed journals. Cochrane (2000) analyzed the effects of participation in the Open Minds program on reflective writing of 3rd grade students. Results demonstrated a 24% increase in grade level writing proficiency (2.5-3.7) in the 134 students in the experimental group versus a 6% increase (2.5-2.8) in the 132 students in the control group between the pre-test in October and the post-test in February. Cochrane (2000) concluded that the Open Minds model helps students improve reflective writing; however, this study was published only on the Chevron Open Minds website rather than in a peer reviewed journal.

Kydd (2004), in her dissertation, described the development process for the Campus Calgary/Open Minds programs and conducted a qualitative case study of one participating teacher that analyzed the impacts of the program on teacher practice. The case study of one teacher over several years demonstrated qualitative changes in teacher practice in lesson design. The review approach incorporated a single "big idea," a focus on "habits of the mind" (observation, drawing, descriptive writing, and slowing down to improve understanding), and a refined structure for field trips, including improved training for volunteers on expectations and roles. While this study provides insights into potential changes in a single teacher's practices, no assessment of the impact on students was conducted.

Kesler Lund (2013) observed a group of 14 third-grade students and their teacher participating in the BIG History Lesson for five consecutive days and conducted pre- and post-interviews with five selected students of varying academic abilities. She focused on the use of historical thinking skills (sourcing, contextualizing, inferring, and corroborating) by these students to examine if the BIG History Lesson provided students with the opportunity to "do history" as a historian would, using artifacts to discover history and compose a story of the past. Results from this study demonstrated that the BIG History Lesson provided an opportunity for students to utilize historical thinking skills; however, many students struggled because they were not prepared enough to engage with these museum artifacts. Pre- and post-interviews demonstrated that when activities were adequately modelled and scaffolded, that students were better able to apply these historical thinking skills (Kesler Lund, 2013). While insights were made about the strengths of the BIG History Lesson and, consequently, the BIG Lesson model, the impact on student learning was not evaluated.

Historical thinking skills and scientific practices of STEM learning share many similarities, suggesting that the BIG Lesson model would also provide opportunities for applying these practices. The focus of “doing history” is like “doing science” described in the BIG Zoo Lesson, further suggesting that issues with preparedness for student investigations could affect the impact on STEM learning in students participating in the BIG Zoo Lesson.

Framing Science Learning in the BIG Zoo Lesson

Impacts of Observing Live Animals

A novel and foundational component of the BZL is the student daily observations of their selected animal(s) over five consecutive days. This component is key to the concept of “students as scientists” and is completed by all students participating in the BZL. These observations can include both qualitative and quantitative data collection at the discretion of the classroom teacher; however, no formal training is provided by the BZL program on how to teach students to conduct these types of data collection or analysis (Holtschlag pers. comm., 2017; Laidler, pers. comm., 2017). There are examples of a few selected teachers training their students to make animal observations (Holtschlag pers. comm., 2017); however, the content and methodology used for these trainings are unknown.

Anecdotal evidence suggests that student observations improve over their five days of animal observations at the zoo (Laidler pers. comm., 2017); however, a formal analysis of student observations has not been conducted to verify these claims. Published research supports the notion that students would improve in the application of science skills used in animal observations over time; however, they show a much greater improvement when provided with instruction prior to conducting their investigations (Kuhn & Dean, 2005).

Possible Impacts of BIG Zoo Lesson Structure on Learning

The BIG Zoo Lesson's structure is unique compared to other upper-elementary zoo education programs. These structural differences have possible impacts on learning. While informal education at zoos is not well studied (Marino *et al.,* 2010; Moss & Esson, 2013; Jensen, 2014; Jensen, 2017; Collins *et al.*, 2019; Collins, 2020), this is not true for museums.

The BZL is described as a program where students are "doing" science through various activities, including the daily one-hour animal observations. This requires that students have a set of science skills and knowledge necessary to conduct observational investigations. Without prior knowledge and skills, the time spent "doing" science during these animal observations may not be effectively utilized, and significant learning experiences may be missed. While it is believed that some teachers are teaching these skills prior to their week at the zoo (Holtschlag pers. comm., 2017; Laidler pers. comm., 2017), it is not clear what is being taught and how this is impacting students during their live animal observations. The BIG Zoo Lesson does not include any type of student instruction on how to conduct observational investigations of live animals. Teaching of these skills and strategies is the responsibility of the classroom teachers (Holtschlag pers. comm., 2017). Understanding how students are being prepared prior to their week at the zoo is important to understanding the factors impacting learning during the BZL.

Currently, there is no published research involving upper-elementary students conducting scientific observations of zoo animals as a part of zoo education programs. Single-day zoo education programs involving animal observations for upper elementary students do exist at other facilities: Lincoln Park Zoo: *Zoo Explorers Program*; Smithsonian's National Zoo: *Junior Zoologist School Program*; and the Indianapolis Zoo: *Field Observations Ethograms and Animal Behavior*. Observation of live animals in these programs is framed as an opportunity for students to act like zoo biologists, collecting data on their animals to better understand them. This creates the potential for an authentic learning experience for students, whereby they can both practice their use of science practices and develop a deeper understanding of how and why science is conducted in the real world. These are single-day programs, however; thus, the opportunity to observe changes in student observations over time is limited.

Previous research demonstrated that when instruction is properly scaffolded, upper-elementary students can utilize numerous science skills in observational experiments with live animals (crickets) in a formal classroom environment (Metz, 2004). Students developed research questions, designed appropriate experiments, collected, and analyzed observational data, developed conclusions from the analysis of their data, and presented their findings (Metz, 2004). While this research demonstrated that it is possible for upper-elementary students to carry out observational studies of live animals, differences between Metz's (2004) study and animal observations conducted during the BIG Zoo Lesson leave many questions unanswered.

Animal observations conducted during the BZL generally are conducted by individual students, not in pairs or small groups of students as in Metz (2004). In the context of social constructivism, this may impact the how students progress in their use of science practices involved in conducting live animal observations. The lack of collaboration during animal observations at PPZ also limits the second component of the Contextual Model of Learning, the Sociocultural Context. Individualized observational investigations restrict social interactions, which are key factors in meaning making during informal learning experiences (Falk and Dierking 2000).

In Metz's (2004) study, students conducted their animal observational experiments on crickets. During the BZL most students observe mammals, most of which qualify as "charismatic megafauna." Charismatic megafauna are often exhibited in zoos and used when presenting conservation issues because of the emotional connection the public has with them (Ducarme *et al.*, 2013). The emotional connection typically had with these charismatic species may influence student observations of these animals.

Metz's (2004) study was conducted entirely at the students' school, a formal learning setting. In the BZL, all lessons, including animal observations, are conducted at the zoo, an informal learning environment. While informal learning environments can provide resources, expertise, and novel and engaging learning experiences for students, there are challenges in conducting lessons in these environments that must be identified and planned for to maximize the learning experience for students (Falk and Dierking 2000; National Research Council, 2009).

While the daily one-hour observations are designed as independent activities, there is evidence that the BZL addresses the Social Context for learners. The group learning environment of the BZL is believed to mediate learning as students work together in small group activities that supplement the personal observations (Holtschlag 2017; Laidler 2017). Additionally, the roles of teachers as facilitators of learning, and parents as both co-teachers and co-learners rather than chaperones differs from those during a typical zoo field trip. It is believed that this provides a sociocultural context focused on education rather than recreation during this program (Holtschlag pers. comm., 2017; Laidler pers. comm., 2017). Several lessons in the BZL are led by docents or zoo education staff. Zoo staff and many docents are trained educators having significant experience in education. It is believed that these lessons are led by skilled facilitators of learning and that this significantly impacts student learning in the BZL.

The final component of the Contextual Model of Learning that the BZL appears to address is the Physical Context. A Physical Context factor affecting learning is the novelty of the learning environment. The construction of the BZL as five consecutive days is believed to limit the effect of novelty associated with many informal learning environments (Holtschlag pers. comm., 2017; Laidler pers. comm., 2017). Mondays are used primarily for students to become familiar with the zoo through exploration activities, with no content knowledge being taught during that day (Holtschlag pers. comm., 2017; Laidler pers. comm, 2017). By Wednesday the novelty is gone and students "act like it is business as usual," treating the zoo as if it is their classroom (Laidler 2017). Research by Falk *et al.* (1978) supports observations by Holtschlag and Laidler. Falk *et al.* (1978) found that students in an unfamiliar informal learning environment failed to build conceptual knowledge during a structured learning activity; however, students who were familiarized with the learning environment prior to the structured learning activity demonstrated significant gains in conceptual knowledge. This disparity is explained by the novel field-trip phenomenon, a barrier to learning common to single-day field trips (Falk *et al.*, 1978). Limiting the perception of novelty through advanced orientation to the Physical Context of the informal learning environment is a key factor influencing learning (Falk & Dierking, 2000). The five consecutive days may produce the necessary orientation to the learning environment while still allowing for a proper amount of perceived novelty to keep students engaged in learning activities (Falk *et al.,* 1978; Falk, 1983; Anderson & Lucas, 1997; Falk & Dierking, 2000). While anecdotal evidence suggests that the five-consecutive-day design of the BZL reduces the novel field-trip phenomenon, related research had not been done prior to this study.

CHAPTER 3: METHODS

A case study research design (Merriam, 1998; Yazan, 2015) was used to examine the BIG Zoo Lesson program and determine the factors that impact student learning. Case study design was ideal because it allowed the researcher to use a broad range of methodological tools to gain an understanding of a complex situation (Merriam, 1998; Grauer, 2012; Yazan, 2015). Yin (2003) argued that case study design is appropriate for investigating complex phenomena within a real-life context by using multiple sources of evidence. Therefore, in this investigation several smaller case studies were combined to identify factors that influence student learning in the BIG Zoo Lesson.

BZL Implementation

The BIG Zoo Lesson took place on five consecutive days, Monday through Friday, when students spent most if not all their school day at the zoo. Transportation issues and travel distance from the zoo influenced the total number of hours that each class could spend at the zoo, with most classes spending at least five hours per day at the zoo. Teachers new to the program completed a two-day orientation and training program to familiarize themselves with the available options and the many lessons they could choose from during their planning meetings. Teachers worked with the BZL program director to select a combination of learning experiences, including docent-led lessons, teacher-led lessons, live animal presentations, and animal observations. Teachers selected from a catalog of these activities to build their zoo schedule for their week. Teachers and the BZL program director collaboratively constructed a week-long curriculum that made connections between concepts and sequentially built upon previous daily learning. Ultimately, the schedule was determined by the teacher, with zoo staff offering guidance and constraints based upon class needs and available resources. While no two BIG Zoo

Lesson weeks were the same, there were several common requirements to which teachers had to adhere.

Each day at the zoo included a one-hour student animal observation activity. Each student independently observed a single species of animal, targeting either a single individual animal or a group of animals, depending on the species assigned to the student. Teachers generally provided some level of choice to students so they could observe a species in which they were interested. However, factors such as weather, season, class size, and the number of chaperones available all influenced the species selection. On rare occasions, when an animal was off-exhibit, students were assigned a closely related animal for one or more days of observation.

The BZL requires that enough chaperones be available to help during the daily one-hour animal observations. Chaperone number depended on class size, number of different species being observed, proximity of class groups to one another, and individual student needs. Student groups observing a single exhibit ranged from one to six students. Of those students, no more than two from any one observational animal group were focal students for this research. Most classes had 4-6 chaperones per day.

Every animal observation and major lesson (live animal presentation or docent led lesson) was followed by a debriefing period that helped students think about what they had just learned and incorporate their new learning into their existing understanding of the concepts related to that lesson.

Study Site and Facilities

Potter Park Zoo, located in Lansing, MI, is an AZA-accredited municipal zoo that currently houses 160 species of animals with over 500 individuals (Potter Park Zoo, 2021). The zoo features a Bird and Reptile House of indoor exhibits, a Feline and Primate House with both indoor and outdoor exhibit space, and numerous outdoor exhibits of both regional and exotic wildlife capable of enduring the local temperate climate.

Potter Park Zoo provides classroom space in their Exploration and Discovery Center for Education, which contains two full-sized classrooms, and the Safari Room, a conference-style space that can accommodate two additional classes. In addition, the VEZU room, a separate building in the center of the zoo, also was used as classroom space during the BIG Zoo Lesson, allowing Potter Park Zoo to accommodate up to five separate classes of students at one time; however, typically three or four classes of students are accommodated per week for the BIG Zoo Lesson.

Elementary Schools and classes within each school chosen to participate in this research were selected from a list of teachers who volunteered. From the list of volunteer teachers, a schedule was developed to ensure that there was time allowed to collect the necessary data prior to and following that class's week at the zoo, typically one to two weeks before and after a class's BZL week. Grade levels of classes ranged from 2^{nd} grade through 6^{th} grade, with most participants in the 3^{rd} and 4^{th} grades. The 2^{nd} grade participants were part of a mixed classroom of 1^{st} through 3^{rd} grade students in a Montessori setting. Participating schools were from a mixture of urban, suburban, and rural school districts, with four classes, two classes, and two classes, respectively. Within the urban schools there was diversity as well with two traditional public schools, one public Montessori school, and one parochial school. Within each class, data was collected on six teacher-selected focal students. Each group of six focal students in each class were comprised of two students for each teacher-determined achievement level, high, medium, and low. Demographic information for the eight participating classes is displayed in Table 1.

Table 1. *Characteristics of participating classes (A through H)*

Class	School Type*	Grade Level	# Students	# Teachers	Study Round
A	RTP	6	24	1	1
B	UMP	1-3	14	1	1
C	UTpar	3	29	2	1
D	RTP	3	24	1	1
E	STP	4	24	1	2
F	STP	4	25	1	2
G	UTP	3	23	1	2
H	UTP	3	24	1	2

*Abbreviations: R = rural, S = suburban, U = urban, M = Montessori, T = traditional, P = Public, par = parochial
Note: all data reported in this study were collected from only six teacher-selected focal students, two high (H) achieving, two medium (M) achieving, and two low (L) achieving.

Participants

Teacher Participants varied considerably with respect to both total years of experience in education and total years participating in BZL. A total of nine teachers participated in the research, seven from the public schools and two from the parochial school. Due to the small size of the two parochial school classes, they were combined and led by both of their teachers. The teachers were predominantly female (eight females and one male), a ratio that resembled the gender diversity of typical elementary education faculty (Hussar *et al.*, 2020).

Student Participants were selected from a list of student volunteers who, along with their parents, had agreed to participate in the research. Teachers were asked to select a diverse group of six students to be focal students for data collection, two each that they would classify as high (H), medium (M), and low (L) regarding academic achievement. The researcher was not given those designations until after data collection was complete to avoid bias during data collection. A total of 48 focal students (six per class) participated in the research, completing both the pre- and post-interviews, and participating in most of the days at the zoo. Five students missed one or two days at the zoo due to illness, possibly related to the considerable amount of time spent outdoors, often at freezing temperatures.

Time Frame and Study Rounds

Data collection was conducted in two rounds. The first round of data collection was from February 2019 through May 2019 and included four student classes (A-D) and five teachers. During this data collection period, I observed that students appeared to lack the skills for collecting data during live animal observations. There was no clear evidence in students' observation journals that students were collecting data during their animal observations. Interviews with teachers indicated that if students were trained prior to their BZL week in conducting live animal observations, it was through practice sketching animals using either live animals brought into the classroom or through videos or live streams. During several discussions with teachers and formal interviews. I learned that these teachers were not familiar with techniques for conducting live animal observations and were not provided with these techniques as a part of their BZL preparation.

The BZL program was marketed as a program in which "students do science" (BIG, 2018), but without the ability to collect data, it is not possible to "do science." I wanted to see if a lesson teaching students fundamental principles and techniques for collecting data during live animal observations would impact student behavior during animal observations.

The lesson, "How to do Live Animal Research like a Scientist" (Appendix H), was developed and taught by the researcher to the four classes of students (E-H) used in Round 2 of data collection. Lessons lasted between 60-90 minutes, dependent on available time scheduled for that class. The 90-minute format proved to be ideal, allowing enough time to scaffold the lesson. The lesson was scaffolded so that each skill was first introduced, then modeled, then practiced together, and finally practiced alone. The skills practiced in this lesson consisted of: writing a testable question that could be answered through animal observation; collecting animal behavior data using ethograms and scripted observations; and analyzing ethograms and scripted observations to form conclusions. Students were given several opportunities to both collect and analyze data in multiple formats. The feedback from both teachers and students regarding the lesson was overwhelmingly positive, with a high level of engagement by all students. Several teachers commented on how well the students remained engaged during such a "long" lesson.

Data Collection

Student data were gathered in several different forms. The six focal students in each class participated in interviews one to two weeks before and one to two weeks after their BZL week. Interviews lasted from about 15 to 30 minutes and were conducted either in the hallway outside the classroom or in an adjoining room or classroom to minimize extraneous noise and distractions. The pre-BZL interview questions focused on previous experiences with field trips and zoos, recent experiences learning science, and expectations for the BZL (Appendix A). The post-BZL interview questions focused on students' perceptions of their BZL week (Appendix B). The interviews were semi-structured (Miles *et al.* 2014) and followed the Interview Guides (Appendices A & B), with occasional follow-up or clarifying questions used as needed. All interviews were digitally recorded, and notes were taken as backup in case of error with digital recording. Digital recordings were used to produce verbatim transcripts of all student interviews.

Two types of observations of students were made during the BZL week. The first was observations of student behavior during their daily animal observation time. Data were collected by the researcher using an instantaneous ethogram format at one-minute time intervals. Precise one-minute intervals were tracked using an app (Time Timer) paired between a smart watch and smart phone set to vibrate every minute for the one hour of daily animal observations. This provided a silent cue evident only to the researcher.

Ethograms are an animal observation tool that have demonstrated effectiveness at capturing a set of student behaviors accurately using a standardized coding scheme (Bexell *et al.*, 2013; Kline, 2017). Data collection was done through a coded technique that focused on individual student behavior. At each one-minute interval the student's behavior at that instant was recorded as one of the six possible observed behaviors described below. The codes used were ambiguous and known only to the researcher. Codes are defined in Table 2.

Table 2. *Student Behavior Ethogram and corresponding codes used to record focal student behaviors during animal observations.*

Code Used	Engagement	Description
I	On-task	Writing or drawing in journal as appropriate or reading signage or other interpretive material in the process of completing assigned task
X	Off-task	Not writing, drawing, reading interpretive materials, or engaging in other behaviors not contributing to assigned task completion
O	On-task	Observing assigned animal or the designated replacement animal should the assigned animal be unavailable for observation that day.
o	Off-task	Observing unassigned animal (the student has left the assigned exhibit and is observing another animal in another exhibit)
T	On-task	Talking about animal observations with peer, parent chaperone, or teacher
t	Off-task	Talking with peer or parent chaperone about something not related to animal observations

An effort was made to observe each focal student each day for roughly equal time periods during the animal observations. The time within the animal observation activity that each focal student was observed rotated daily so that all students were observed at the beginning, middle, and end of animal observation activities during their BZL week. Total observation time for each student varied depending primarily upon the number of shared species being observed. For example, if a total of four different species were being observed by the six focal students, then each student could be observed for a longer time than if all six focal students were observing different species. In total, 20 focal students did not share their observation animal with another focal student, 22 shared their observation animal with one other focal student, and 6 shared their observation animal with two other focal students. Additionally, total time of actual animal observation period and physical distance between exhibits caused slight variations in total time each student was observed. Scripted observations also were done during these observations to capture data to provide greater context for the student behavior data collected.

Students also were observed during all learning activities, and data were collected through scripted observations to capture a clear narrative of events.

The final sources of student data were their BIG Zoo Lesson journals, which were collected after program completion. Each student's journal was digitally scanned and uploaded as a collection of images for analysis of student work. In rare instances, additional student artifacts not included in the journal, such as separate packets or worksheets, were also scanned as evidence of student work.

Teacher data were collected through both pre- and post-BZL week interviews conducted typically one to two weeks prior to and one to two weeks following the BZL week. The pre-BZL interview questions focused on teacher experience with field trips, experience and motivation for participation, preparation and extension activities for students, and expectations for student learning from BZL (Appendix C). The post-BZL interviews focused on teacher perceptions of their BZL week, desire for future participation, and changes they would make for future participation (Appendix D).

Teacher interviews also were conducted in a semi-structured format (Miles *et al.* 2014) and followed the prescribed interview guides (Appendices C & D), with additional follow-up or clarification questions, used as necessary. Interviews lasted between 40 and 60 minutes, generally in one session; however, due to time constraints, three teacher interviews were extended over two sessions. All interviews were digitally recorded and later transcribed verbatim. Notes also were taken as backup in case of equipment malfunction.

Scripted records of teacher behavior were kept as a part of scripted observations of all learning activities.

Additional data were collected through daily memos that focused on my impressions of that day's events (through the perspective of the researcher). This form of data collection followed protocols typical of participant observation techniques (Miles *et al.*, 2014) and provided data regarding what was done during zoo visits and provided additional context for scripted observations, ethograms, and interviews.

Data Analysis

Qualitative data were analyzed through the process of inductive coding (Miles *et al.* 2014), a technique whereby concepts and themes are derived from analysis of raw textual data (Thomas, 2006). Inductive coding is the best choice for exploratory research when little is known about the subjects and context being investigated (Thomas, 2006; Miles *et al.* 2014). Inductive coding is a bottom-up approach that allows themes and subthemes to emerge through the process of coding. By letting themes and subthemes naturally emerge rather than purposefully seeking out predetermined themes as done in deductive coding, researchers are less prone to bias and more open to new ideas previously not considered (Miles *et al.* 2014).

Students and teachers were assigned alphanumeric pseudonyms to assist with cross-referencing data from multiple sources for each participant. Daily memos, scripted observations, and interview transcripts were analyzed using MAXQDA, a qualitative data analysis program commonly used in education research (Kuckartz & Rädiker, 2019). A codebook was developed and amended through several rounds of coding. A supporting document was developed to define specific codes, provide appropriate examples for using that code, and identify near misses (i.e., data that did not quite meet the criteria with an explanation of why). An excerpt from this codebook is provided as a reference in Appendix L. Memos were developed during the data collection process that described findings, including connections for individual subjects and across subject groups (Miles *et al.* 2014). Additional memos were developed to explain potential findings and trends as they became apparent.

Data from ethograms developed through observations of students during their daily animal observations were uploaded into a spreadsheet for analysis. Alphanumeric codes were used to identify each student, students' teacher-determined academic performance level, and each class of students. For example, A4H denoted the fourth student interviewed in pre-BZL interviews for class A, who was determined by their teacher as a high-achieving student. This allowed me to easily cross-reference each student's data points from interviews, observations, and student artifacts during the coding process. Ethogram data were analyzed to find individual behavioral trends, class behavioral trends, trends across ability levels, and trends between Round 1 and Round 2 (students who received "How to do Live Animal Research like a Scientist" lesson) subgroups.

Student artifacts were used primarily to provide triangulation of data, or additional context with regards to student behavior during animal observations and other educational activities. Each student's artifacts for each lesson were combined and scored as a group. For example, if one day's daily animal observation utilized 5 journal pages, these pages were grouped together and scored by the researcher as a single artifact. Each artifact was scored on a 0-5 scale, the scoring rubric is detailed below in Table 3. To control for the abilities of each student, both due to grade level and individual student ability, the effort component of the rubric was determined by informal assessment of each student's entire BZL journal. Each student artifact was then scored on an individual basis for each student using the rubric below. Scores were entered into a spreadsheet for analysis.

Table 3. *Student artifact scoring rubric.*

Score	Criteria
0	Student was present for lesson or activity and no student artifact found in journal
1	Some tasks for lesson or activity are completed. Work low quality.
2	Approximately half of tasks for lesson or activity are completed. Work low quality.
3	More than half of tasks for lesson or activity completed. Work at moderate level of quality.
4	All tasks for lesson or activity completed. Work at moderate level of quality. Or Nearly all tasks for lesson or activity completed. Work at high level with maximal effort put forth by student.
5	All tasks for lesson or activity completed. Work at high level with maximal effort put forth by student

My Role as a Researcher

For this study, my intent was to act as a non-participant researcher conducting observations during BZL weeks as a natural observer (Miles *et al.* 2014; Price *et al.* 2017). It became quickly evident during my first round of data collection that it was not possible to be a purely natural observer during all activities due to BZL culture. During the BZL, teachers elicit the support of zoo staff, docents, and parents to maximize the learning experience for students. On several occasions, I was asked by teachers to explain something to the class that they were unsure, or to assist, if possible, with a lesson because of an issue with a missing chaperone or other logistical issue. These occurrences were noted in both my daily journals and scripted observations. I believe that refusal to assist in either of these situations would have harmed the relationship between teacher and researcher that allowed for the openness and honesty I desired (Talbert, 1970). While these instances may have limited the scripted observation data collection when they occurred, I believe that the benefits of these occurrences outweighed the potential lost data.

My continual presence during the BZL week also contributed to a high level of comfort with the students. There were several occasions when students asked me for assistance regarding an activity in which they were engaged and numerous times when students approached me during transition periods between activities to discuss what they had just observed or learned that they were excited about. These transition periods could last up to 10 minutes, depending on the physical space between the sites for activities. During these instances I acted as a participant observer to build and maintain the comfort level with my presence and maintain trust with the students (Talbert, 1970). I believe that the students' comfort level with my presence due to these interactions provided insights captured in daily journals that were not otherwise possible, and allowed students to behave as they would have without my presence during observations.

During the daily animal observations, I maintained a clear role as a natural or non-participant observer for several reasons (Miles *et al.* 2014; Price *et al.* 2017). First, I felt that interactions with students, parent chaperones, or teachers during this time could influence behavior and thus provide an inaccurate account of typical student behavior. Second, I felt that interactions with students, parent chaperones, or teachers could change the climate of the activity and inadvertently give students permission to engage in conversation during their observation activity, although they had been instructed to sit quietly and observe their animal for one-hour.

Lastly, interactions with students would likely result in missed data collection during a time when I was collecting student behavior data through instantaneous ethograms and contextual data through scripted observations.

The methods used in this research were grounded in the constructivist epistemology. Constructivism argues that learners generate knowledge and meaning through the interactions of their ideas and their experiences. The data collection procedures utilized in this research were designed to observe these learning experiences and identify student's ideas through interviews and student artifacts. Daily journals and student behavioral data were collected to provide additional information and context to help understand this complex program.

CHAPTER 4: RESULTS

Data were collected through a combination of pre- and post-BZL student and teacher interviews, scripted observations of classes during their BZL lessons, student behavioral data during animal observations, student artifacts, and participant observational journals. Results from each of these individual sets of data are presented in this chapter.

BZL Week Observations

Student Behavior During Animal Observations

Student behavior data collected during the students' daily one-hour live animal observations yielded 2,537 total data points involving a total of 48 focal students (Table 4). Data points were then analyzed for each class, in total, and as comparisons between teacher-designated student achievement levels (high, medium, and low) and data collection Rounds 1 and 2. Each data point represents the instantaneous behavior of a single student at each one-minute time intervals using the ethogram shown in Table 2.

Student Behavior by Class

The total number of data collections varied between classes due to several factors, including proximity of focal students to one another, total time spent on daily animal observation activities, and occasional student or researcher absences.

Table 4. *Total Number of Focal Student Observations by Class and Behavior Category*

	A	B	C	D	E	F	G	H	Total
Total I	163	104	74	221	151	174	211	120	1218
Total X	62	65	52	43	21	15	23	15	296
Total O	27	54	58	37	105	137	88	135	641
Total o	0	25	37	9	20	14	4	1	110
Total T	14	14	19	49	27	47	45	22	237
Total t	11	0	1	11	8	0	0	4	35
Total	277	262	241	370	332	387	371	297	2537

Note: Each observation of student behavior at one-minute time intervals was combined for all five days of live animal observations for each class.

Instantaneous ethograms can provide indications of the percentage of time spent engaging in types of behavior (Bexell *et al.*, 2013; Kline, 2017). The percentage of on-task behavior during animal observations ranged from 62.7% in Class C to 93.3% in Class H, and averaged 81.1% across all classes (Table 5).

A chi-squared test was used to test the Null hypothesis: *The probability of a student displaying on-task behavior was independent of the school group to which they belonged*. The null hypothesis was rejected with a chi-squared stat of 212.7, which corresponds to a $p<.001$. The chi-squared test thus supported the hypothesis that a student's probability of displaying on-task behavior was affected by the school group to which they belonged. This corresponds to a time-off-task value of 19.9% on average, considerably less than the 25-50% observed in previous research (Karweit & Slavin, 1981; Godwin & Fisher, 2011). Classes of teachers that described mandatory formal parent training programs in pre-interviews (D, E, F, G) had at least 83% on-task behaviors during daily animal observations, while those that used parent chaperones without mandatory training (A, B, C) had 73.6% or lower on-task behaviors during daily animal observations. Qualitative data from scripted observations, student and teacher interviews, and student artifacts discussed later were used to suggest potential reasons for these differences.

Table 5. *On-task and Off-task Behavior by Class*

Behaviors	A	B	C	D	E	F	G	H	Avg.
I + O + T (on-task)	0.736	0.656	0.627	0.830	0.852	0.924	0.927	0.933	0.811
X + o + t (off-task)	0.264	0.344	0.373	0.170	0.148	0.076	0.073	0.067	0.189

Note: The total proportion of time represented as a decimal for each class A-H was determined by dividing the total number or On-task behaviors observed at one-minute intervals (I, O, T) divided by the total number of observations for each class.

A significant difference was found between on-task behavior of low achievement students compared to both medium and high achievement students ($p<.001$). Low achievement students displayed on-task behavior 69.6% of the time compared to 85.7% and 88.4% for the medium and high achievement students, respectively (Table 6).

Table 6. *On-task vs Off-task Behavior per Teacher-Designated Achievement Level (AL) per Class*

AL Behaviors	A	B	C	D	E	F	G	H	Avg.
H (I + O + T) on-task	0.974	0.681	0.695	0.909	0.931	0.977	1.000	0.906	0.884
H (X + o + t) off-task	0.026	0.319	0.305	0.091	0.069	0.023	0.000	0.094	0.116
M (I + O + T) on-task	0.851	0.722	0.764	0.724	0.915	0.990	0.898	0.988	0.857
M (X + o + t) off-task	0.149	0.278	0.236	0.276	0.085	0.010	0.102	0.012	0.143
L (I + O + T) on-task	0.434	0.583	0.363	0.837	0.711	0.834	0.889	0.915	0.696
L (X + o + t) off-task	0.566	0.417	0.638	0.163	0.289	0.166	0.111	0.085	0.304

Note: The proportion of time represented in decimal form for each teacher designated achievement level for each class A-H was determined by dividing the number of On-task behaviors (I, O, T) observed at precise one-minute time intervals for that group by the total number of behaviors observed for that group.

Comparing Round 1 to Round 2, significant differences in on-task versus off-task behavior were observed. Table 7 shows that Round 2 students displayed on-task behaviors 90.9% of the time compared to 71.2% of the time for Round 1 students. This difference of 19.7% was significant ($p<.001$) as determined by chi-squared test used to test the Null hypothesis: *The students' percentage of on-task behavior is independent having pre-observation instruction.*

Table 7. *On-task vs Off-task Behavior Comparison Without Pre-Observation Training vs. With Pre-Observation Training*

Behavior	Round 1	Round 2	Difference
I + O + T (on-task)	0.712	0.909	-0.197
X + o + t (off-task)	0.288	0.091	0.197

Note: The proportion of On-task behaviors represented in decimal form was determined for each round by dividing the number of number of On-task behaviors (I, O, T) observed at precise one-minute time intervals observed for each round (Round 1 classes A-D, Round 2 classes E-H) by the total number of behaviors observed for that round.

Preliminary interviews and anecdotal evidence indicated that engagement of teacher designated low-performing students would be significantly different from medium- or high-performing students. It was hypothesized that the engagement gap between low, medium, and high students would be reduced because of the active learning environment provided during the BIG Zoo Lesson. Table 8 shows the engagement levels of low, medium, and high students for both Rounds. Analysis utilizing the z-test within each round found a significant difference in percentage of on-task behaviors between high and medium achievement students for Round 1 ($p=0.031$) but not for Round 2 ($p=0.055$). Significant differences ($p<0.001$) were found when comparing percentage of on-task behaviors between high and low, and medium and low, for both Round 1 and Round 2 students.

High, medium, and low students in Round 1 displayed an average engagement of 83.8%, 78.3%, and 54.5%, respectively, with significant differences between high and medium (5.5%, $p=0.031$), high and low (29.3%, $p<0.001$) and medium and low (23.8%, $p<0.001$). A much smaller difference was found between the average engagement percentage between high, medium, and low students in Round 2 (Table 8). High, medium, and low students in Round 2 displayed average engagements of 95.6%, 93.2%, and 84.6% respectively. The difference between high and medium student engagement was not significant (2.4%, $p=0.055$), but the difference between high and low (11%, $p<0.001$) and medium and low were both significant (8.36%, $p<0.001$). While significant differences between student engagement by performance level were observed in both Round 1 and Round 2 students with only one exception, the percentage differences between groups were much greater in Round 1 than in Round 2. This indicates a meaningful difference in engagement for students at all levels after participation in the lesson on collecting data during live animal observations (Table 8).

Comparing achievement levels between the two rounds, additional significant differences were observed. On-task engagement levels for all three achievement levels were significantly higher in Round 2 compared to Round 1 (Table 8). High, medium, and low students in Round 2 displayed engagement levels 11.9% ($p<0.001$), 14.9% ($p<0.001$), and 30.0% ($p<0.001$) higher, respectively, than their Round 1 counterparts.

Table 8. *Relative Occurrence of On-task vs Off-task Behavior by Achievement Level (AL) and Round*

AL (Behavior)	Round 1	Round 2	Difference
H (I + O + T) on-task	0.838	0.956	-0.119
H (X + o + t) off-task	0.162	0.044	0.119
M (I + O + T) on-task	0.783	0.932	-0.149
M (X + o + t) off-task	0.217	0.068	0.149
L (I + O + T) on-task	0.545	0.846	-0.300
L (X + o + t) off-task	0.455	0.154	0.300

Comparing Round 2 students to Round 1 students, an 18.1% (chi-square test, $p<0.001$) increase in time spent (34.2% vs. 16.1%) observing the students' appropriate animal was observed (Table 9).

Table 9. *Relative occurrence of student Behavior O (observing the assigned animal) in Rounds 1 and 2.*

Behavior	Round 1	Round 2	Difference
O	0.161	0.342	-0.181

When active observation time was compared by achievement level, significant differences also were observed (Table 10). Round 1 high-achieving students spent an average of 21.5% of their time observing their animal compared to 34.1% for high-achieving Round 2 students, a 12.6% difference (chi-square test, $p<0.001$). The differences for low and medium achieving students were even higher with Round 1 medium achieving students spending 16.5% of their time compared to 40.9% for Round 2 students, and 10.6% for Round 1 low achieving students compared to 28.8% for Round 2, a 24.4% ($p<0.001$) and 18.3% ($p<0.001$) difference for medium and low achieving students, respectively. Again, while there are clear correlations between being taught how to collect data through live animal observations and time spent observing their observation animal, the reasons why this was observed are unclear. Student artifacts scores based on task completion rate and level of effort as described in Table 3, did not demonstrate significant differences in student tasks that could explain these differences.

Table 10. *Relative occurrence of student Behavior O (observing the assigned animal) by achievement level (AL) in Rounds 1 and 2.*

AL	Round 1	Round 2	Difference
H	0.215	0.341	-0.126
M	0.165	0.409	-0.244
L	0.106	0.289	-0.183

Note: The proportion of time students spent observing their assigned observation animal for each teacher designated achievement level of students in each round (Round 1 classes A-D, Round 2 classes E-H) was calculated by dividing the total number of observations of students observing their assigned animal at precise one-minute intervals by the total number of behavioral observations for each teacher-designated achievement level in each round.

Interviews

Teacher Interviews

Pre-BZL Week Teacher Interviews

Eight of nine teachers who participated in the research had previously participated in the BIG Zoo Lesson at least the previous year, but the number of years they had participated varied considerably from as little as 2 years up to 13 years. The ninth teacher had participated in another BIG Lesson program (Annie's BIG Nature Lesson) the previous 6 years, but this was her first experience with the BZL. The number of years that a teacher participated in the program was more dependent on that teacher's teaching position rather than a willingness to participate in the program. It was clear that participation in the BZL was firmly established into grade level cultures of participating schools and that most teachers new to the program were simply new to that teaching position.

Analysis of pre-BZL teacher interviews yielded several common themes and subthemes, listed in Table 11 and described more fully in the subsections following Table 11.

Themes and Subthemes from Teacher Pre-BZL Interviews

Table 11. *Themes and Subthemes Derived from Pre-BZL Teacher Interviews*

Pre-BZL Teacher Interview Themes	Subthemes
Program Design	Teacher Choice Teacher Support
Learning Opportunities	Active Differentiated Cooperative Experiential
Curriculum Focus	Multidisciplinary Science Teaching

Note: Themes and subthemes were determined through the inductive coding process of the pre-BZL teacher interview transcripts.

Program Design

Teachers spoke positively about the design of the BZL program based predominantly on support they received from BZL and zoo staff (BZL Program Director, Education Curator, Assistant Education Curator, docents, and zookeepers), program flexibility, and choices provided to teachers. Teachers felt they were supported at high levels by BZL and zoo education staff.

Several teachers noted how well the training their first year in the program prepared them to be successful. A teacher in the third year of the program noted her experience beginning the BIG Zoo Lesson:

> *The first year we had no idea what we were getting ourselves into. We went to, when I say we, I mean ___ and I. We went to the training and thought it was really cool and were excited to see what it was going to look like. Had a lot of guidance from Margaret and the whole Big Zoo Lesson team and just making sure that we were prepared as much as we could be for the week and felt pretty confident in that. The week went by really well just because of all the advanced planning beforehand.*

It was also noted by several teachers that, as they had participated in successive years, the staff was willing to work with them in both development and implementation of new lessons. A teacher who had participated in the program for over 10 years noted, “Margaret is great about working with us when we want to try something new, either a new lesson or change up one we have been doing for a while.”

All teachers spoke positively regarding the support they were provided and gave the impression that they felt comfortable asking for additional support if they believed they needed it. Teachers also spoke positively about teacher choice regarding the development of their BZL week curriculum. They enjoyed the choice and flexibility they were given regarding the available lessons for the program and their ability to develop and implement their own lessons should they choose to do so.

Learning Opportunities

Teachers spoke often about learning opportunities the BZL program provided their students. Several teachers expressed how the less-structured learning environment allowed for more differentiated learning and opportunities for students who did not excel in the traditional learning environment. These ideas were expressed both in the context of what they believed was possible and what they had observed with other students in the past. Several teachers also focused on how getting out of the classroom and having freedom to move around and learn through experiences was important to their students' development. Many teachers expressed their belief that this opportunity provided experiences that their students would not otherwise have outside of this program. Teachers also expressed how the change in learning environment would also change their role as a teacher. One teacher stated, "I enjoy that I can learn along with them and take a step back from being the one with all the answers." These teachers recognized that lessons during the BZL were more student-focused. The role of the teacher was to provide a learning environment in which students could explore ideas on their own. When asked how she believed her students would benefit from participating in the BIG Zoo Lesson, one teacher replied:

> *Asking more questions, why questions, deeper thinker, higher depth of knowledge type stuff and then also I'm hoping that it will teach them to be critical thinkers, problem solvers, because I would like them to look, look at the enclosure, why is it designed this way, how can I figure out why they did this, this way and think about finding some of their answers on their own being intrinsically motivated.*

In this way teachers acted as facilitators of learning experiences rather than repositories of knowledge to be passed along. During docent-led lessons, teachers' roles changed again because they could be co-learners alongside their students. Several teachers expressed how they continued to learn new things even after participating in the BZL for several years and how the BZL helped them be better teachers. When asked if she thought participating in the BZL was going to help improve her teaching, one teacher replied:

It always does. It makes me, I enjoy it. I enjoy teaching more because I get to do this. I am sad when Friday comes; I wish I could do it more. It has influenced me in how I have kids approach things, I use some of the strategies like Wows and Wonders, I use for all kind of different things, especially with our new Wonders program. It just fits so well. Every week we are wondering about something new and I kind of approach it with the big lesson mindset. It makes me want to get, it shows me that you can do, kids are capable of so much more than sitting at their desk and filling in the blanks. I can learn from them as well as we can go out and do things. We can get ourselves involved in projects and we can learn by doing things that are non-traditional.

Lastly, many teachers believed this experience would help their students learn how to work together and learn cooperatively more than they do in the typical classroom environment. Collectively, the learning opportunities the BZL provided students seemed to be a significant reason that teachers felt positively about their BZL participation.

Curriculum Focus

Two dominant subthemes emerged when teachers discussed the focus of their BZL week curriculum. First, all teachers expressed how they incorporated a multidisciplinary curriculum focus into their lessons during their week at the zoo and were clear that their focus was not simply on science. One of the parochial schoolteachers expressed how she integrated several subjects into their week at the zoo:

We can integrate anything so being at Christian school we were able to talk about God's creation so that's one of the teacher-led lessons we do is just incorporating how all of these things are good and beautiful and God created them, so that's really cool to do that and have that ability to do that. Obviously, science we are doing it all week long and *writing, kids have a purpose for writing and it's not just here's a question now answer it, rather this is your investigation, your animal, you're observing so there's a purpose for the writing that they are able to share. So that's been really neat to see even students who don't enjoy writing in class actually enjoy writing and wanting to take notes or draw sketches, so the art comes into that as well of drawing sketches zooming into things, as well as math hopefully this year we will do it even more of learning how to create data and comparing it, keeping track of maybe time during an observation and just showing information in that way. Obviously reading, anything that we do there a lot of signs or walking around the zoo with animals. History, we even learn a little bit of the history of the zoo and animals and extinction and so all of those just every aspect of teaching is brought out in the Big Zoo Lesson.*

Literacy was the most prominent cross-curricular focus, with several different forms of writing and literacy skills being emphasized. Teachers also connected lessons to concepts in math, social studies, and art to lesser degrees. This was to be expected because all participating classes were middle and upper elementary classes for which a single teacher was responsible for teaching core subjects of literacy, math, science, and social studies. Interestingly, most teachers expressed how the BZL week was their primary time to focus on science for the school year.

These teachers explained that the elementary education focus on literacy and math left them very little time to teach science, and that they were using their BZL week as the foundation of their science instruction for the school year. One teacher explained:

It's prioritized that we cover all of the reading and math standards first and we also have especially with reading we are supposed to be spending a certain amount of time on reading per day and math so by the time that we do all of those things, we figured it out *that there would be no break, no recess, and like very minimal transition time in order to fit in science…..So I try to do it overlapping with our reading program,…but obviously there is no time to go into any level of depth with it because the next week we are moving on to something else.*

Pre-BZL Teacher Interview Takeaways

Overall, the pre-BZL teacher interviews were overwhelmingly positive and filled with hopeful and encouraging ideas regarding learning experiences they expected for their students. It was clear that these teachers felt strongly that their students would benefit significantly from their week at the zoo and that this program was providing both opportunities and resources that would not have been available in a classroom setting.

Post-BZL Week Teacher Interviews

These interviews focused on the teachers' perceptions of their week at the zoo, future participation in BZL, and changes they would make if they were to participate next year. Several themes and subthemes were identified after coding these interviews. (see Table 12).

Themes and Subthemes from Teacher Post-BZL Interviews

Table 12. *Themes and Subthemes from Post-BZL Teacher Interviews*

Post-BZL Teacher Interview Themes	Subthemes
Effective Lessons	Active Learning Hands-on Learning Live Animals
Pedagogy	Facilitator Co-Learner

	Feedback
Experience	Valuable Beyond Learning Objectives Repeat

Note: Themes and subthemes were determined through the inductive coding process of the post-BZL teacher interview transcripts.

Effective Lessons

The lessons that teachers believed were most effective, described in Appendix N, fell into two distinct categories: active learning lessons and lessons that included live animals. These same two lesson types were also the most referenced in student interviews as lessons which were their favorites or in descriptions of what they had learned.

The active learning lessons most often referenced were the bird beak tool lesson, the pelts camouflage lesson, and the mammal skull lesson. Only the pelts camouflage lesson was truly hands-on, during which students were able to carefully touch the pelts. The bird beak lesson and the mammal skulls lesson both included delicate objects that students were able to investigate closely, although they could not physically touch the items. All three lessons were student-led investigations during which small groups of students worked together to determine characteristics of the animal artifacts and develop conclusions based upon those characteristics. All three lessons included animal artifacts that few elementary teachers would have access to in their classrooms. As one teacher expressed, “And that I think is a powerful way to teach, it’s not just to give a lecture, but also to see things, to touch it, um to sort of wrap our mind around, what does this look like in the real life.” Many teachers expressed how these experiences could exist only at the zoo because these resources directly contributed to the effectiveness of these lessons.

Lessons that included live animals also were perceived by teachers as effective and engaging. For the Round 1 classes, this was overwhelmingly the *Rhino Encounter lesson*, which provided students the opportunity to physically touch a live female black rhino. This lesson was always given on the Friday of their BZL week because, as teachers noted, it is difficult to top touching a live black rhino. As one teacher explained in her post interview:

> *Getting to touch a black rhino is a once-in-a-lifetime experience that most people will never get. It is one thing to see an animal up close, but it is another when it is just the student and the zookeeper, and they get to touch her horn and rub the top of her lip. They really seem to connect with the rhino after that. That experience is powerful and something they will never forget.*

Round 2 classes also participated in this lesson, but direct contact with the black rhino was prohibited because of the rhino's advanced pregnancy. Consequently, no Round 2 teachers included the Rhino Encounter lesson as one they perceived as a student favorite, highly engaging, or highly effective.

For Round 2 classes, the docent-led animal encounters were perceived to be among the most effective and engaging lessons. The two animal encounter lessons referenced were the physical and behavioral adaptations lesson, which included six or seven species that varied across presentations, and the animal encounter lesson that included a Eurasian eagle owl. While students were not allowed to physically touch the animals, they were within a few feet of them during the presentation. When asked which activities were most engaging for her students, one teacher replied:

> *Oh, the animal lessons that the docents shared with the live animals; obviously that was a highlight because kids got to learn about new animals or reptiles that they might not have*

exposure to on a regular basis like the blue tongue lizard …and the Eurasian Eagle Owl as well, being able to ask questions, those were a lot of their highlights.

The daily animal observation lessons also were referenced by several teachers who believed they were highly effective. These teachers commented on how engaging the animal observations were, based on the level of detail they observed in many student drawings of these animals, and on how excited their students were to teach their peers about their animal. One teacher also talked about how her students bonded strongly with their observation animals, and how this emotional bond caused them to experience the SSP (species survival plan) lesson differently than expected.

The observation time helped them to build a connection with their animal so um they just kind of bonded with their animal and then the SSP. I think it was surprising to them then because they had bonded with their animal to realize the dangers in the world that affect their animal, so it gave them that emotional connection, so it made them feel like a higher level of concern. We had the SSP lesson later in the week and I think that they were really surprised, so I even had kids last night told me they were meeting at the park at 6 o'clock to clean up trash.

Pedagogy

Teacher post-interviews shared common themes related to pedagogy. Common among nearly all teachers was a recognition of how their role changed during their week at the zoo. These role changes were expressed in two different ways. Many of the teachers recognized that they became much more a facilitator of learning experiences and less a disseminator of knowledge. Teachers who recognized this role change generally embraced and enjoyed it. The second common way that many of the teachers expressed the change in their role was as co-learners alongside their students. These teachers expressed how learning alongside their students changed the student-teacher dynamic and improved relationships between them and the students. One teacher said that "Learning alongside my students helps them see that sometimes I don't have all the answers, and that's OK." Another teacher said "I think the BIG Zoo Lesson helped me get to know my students much better. In this environment, in the classroom, they act one way. At the zoo, though, I saw a lot of them come out of their shell. I also had the chance to get to know them better, which is going to help me the rest of the year."

Most teachers stated that they provided feedback in some way to students daily in their BZL journals. The mechanisms of feedback differed significantly between teachers. Some teachers provided quantitative feedback through a numerical scale that assessed their perceived amount of student effort and expectations met, others provided short written feedback, and others provided recognition to only a select few high performing, or significantly improved students for that day. Most feedback focused on daily animal observations. Teachers commented on the difficulty in providing significant feedback during their BZL week due to time constraints, with several teachers stating that they spent hours providing feedback each evening of the zoo week. Teachers who provided significant feedback felt that this was important because it clarified expectations for upcoming lessons and improved student performance through the BZL week.

Experience

All nine of the participating teachers believed that the benefits of the BZL program, given the learning opportunities and experiences it provided, outweighed their time out of the classroom and the program's financial costs. Their reasoning included access to resources they otherwise could not access, learning experiences they could not mimic within the constraints of the classroom, and learning opportunities that addressed both formal learning objectives and experiential learning outside of these objectives. All nine of the participating teachers expressed their desire to continue to participate in the BZL the following year.

Post-BZL Teacher Interview Takeaways

Teachers indicated that active learning lessons and lessons that included close contact with live animals were the most effective and enjoyable lessons for students. The pedagogy changes for the BZL lessons included teacher roles moving to co-learners and facilitators of learning experiences, a welcome shift for all teachers. All teachers expressed that the costs, both financial and in time out of the classroom, were outweighed by the benefits of the program, which extended beyond the formal learning objectives addressed and reinforced their desire to continue their participation in the BZL the subsequent year.

Student Interviews

Pre-BZL week Student Interviews

The student pre-BZL week interviews were designed to obtain contextual information regarding the students' previous experiences learning science, with field trips, with zoos, and their prior knowledge about their individual observation animal species. These interviews yielded several prominent themes, as listed below in Table 13.

Themes and Subthemes from Pre-BZL Student Interviews

Table 13. *Themes and Subthemes Derived from Pre-BZL Focal Student Interviews*

Pre-BZL Student Interview Themes	Subthemes
Science Learning	Previous learning Positive attitude Learning methods
Field trips	Memorable

	Learning vs Recreational
Zoos	Previous Experiences Expectations
Observation Animal	Prior Knowledge Connectedness

Note: Themes and subthemes were determined through the inductive coding process of the 48 pre-BZL student interview transcripts.

Science Learning

Student answers provided several insights regarding their previous experiences learning science and how they felt about learning science. Most students spoke positively about their learning experiences, often saying that they "liked science" and "science was fun." However, many of them had difficulty explaining why they liked science or what made it fun. Students would use examples of a demonstration that was performed in class or cited something that they watched on a video during science instruction. Students from several different schools referenced a video series "Mystery Doug" where different topics were explored by "Doug" in what, from their descriptions, seemed like a scientific method. They were able to explain the specific concepts that, at least in their minds, were the focus of that lesson. Most of what they said seemed factually accurate, but none of the students described a scenario in which they were carrying out an investigation, collecting data, analyzing data, or any of the typical characteristics of a lesson in which students are "doing science." There was also significant overlap across science learning experiences discussed by students in the same class, indicating that either science instructional time was limited to a small number of lessons or that only a small number of lessons were memorable. While students had positive associations with learning science, their science instructional time was limited, and they had minimal opportunities to conduct their own investigations.

Field trip Experience

Field trips were memorable events that all interviewed students had experienced prior to the BZL. All 48 students were able to explain in detail one of the previous field trips in which they had participated. Several students explained multiple field trips from both their current grade and previous grades, often going back several years. They spoke positively about these field trips and generally focused on a singular event that had made an impression on them and created a strong memory. The field trip stories varied, with some overlap between students in the same class. Types of field trips varied, including to cider mills, historical villages, historical museums, science museums, and nature centers. Accounts often focused on recreational aspects of the field trip, but in several cases conceptual knowledge in social studies or science clearly was built during that experience, evidenced by students' ability to explain concepts learned in some cases years after the field trip occurred. While it was clear that the field trip experience was memorable, the impact on learning derived from formal education concepts appeared to be mixed and is presented later in student post-interview results.

Zoo Experiences

All 48 interviewed students had some experience visiting a zoo that they could remember, and most of them recalled several experiences visiting zoos. Most students recalled experiences involving zoo trips with either immediate or extended family members. Many students described the last time they visited the Potter Park Zoo (BZL study site) and were familiar with the layout and many species displayed there. Several students also described visiting zoos in other locations around the state or zoos in other states. Interestingly, on several occasions, students described observing species not housed or displayed at those zoos, at least not within their lifetimes. On several occasions, students combined experiences from multiple zoo visits at different zoos, describing animals that occur at several different zoos in what was described as a single trip with their family. Student descriptions of these zoo visits included when they saw an animal, but rarely included what they observed the animal doing or what they learned about that animal during their visit. It appeared that zoo visits were not a novel experience for these students; however, their previous zoo visits were fundamentally recreational.

The pre-BZL interviews demonstrated that students' expectations of what they were about to see and learn at the zoo focused more on educational experiences. Most students listed different species that they expected to see at the zoo. These lists were often very similar to the list of animals given to teachers for animals that students could observe during their daily one-hour observations. Several students also listed species they were expecting to see at the zoo that were not housed at the zoo and had not been during their lifetime. These species included charismatic megafauna associated with zoos, including giraffes, elephants, gorillas, and bears. It is unclear if these expectations were the result of a generic idea of species found at a zoo, or if students were combining previous experiences from other zoos in their expectations.

Student expectations of what they were going to learn at the zoo was mostly information about the animals, what they ate, where they lived, how they hunted, how long they can live, how big they are, etc. Eight students, however, did focus on what they could learn by observing their daily observation animal. These expectations were predominantly behavior-focused and indicated some base level of knowledge of their species. One of these students who observed wolves stated, "I think I am going to learn what they do all day. What they eat, and um if they fight with each other." Another student who observed penguins stated, "I am going to learn how the penguins act in the snow. It is supposed to snow next week, and I think they are gonna like that. I don't know they might not, but they like it cold so." While most students' previous experiences with zoos were clearly recreationally focused, they also had clearly internalized that the focus during this week-long field trip was expected to be educational.

Observation Animal

Several factors seemed to impact students' prior knowledge and personal connection to their daily observation animal. At the time of the pre-BZL interviews, six of the eight classes of students had already been assigned their observation animals. Most who had been assigned an animal were able to provide information, including where they are found, their habitat type, what they eat, and conservation status. One student who would observe the red pandas explained, "Red pandas are an endangered species. They live in Asia in the mountains, the Himalayas, I think. They mostly eat bamboo but also fruits, small lizards, and bugs." This information was factually correct and one example of a student who seemed well informed about their species prior to their BZL week.

While most of these accounts were factually correct, several students explained things that they "knew" about their animal that were inaccurate. One student who observed the tigers said "They live in jungles in Africa, I think. They eat gazelles and zebras and giraffes." He was obviously confusing lions and tigers. A few students who made errors about their animals referenced Africa as where their animal lived. It appeared that for many students Africa was associated with exotic animals. The source of these inaccuracies was unclear. They may have confused species, or may have tried to impress the interviewer with their knowledge and resorted to guessing. Students who had been assigned their observation animal before the pre-BZL interview clearly had some level of background knowledge about their species.

It appeared that student choice regarding their observational animal was personally very important. Teachers had explained in their interviews that they did their best to assign students one of their top choices to promote buy-in and student interest in their species. This strategy seemed to be effective prior to the BZL week, as most students were excited to tell the interviewer about their animal and how excited they were to learn more about it. In one significant occurrence, a student adamantly expressed his displeasure with being assigned the lions instead of his favorite animal, the tiger. This student explained several times during the interview that he did not know much about lions, but that he did know a lot about tigers. When asked what he knew about lions, he responded:

> *I don't know anything about lions. Tigers are my favorite animals. I know that tigers live in Asia. There're different kinds of tigers like Bengal tigers and Siberian tigers. Siberian tigers are my favorite, they are the biggest tigers.*

This negative attitude significantly impacted that student's buy-in during the BZL week. He spent little time on-task during animal observations, refused to present about lions during the *Junior Docent Activity* that concluded the BZL week, and also refused to discuss what he learned about lions, instead choosing to refocus the conversation toward his knowledge about tigers. "I didn't learn anything about lions, I didn't want to learn about lions. I wanted to learn more about tigers. I learned that the two tigers at the zoo are the dad and one of his daughters…" the student explained when asked what he learned about his observation animal during his week at the zoo. Artifacts from this student displayed lower engagement in animal observation daily tasks compared to class peers, and ethogram-recorded student behavior showed lower engagement due to significant off-task behavior, both suggesting significant impacts to this child's learning process. This student accounted for 71% of the observation of animals other than assigned observation animal (o) and 47% of the general off-task observed behavior for this student's class (n=6). Student choice was clearly important to this student and appeared to facilitate buy-in for other students.

Pre-BZL Student Interview Takeaways

While the participating students had previous experience with both field trips and zoos, the focus of these experiences from student descriptions appeared to be largely recreational. Participating elementary students had previous science learning experiences, but they appeared to have little experience conducting scientific investigations. Most students' science learning experiences consisted primarily of watching other people "do science" in videos, or less commonly, in teacher demonstrations. Students who were assigned their observation animals prior to pre-BZL interviews had background knowledge about their animal that was predominantly accurate. Student choice in selection of their daily observation species appeared to have significant impact on level and direction of student buy-in, especially when the student was not assigned his first choice.

Post-BZL Week Student Interviews

Student post-interviews focused on their perceptions of their experiences at the zoo, learning and learning experiences, and their desire to visit the zoo in the future. After analysis of these interviews, several themes and subthemes emerged (Table 14).

Themes and Subthemes from Post-BZL Student Interviews

Table 14. *Themes and Subthemes Derived from Post-BZL Student Interviews*

Post-BZL Student Interview Themes	Subthemes
Effective Lessons	Active Learning Hands-on

	Live Animals
Learning Animal Observations	Animal Facts Observered Behavior
Perception of Learning	Helped learn science Factual information Conservation, Zoo Roles
Experience	Positive Return to observe/learn more Return to teach family

Note: Themes and subthemes were determined through the inductive coding process of the post-BZL student interview transcripts.

Effective Lessons

There was significant overlap between what teachers and students perceived to be effective lessons. Student favorite lessons often involved active learning, live animals, or both. Students identified the *pelt lesson*, *mammalian skull lesson*, *rhino encounter*, and *daily animal observations* most often as their favorite activities. When asked why these were their favorites, most students said that it was because they were doing things, seeing things they could not otherwise see, or having experiences that were unique or could not happen at their school. One student explained, "I really liked the skulls lesson, I liked drawing them and guessing what kind of animal they were. I got most of them right." Several students made comments regarding the animal encounter docent-led lessons. One student explained "I really liked the lesson with the snake, and the blue-tongued lizard, and the box turtle and the ferret. We got to learn about camouflage, and it was really cool to see them up close."

In the Round 1 classes, the most often identified activity was the rhino encounter (n=15 of 24). It appeared that the opportunity to have physical contact with the female black rhino was a significant experience for many students. No Round 2 students, who had no opportunity to touch the female rhino, considered the Rhino Encounter as their favorite activity (n=0 of 24). Instead, Round 2 students most often identified daily animal observations to have been their favorite activity (n=13 of 24). When students did not identify either the rhino encounter or the daily animal observations as their favorite lesson, most stated that the active learning activities, including the mammalian skull lesson and the pelt lesson, were their favorite.

Learning Animal Observations

When asked what they learned about their animal during their daily animal observations, most information referenced by students was what they had learned from their research. A good example was a student who discussed what she learned about the arctic fox:

> *I remember the arctic fox sometimes follows polar bears and takes their leftovers. Um, I remember that the arctic fox likes to hide if they hear something coming then they just start to hide just in case it is a predator because in the arctic in the snow the arctic fox blends in with the snow when it starts to lie down, puts the tail over its face so it won't see the black on it and in the summer for other predators it camouflages. It turns to brown so it can blend in with the trees and the mud so other predators won't see it.*

It is unclear if this knowledge was obtained prior to their week at the zoo, from signage, the pelts lesson, or during post-BZL projects. What is clear is that this information was not learned through the observation of the arctic foxes in their exhibit. Some students learned from direct animal observations such as: "the penguins spent more time in the water when it was colder than they did when it was warmer." and another said, "the girl peacocks spent most of their time near the reptile house while the boy peacocks were found all over the zoo." These two accounts appeared to be based on more than a single observed occurrence of a behavior. In several other cases, a single observed behavior was combined with information of unknown origin.

When asked what they learned about wolves during their observations at the zoo, one student answered:

> *That they eat anything from the size of an elk to a rabbit and they are at the top of the food chain nothing eats it but bears can necessarily kill wolf pups and they can kill wolf adults when if they are in a territorial fight and they get mad at each other, the bear will do that but also these animals just kill for food but necessarily don't do it that much. That from observing that they get excited when they see a, in captivity of course, they get excited seeing a keeper even when it's going to do another thing. Because the two brothers were like running around chasing each other and getting super excited like running at the walls and one of them actually ran into the wall. I learned on a sign that wolves were hunted to nearly extinction there were, and now there's only a couple more places including Michigan that you can actually see wolves in the wild. I'm pretty sure the other ones are Asia, I can only remember Asia, but Asia and Michigan I know you can see them in the wild so that's sad because they were, we can barely ever see wolves in the wild. I wouldn't want to see a wolf in the wild anyways but that's bad that we only have a couple wolves left in every place that they can be found.*

This student demonstrated a pattern in their answer similar to those of several students who included an observation of their animal in their description of learning. Their focus was most often on information gained from signage or from outside sources; however, they included a single anecdote about an observation they had made.

Perception of Learning

Nearly all students said that their participation in the BZL helped them to learn science. Why students believed the BZL helped them learn science varied. The most prominent reason cited by students was formulated well by one student:

> *We could observe the animals (at the zoo) like um and at school we wouldn't be able to we would just learn about it and write it down, learn about it and write it down, but at the zoo we could watch the animal and learn about, write it down, watch it again, learn about it, write it down, watch it again, watch it all over again and the animals were usually doing different things except for the mandrill Loco, he didn't do anything.*

When asked what they had learned or what they could remember from the zoo, most students identified information about animals, with very few students identifying broad ideas or conceptual knowledge. When conceptual knowledge was communicated, it most often was related to conservation and the role of zoos in conservation. While this concept was integrated into several different lessons in small amounts, it was the main topic of the "What do Zoos Do?" lesson, a Species Survival Plan (SSP)-focused presentation conducted by the BZL site coordinator. While this lesson was not perceived by teachers or students to be among the most impactful or engaging, it clearly had a lasting impact on some students.

Experience

Most students felt that the BZL experience helped them learn science. Nearly all students expressed the desire to return to the zoo soon. Their desire to return to the zoo was generally because they wanted to communicate what they had learned to their family members, or to learn more about either their observation animal or to have the opportunity to focus on another species for extended observations. When asked if there was anything that they wanted to spend more time doing at the zoo, most students wanted to spend more time directly observing animals.

Post-BZL Student Interview Takeaways

Student perceptions of effective lessons aligned significantly with teacher perceptions, and generally included lessons with proximity to or direct contact with animals, and/or active learning activities. While many students expressed their enjoyment of daily animal observations, few were able to demonstrate significant learning about their animal beyond information gleaned from signage and independent research. Students perceived their week at the zoo as a significant learning experience; however, most had difficulty demonstrating learning beyond the knowledge level, with few students demonstrating the acquisition of conceptual knowledge. This is exemplified by the responses of one student regarding what they remembered learning from the zoo.

> *I remember learning about their beak, the birds' beaks and their feet and how they can be grasping so that they can climb trees to get away from their predators and their beak can be like a piercing beak so that they can like pierce things. They pierce what they eat so it's not alive when they eat it...I remember learning that bird's bones are hollow so that they can fly easier. I learned in my observations that spider monkeys have a prehensile tail, like the rhinos have a prehensile lip. They can use them like a hand to grab things.*

This student clearly remembered interesting characteristics about the animals or artifacts they observed during their lessons. However, they did not make the connection that these features are physical adaptations which help the animals survive.

Most students expressed the desire to return to the zoo to either teach their family what they had learned or to acquire more information by observing animals.

Student Artifacts

Student artifacts included predominantly their BZL Week Journals, but also may have included additional worksheets or post-BZL projects. These artifacts were scored using the student artifact scoring rubric (Table 3) through several rounds, to ensure consistency. It was determined that the student artifacts related to the one-hour daily animal observations be separated from the other student artifacts because they could be cross referenced with student behavior data as well.

The number of artifacts created by each student during their BZL week was highly variable, ranging from as few as 10 pages to over 100 pages. These differences were influenced by various factors, including expectations of teachers, student behavior during activities, post-BZL week projects, and student effort and participation in activities. There was no correlation between teacher-determined performance level and number of pages per student.

Only one relationship was found between behavioral data during animal observations and student artifact output. Students observed off-task (X, o, t) greater than 50% of that day's animal observation rarely scored higher than a 2 that day's student artifact. No other relationships were found between student observed behavioral data during animal observations and animal observation student artifact scores.

Surprisingly, no relationships were found between teacher-determined student achievement levels and student artifact score of animal observation artifacts. This may have been due to the norming procedure for each student done by the researcher to account for student grade and ability level prior to scoring of student artifacts. There was also no relationship between the percentage of time a student spent observing their animal and the student artifact score for that day. It is unclear why no relationships were found, but this could be related to several factors including student-perceived teacher expectations, teacher-assigned observation tasks, and data collection procedures of student behavior data by the researcher.

Participant Observation Journals

The daily journal entries written by the researcher following each class's BZL week were analyzed through several rounds of coding. These journals were used to capture the researcher's perceptions from experiences of each day in a participant observation style. As such they helped me to identify trends across all classes and provide insight into prominent themes for each class of students.

Themes and Subthemes from Researcher's Daily Participant Observation Journal Entries

Table 15. *Themes and Subthemes from Daily Participant Observation Journal Entries*

Daily Participant Observation Themes	Subthemes
Time	Adherence to schedule Overscheduling
Teacher Expectations	Communication Feedback
Parents	Benefit Neutral Detriment

Note: Themes and subthemes were determined through the inductive coding process of the interviewer's daily participant observation journal entries.

Time

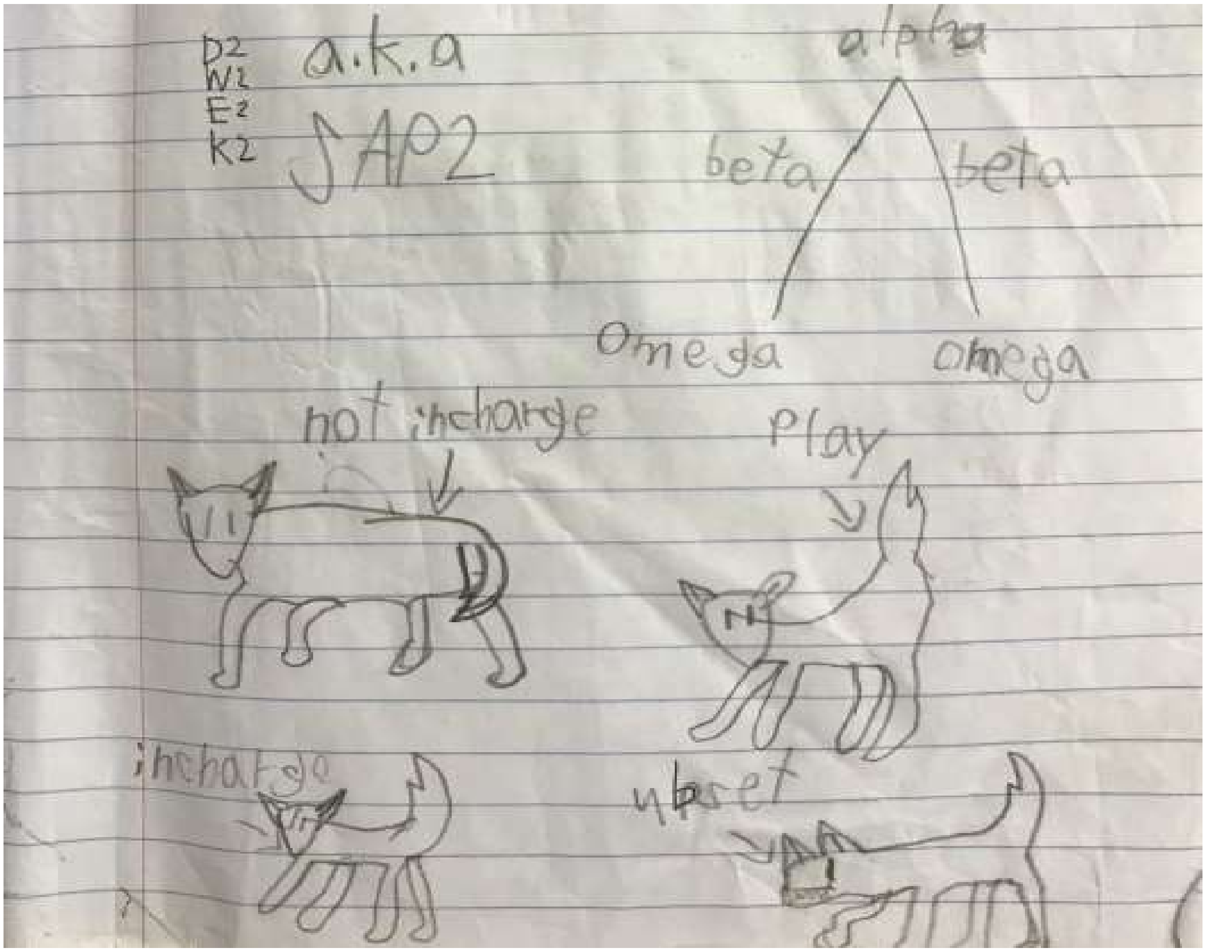
Teacher time management during the BZL week appeared to impact student learning in several ways. Each day's schedule of lessons was fixed for teachers, and was difficult to change for several reasons including scheduling conflicts surrounding room use, docent availability, and husbandry staff schedules. Therefore, events such as a late bus, returning late from a lesson, unscheduled bathroom breaks, or any number of potential occurrences significantly impacted available lesson time. Generally, teachers modified lessons as needed, but it resulted in instructional time loss on several occasions. The most likely blocks of time that were either cut short or cut out altogether were reflection opportunities scheduled after major lessons (animal observations, docent-led lessons, and live animal experiences.). These reflection opportunities were considered critical components of the BZL program by zoo education staff. Reducing or eliminating reflection activities likely reduced building knowledge and understanding for students.

Teacher Expectations

How a teacher's expectations were communicated to and perceived by students appeared to impact student learning. Most lessons included the teacher, who could redirect students as necessary and provide instantaneous feedback regarding students' focus, attention to detail, on-task behavior, and effort. However, during live animal observations, teachers were rarely in proximity of most students. Teachers moved around, checking on each group for a short time before moving to the next group. This seemed to make communication of clear expectations critical to a student's performance during animal observations.

When teachers took time to explain expectations and in some cases model these expectations, the detail of sketches in student journals and extent of task completion was higher. This was most evident with class H. Student journals showed that they had practiced making sketches from observations 12 times prior to beginning their week at the zoo. This class of students demonstrated overall high levels of details in their sketches, both of their daily observation animals and during other lessons and activities. An example showing the detail of these sketches, from the wolf encounter lesson, is in Figure 1. This third grade student sketched four wolves demonstrating how the ears, head, and tail placement show the social status of individual wolves and their intended interactions with other wolves.

Figure 1 *Student Artifact Example of Sketching Animal Behavior*



When parent chaperones were present for explanations of expectations, on-task behavior, detail in sketches, and completion of tasks increased even more. Making time to communicate teacher expectations had a positive impact on overall student learning experience, evident from student artifacts which scored nearly 1 point higher (0-5 scale) when teachers communicated expectations clearly prior to the lesson or activity.

Teacher feedback also affected student output and behavior during animal observations. Several teachers collected students' journals each day and provided written feedback and, at times, scored effort by the student. This process is likely time-consuming demonstrating that teachers believed it was an important use of their time. Several teachers also took opportunities during the week to present journals of students who had done particularly well on the previous day's animal observation to the class. When class feedback and praise were given regularly, student artifact scores assessing task completeness and effort increased over time for most students. Without regular feedback, students with low intrinsic motivation seemed to reduce their effort during subsequent animal observations characterized by lower averages scores of their student artifacts and greater time off-task during animal observations. It was clear that time and effort utilized by teachers to provide regular feedback positively affected both future student effort and on-task behavior.

Parents

Parent chaperones were one of the most important factors in student engagement and effort during animal observations. The addition of parent chaperones to the learning environment was beneficial, neutral, or detrimental depending on several factors. One Round 1 class (class D) came from a self-described "BIG Lesson School," because each grade participated in one of the BIG lessons each year: Annie's BIG Nature Lesson, BIG History Lesson, BIG Science Lesson, and the BIG Zoo Lesson. The teacher explained that, while they mandated all participating parent chaperones to attend a meeting before they could participate, most of these parents had chaperoned for other BIG Lessons and clearly understood their role. The behavior of parent chaperones, and consequently students, during animal observations reflected that parents fulfilled their role as co-teacher and co-learner consistent with the description of the BZL (BZL, 2018). Class D students displayed overall high on-task behavior, and significantly more parents were observed using teaching behaviors including redirection, modeling, providing feedback, and communicating or reinforcing expectations as documented through the scripted observations taken during daily animal observations.

Other classes also had parent chaperones who appeared to positively impact student learning demonstrated by higher levels of on-task behavior and higher student artifact scores. In several instances, chaperones were former educators and used teaching behaviors to manage student behavior and output. In other cases, particularly for some of the lower performing students, an increase in effort was observed when that student's parent was present. Several other parents who seemed known by students also helped to keep students on-task and meeting expectations. There did not seem to be a clear single determining factor that led to higher levels of on-task behavior or higher student artifact scores for students other than the parents' focus on education during the learning experience.

The presence of several parents seemed to have minimal impact on student learning. Many of the parents stayed back, in a position from which they could observe all the students to make sure that no students wandered away from their group. Student behavior was rarely addressed by these parents, and teacher behaviors such as modeling, redirection, communicating or reinforcing expectations, and providing feedback were rarely observed. Other than assuring students stayed safe and remained with the group, these parents appeared to have very little interaction with the student learning process during animal observations.

Several parent chaperone behaviors appeared to negatively affect the learning experience for students. Several parents were observed encouraging students to finish up their animal observations so that they could go on a tour of the zoo and see other exhibits. In several instances, parents focused heavily on taking pictures with students, presumably for social media use. There were also cases in which a student's behavior worsened when their parent attended as a chaperone, because the parent's perception of the activity appeared more recreation-oriented than education-oriented. In these cases, those students received lower student artifact scores and lower rates of on-task behaviors compared to days without their parent as a chaperone.

One teacher (H) who had participated in the BZL program the previous six years chose not to use any parent chaperones during animal observations. Instead, the teacher recruited two or three of their own family members (parents and sibling) as adult chaperones during animal observations. When asked about this, the teacher explained:

> *In the past I used parent chaperones, but it was a problem. Even when I met with the parents and explained my expectations for their role as chaperones, they would do things like take the kids around the zoo to see other animals. I can't force them to do what I ask them to do, so I just stopped using parents.*

Student groups for animal observations were organized for this class so all students could be chaperoned by three or four adults. During one of the days, unforeseen events caused there to be no adult chaperones other than the teacher. Interestingly, there was no change in percentage of on-task student behavior or student artifacts scores during this animal observation period. This group of students displayed the highest percentage of on-task behavior observed over the eight classes of students that participated in this research.

Conversely, the two classes with the lowest levels of on-task behavior did not have any issues with high chaperone to student ratios. Both classes had at least one parent chaperone per animal observation group, typically consisting of three or four students. These two classes also had relatively low teacher to student ratios, with fewer than 15 students per teacher in either class. Parent chaperones in both classes were observed taking their student groups to other exhibits around the zoo. Student journal entries for these days received lower overall student artifact scores for these days, with nearly all students scoring a 2 or lower. It was not clear if this impacted student effort or output on subsequent days for these students. It appeared that the behavior of parent chaperones was far more influential on student learning than the mere availability of parent chaperones.

Participant Observation Takeaways

The role of parent chaperones was a foundational component of the BIG Lesson program and a focus of program orientation and teacher training sessions. BZL staff strongly suggested that these expectations were clearly communicated to all parents wishing to participate. It is unclear how several participating schools communicated this information to parents prior to the BZL week. Several of the interviewed teachers affirmed that these expectations were clearly communicated to parents, so it is unclear why these parents chose not to adhere to expectations. The self-described “BIG Lesson School,” which utilized a mandatory meeting format for all parent volunteers, seemed to communicate these expectations most effectively. However, the parent chaperones’ previous experience with BIG Lesson programs may have contributed greatly to this efficacy. Parent chaperone behavior appeared to significantly impact student learning during daily animal observations, the predominant time when parent chaperones were utilized.

CHAPTER 5: DISCUSSION

The research presented in this dissertation indicated that overall, the BIG Zoo Lesson is a highly engaging educational program valued by students, teachers, and zoo education staff. The design of the BZL addressed the needs of learners in the Contextual Model of Learning (Falk & Dierking, 2000), allowing students to build knowledge and understanding through powerful experiences made possible by zoo resources. Program design was deeply rooted in constructivism and social constructivism, providing learning experiences and social interactions that helped learners construct meaning from these experiences and reconcile that meaning with their existing understanding.

However, on several occasions the foundation of the BZL was weakened, resulting in missed learning opportunities for students. It is the contention of this researcher that decisions that led to these missed opportunities were made because the consequences of these decisions were not understood by the individuals who made them. The two most prominent examples of this type of decision making were decisions by teachers to cut out reflection time following major lessons, and decisions by parents to disregard their role as a co-teacher and co-learner while they chaperoned students during animal observations.

Data for this study were collected in several different forms. Study participants included 48 students and nine teachers from eight elementary school classes. Student and teacher interview data were collected both pre- and post-BZL participation week. Observational data were collected over five school days for each class's BZL week through scripted observations of participating students and teachers. Student behavioral data were collected using an ethogram system during their daily one-hour animal observations, and participant observational data were collected through daily memos following each class's zoo day.

Additionally, 2,628 digital scans of student artifacts were collected, including student research journals, all work completed by students during their BZL week, and some additional artifacts from post-BZL student projects and closure activities. This diversity and quantity of data provided a comprehensive picture of a zoo education program, leading to a deep understanding of how students learned during the BZL and what factors may have been influencing that learning.

How do students learn during participation in the BIG Zoo Lesson?

By cross-referencing data collected through various methods, I began to understand how students learned during the BZL. While no two learners' experiences during this program were alike, several common themes emerged.

1. The BZL facilitated active STEM learning by upper elementary students

Active learning, through which students are both physically and mentally engaged in the learning process (AAAS, 2011; Metz & McLaughlin, 2016), was the most common method of student learning during the BZL. Student-centered active learning was the predominant form of learning observed for all eight participating classes. Students also identified active learning lessons and activities as their favorite activities. When asked what they had learned during their zoo week, most students referenced knowledge they had attained through active learning lessons. These findings agree with Nadelson & Jordan (2012), who found that active learning activities during an outdoor field trip were the most often recalled by students as activities in which they had learned. Randler, Kummer, & Wilhelm, (2012) found the most learning and highest retention of knowledge occurred with student-centered active learning lessons compared to both teacher-guided and zoo staff-guided activities during a zoo educational program for 5th and 6th grade students.

2. Learning recorded in student artifacts during the BZL was retained at greater rates than learning not recorded by upper elementary students

Beyond active learning, students retained more when they were actively developing artifacts of their learning through drawings, textual information through notes, developing models, and collecting data. When student responses during post-interviews regarding what they learned from their week at the zoo were cross-referenced with the existence of student artifacts for that lesson or activity, nearly all referenced learning corresponded to a lesson or activity where students were tasked with collecting information during that lesson by taking notes or making sketches. Previous research suggests that notetaking, a type of semantic encoding, has a modest positive effect on encoding, the process of acquiring and storing information (Kobayashi, 2005). Note-taking may be limited as a strategy to promote encoding because of the mechanical demands (the act of writing) on students (Kobayashi, 2005), and recent research has shown that creating visuals such as drawings and models to record learning may be more effective at promoting encoding (Fernandes *et al.*, 2018).

Van Meter & Garner (2005) believed drawing is impactful because learners must integrate information to generate their own representations of the information being learned. This idea was taken further by Fernandes *et al.* (2018), who proposed that creating visual representations of learning through drawings and modeling has a greater impact on encoding because it includes elaborative, motor, and pictorial components. Drawing requires learners to elaborate beyond the semantic encoding used during note-taking, create visuals requiring fine and deliberate motor actions, and inspect their drawings through the process of pictorial processing to ensure that their drawing portrays the information in the way they intended (Fernandes *et al.*, 2018). Much of the data collected by students was visual, including drawings of animal bodies, body parts, and exhibits. Research has demonstrated that recording information through both note-taking and developing visual representations such as drawings and models increase encoding and retention of information (Kobayashi, 2005; Van Meter & Garner, 2005; Fernandes *et al.*, 2018). While results indicated this was also true for BZL students, the current research cannot speak to the strength of this impact.

3. Proximity to and observation of live animals during the BZL facilitated engagement in learning for upper elementary students

The design of BZL learning experiences also played a significant role in student learning. Lessons that included proximity, engagement with, and observation of live animals had significantly greater impact on student learning in both the retention of concepts and the level of overall student engagement. In post-interviews students often recalled lessons that included the observation of live animals as their favorite lessons. Students also often recalled learning from live animal observations when asked what they had learned during the BZL in post-interviews. These findings align with previous research demonstrating that proximity to animals has positive effects on learning. Packer & Ballantyne (2010) found that when visitors were physically close to animals, significant retention of learning occurred. The interactions also led to significant emotional experiences for the visitors, which prompted self-reflection of their learning regarding animal conservation issues and the impacts of human behaviors (Packer & Ballantyne, 2010). Research involving close contact with less desirable species that often provoke fear responses-- such as snakes, spiders, bats, mice, snails, and insects-- has demonstrated that exposure through educational programs significantly reduces negative attitudes and emotions toward these animals (Morgan *et al.*, 1989; Prokop & Tunnicliffe, 2008; Randler, Hummel, and Prokop, 2012). The negative attitudes and emotions can be a barrier to learning. Many urban students in this my study lacked prior contact with animals and often initially displayed negative emotional responses to both the sights and smells of zoo animals. Repeated close exposure to these animals appeared to reduce the negative emotional responses to the sights and smells of zoo animals. This behavioral change was observed in two class groups of students form urban schools. For each group, negative reactions to smells and weariness of animals while visiting animal exhibits were noted in participant observations journal entries and scripted observations during the first two days of their zoo week. However, on the final day of each class's zoo week, all students touched the rhino during the rhino encounter and there was no observed reactions to the smells inside the rhino barn by students. Reducing negative emotions in students promotes a greater use of cognitive strategies, including planning, organization, monitoring, and elaboration used in inquiry-based learning (King & Areepattamannil, 2014).

Interestingly, the pregnancy of the female black rhino created a natural difference between how Round 1 students and Round 2 students experienced the *Rhino Encounter Lesson*. The lesson included a one- to two-minute opportunity for Round 1 students to ask a zookeeper questions about the rhinos and touch the female black rhino on her horn and lip. Round 2 students were not provided this opportunity because of the female's advanced stage of pregnancy. In place of direct contact with the black rhino, students were shown a short video of the black rhino followed by a question-and-answer session with one of the rhino keepers in a zoo classroom was provided. Both Round 1 and Round 2 students could observe and physically touch many rhino artifacts during this presentation, including bones, a horn, preserved skin, and a black rhino skull. Not surprisingly, several Round 1 (15 out of 24) students named the *Rhino Encounter Lesson* as one of their favorite lessons or as one of the lessons from which they recalled concepts or information, while no Round 2 students (n=24) listed the *Rhino Encounter Lesson* as one of their favorites or as a source of recalled concepts or information. While anecdotal, this observation demonstrates the positive impact that even a short-duration contact experience with a live zoo animal can have on student learning.

This finding agrees with previous research by demonstrating that physical contact with animals in petting zoos (Kid *et al.,* 1995) and touch tables at zoos (Lindemann-Mattheis & Kamer, 2005) increased engagement and receptiveness to learning new information. Lindermann-Mattheis & Kramer (2005) found that visitors who touched a live animal also demonstrated greater retention of their learning, further reinforcing the observations of this study. Zoo education programs should capitalize on these experiences; when safe and respectful live animal use is possible, it clearly positively impacts learning.

The effect of proximity and physical contact with animals on learning can be explained by Fry & Kolb's (1979) experiential learning theory. Zoo education focuses heavily on conservation and seeks to influence the attitudes and beliefs of visitors. Fry & Kolb (1979) would characterize zoos as a highly Affective-Oriented learning environment. Affective learning emphasizes learning through concrete events. Close contact with animals is a powerful concrete experience for learners. This experience is highly engaging and promotes positive emotions in learners. Packer & Ballantyne (2010) found that highly engaging experiences with live animals that promoted positive emotions facilitated observations and reflections by the learner. These observations and reflections then promoted greater understanding or emotional connections with that animal (Packer & Ballantyne, 2010).

It is difficult to determine the individual impacts of active learning, student encoding strategies, and animal proximity and contact on student learning during the BZL, because lessons and activities that appeared most influential on learning contained two or all three of these components. Further research is necessary to determine which components are most effective and how they can best be utilized in zoo education programming.

What factors may be impacting student learning during the BIG Zoo Lesson?

Several factors significantly impacted student learning during the BZL. Many factors coincided directly with the *Contextual Model of Learning* developed and championed by Falk & Dierking (2000). Learning experiences are influenced by the students' personal context (schemata, motivation, expectations, choice, and control of their learning experience), sociocultural context (interactions with other learners and learning facilitators), and physical context (the physical location of learning activities). This study illustrates how the BZL satisfies the needs of learners in the personal, sociocultural, and physical contexts and therefore why it is considered highly successful by stakeholders.

Personal Context

It appeared important that student motivation and expectations for their BZL week aligned with the educational focus of teachers and zoo education staff. Traditional motivation for zoo field trips, especially at elementary level, is most often recreational rather than educational (Tunnicliffe, 1997; Davidson, Passmore, & Anderson, 2009; Randler, Kummer, & Wilhelm, 2012). This frequent recreational focus is reinforced by previous experiences most students have at zoos with their families. The teacher's role in focusing student motivation and expectations to align with their own involves significant planning and proper implementation in advance of the field trip (Behrendt & Franklin, 2014). Based on data collected during teacher pre-BZL interviews, teachers began communicating their motivation for the BZL as an educational experience at least a week prior to their zoo week. While most students understood the educational motivation for the field trip, the behaviors of some parent volunteers suggested that the educational motivation was not shared by these chaperones.

The teachers' motivations for the field trip did not appear to be communicated effectively to many parent chaperones. Given that the shift in motivation for elementary level zoo field trips has only recently begun to focus on education rather than recreation (Kisiel, 2010; Patrick *et al.,* 2013), it is understandable that most parents' attitudes about zoo visits are based on their only experiences with zoo field trips, probably as students themselves decades ago, and were likely recreationally focused (Tunnicliffe, 1997).

While many teachers reported that the education focus and expectations of the students during the live animal observations, the predominant time when parent chaperones were used, were clearly communicated to parent chaperones, it did not appear that this message was understood by several parents. Wood (2010) argued that the role of a chaperone must be clearly defined prior to the field trip. When the chaperones' role is not clearly defined, they will revert to the role with which they are most comfortable (Wood, 2010). If this role conflicts with the teacher's expectations for the chaperone, learning can be affected (Wood, 2010). In the present study, some parents encouraged students in their group to quickly finish their animal observation assignment so they could go on a tour of the zoo for the remainder of the time. These unplanned side-trips reduced student artifact scores for those activities, with most students receiving a 2 or lower, and undermined the motivations and expectations originally instilled by the teachers.

Prior knowledge, interests, and beliefs of students also appeared to impact student learning during their participation in the BZL. This was particularly apparent during the students' daily animal observations. Most students gathered some information about their selected species prior to their zoo week, likely through books, videos, and the Internet. Many students appeared to rely heavily on this sourced information, but later attributed it to what they had learned about their animal during their zoo week.

Wolves were used as assigned animals in five of the eight classes observed. When these students were asked what they had learned about wolves during their daily animal observations, the initial responses focused heavily on factual information such as "they can take down big animals like deer, elk, moose," "they can run 35 miles per hour for more than 20 minutes," "you can hear the wolf's howl more than a mile away", "wolves can eat up to 20 lbs. of meat at a time," and "they are at the top of the food chain." When asked what else they learned during their observations, two students described direct observations of behavior, including "they get excited seeing a keeper even when it's going to do another thing" and "the white one tried to grab a squirrel one time, but it was too far away and got away." These students then transitioned back to learned information not directly observed by them. It was clear that these students remembered observed behaviors of the wolves, but both appeared to be singular incidents and not results of repeated observations of similar behaviors.

Having choice and control also seemed positively impact student learning during the BZL. Choice manifested first in the selection of their daily animal observation species, with students and teachers typically in agreement about their top choices. In a single incident of species misassignment (lions instead of the student's favorite, tigers), the student maintained a recalcitrant attitude throughout the week's activities. In this one case, lack of choice and control significantly reduced the student's performance and, in turn, increased his entire group's off-task behavior scores.

Sociocultural Context

Sociocultural mediation appeared to impact student behavior during daily animal observations. For example, when a student displayed off-task behavior within a group that included a predominantly on-task student, that first student rarely engaged in off-task behaviors greater than 25% of total observed behaviors for that day. This suggests overall high levels of engagement compared to previous research that found 25-50% time-off-task to be the norm (Karweit & Slavin, 1981; Godwin & Fisher, 2011). Several students were observed redirecting classmates during daily animal observations and reminding them of both educational and behavioral expectations. It appeared that some level of within-group sociocultural mediation influenced student behavior and thus student learning during daily animal observations.

In several cases, >50% of total observed behaviors for a group was categorized as off-task. This obviously held true when parent chaperones escorted a student group away from their assigned animal but was also evident in several cases in which students stayed at their assigned exhibit, and otherwise displayed off-task behaviors. There was no evidence from scripted observations that these students were redirected by peers or parent chaperones. It is unclear why this behavior was not addressed. More research is needed to understand why this behavior was not addressed by parent chaperones.

High levels of off-task behavior were linked to student achievement level. Off-task behavior greater than 50% of total observed behavior was observed predominantly in low and medium performance level students, with one distinct exception. When high level students were observed off-task more than 50% of total observed time, it was always because their parent chaperone had led the group away from its assigned animal.

An opportunity for within-group sociocultural mediation was missed in most groups studied. For several classes, parent chaperones were provided a copy of the students' *BZL Research Journal* with which they could conduct their own observations of the selected animal species. Very few parents were observed utilizing this journal and consequently modeling this activity to their student group. The only parents observed modeling how to record animal behavior were from class D, the self-proclaimed BIG Lesson school. Most parents were likely not comfortable modeling this activity because they may not have understood the expectations or did not have the previous experience necessary to confidently undertake this task. It would be interesting to see whether providing training for parent chaperones, such as the animal observation lesson taught to Round 2 students, would foster their willingness to learn alongside students and model the expected behavior.

Facilitated mediation by docents during the BZL also seemed to impact student learning. During several docent-led lessons, docents were observed asking probing questions early in the lesson, which appeared directed toward gauging the classes' overall understanding of concepts central to that lesson. The docents appeared to use information gained through questioning to inform the material they presented. It is unclear if this was a conscious strategy used by docents, a result of their experience as BZL docents, or their previous education experience. Additional research, including interviews with docents, focused observations of docent behavior during docent-led lessons, and analysis of the docent training program would help to better understand docent impact on student learning during the BZL.

Physical Context

Several factors within the physical context of the program seemed to impact student learning during BZL participation. Many of these impacts were positive and directly addressed through BZL program design.

A student's orientation within a place of learning has been shown to significantly affect their ability to construct knowledge and meaning at that location (Falk, 1978; Falk & Storksdieck, 2005; Hauan & Kolosto, 2014). Often the novelty of a space during a field trip is great enough to depress the potential for learning for a student (Falk & Dierking, 2000). This is known as the "novel field trip phenomenon" and is a common issue with single-day field trips at zoos.

The novel field trip phenomenon is an important factor influencing learning during field trips. Falk & Dierking (2000) observed that when learning environments are extremely novel, learning is depressed because the learner focuses their attention on orienting within the environment. On the other hand, when the learning environment is extremely familiar there is little to explore, and natural curiosity of learners is depressed. The ideal learning environment is, therefore, one with moderate novelty where the learner is both comfortable and familiar with their surroundings while surrounded by enough novelty to stimulate their curiosity (Falk & Dierking, 2000).

The sheer novelty of traditional single-day zoo field trips prevents students from deriving significant educational benefits from them. While students may have some familiarity with their local zoo, that experience likely has a recreational context rather than a learning context (Tunnicliffe, 1997; Davidson, Passmore, & Anderson, 2009; Randler, Kummer, & Wilhelm, 2012). When students recreate at a zoo, they focus on "seeing" all the zoo animals. The task is to find all the animals that are on exhibit and point them out to friends and family members. This experience is far different from the learning experience that zoo education programs desire (Randler, Kummer, & Wilhelm, 2012; Behrendt & Franklin, 2014).

In the present study, the novel field trip phenomenon was addressed effectively, as intended by the original design of the BZL program. The first-day curriculum focused heavily on exploring the zoo. All participating classes began their zoo week with an exploratory scavenger hunt either in small groups or with the entire class. This allowed students to "see" all the animals on exhibit so they were not preoccupied with viewing animals other than their assigned species later in the week. This also allowed them to learn the relative location of exhibits and their home base classroom. The number of zoo visitors, that if large, could have distracted students during the BZL, was also relatively low during eight of the zoo weeks. This resulted in students being the vast majority of zoo visitors and further reinforced to students that the zoo was their classroom. The first day's daily animal observations were designed to familiarize students with their assigned animal, reducing the novelty of subsequent observations to the moderate level that is ideal for learning experiences. Monday's observations focused on obtaining information about the animal, sketching the animal and/or its exhibit, and other low-level learning objectives. As the week progressed, learning objectives increased beyond the knowledge level, encouraging students to apply concepts they had learned through other lessons such as camouflage, physical and behavioral adaptations, exhibit design, animal husbandry practices, and animal behavior. By familiarizing students with the zoo and the animals it housed, the novelty of the physical environment was reduced to a moderate level, so that students became comfortable with their surroundings and used the zoo as their classroom as the BZL program intended.

Other Field trip Issues BZL Addressed by Design

Role and Involvement of Teachers

Traditional field trip programming often places teachers outside of their traditional role as disseminators of knowledge or facilitators of learning experiences. Teacher motivation, behavior, and involvement all have been shown to significantly influence the educational potential of field trips (Tunnicliffe *et al.*, 1997; Davidson *et al.*, 2009: Patrick & Tunnicliffe, 2013; Behrendt & Franklin, 2014). The Big Zoo Lesson directly addresses these factors through its design.

The role of the teacher in the BZL is unique among zoo education programs. In traditional programs, teachers are rarely involved beyond the role of behavioral management (Davidson *et al.*, 2009; Behrendt & Franklin, 2014). Limiting a teacher's role in this way hinders the teacher's ability to inform lesson development and teaching practices during zoo education programs. In the BZL, however, teacher involvement in student learning begins during the planning stage, continues throughout the class's week at the zoo, and often beyond. This role change from that in traditional field trips seems to impact teachers in several ways.

First, teacher involvement in the curriculum design process influenced their overall buy-in for the program. Teachers appreciated the ability to design the curriculum for their students to fit the specific learning objectives of their students. Several teachers also expressed that they appreciated the professional courtesy of being allowed to modify lessons or work with zoo education staff to modify lessons to better meet the needs of their students. Teacher involvement in the planning of the BZL curriculum promoted a collaborative relationship between zoo education staff and teachers where all individuals shared a common motivation, i.e. to provide valuable learning experiences for students.

Second, teachers were often directly involved in their students' learning experiences. More than half of the lessons were teacher-led. During these teacher-led lessons, teachers were most often the facilitators of learning experiences rather than the disseminators of knowledge. For most interviewed teachers, this represented a change from their typical classroom role, a change they enjoyed. The remaining lessons were led by zoo education staff, including docents. During these lessons, teachers were co-learners with their students and often modeled learning behaviors such as note-taking, questioning, visual data collection through sketches and engagement. Teachers modeling behavior for students during science-oriented field trips is a powerful teaching tool that has been demonstrated to positively influence student interest in science learning (Tran, 2007). BZL teachers' ability to act as co-learners and model science learning behaviors likely positively influenced these behaviors in their students as well. Three of the eight teachers were observed modeling science learning behaviors and using their own BZL journal. Students' artifact scores in those classes were slightly higher on average (3.9) compared to the other five classes (3.6).
Third, teacher motivations for participation in the BZL clearly did not include recreation, unlike many traditional zoo field trips. Several teachers recounted how they had worked harder during their zoo week than during a typical week at school. These teachers clearly believed in the BZL's benefits for their students and were willing to put forth more effort to maximize the learning experience for their students.

The curriculum design provided the moderate degree of novelty associated with a high potential for learning. While the concepts discussed in lessons overlapped, each lesson explored concepts in novel ways and with new materials. For example, all eight classes had lessons and activities that addressed enrichment as a part of captive animal husbandry. This concept was first introduced when students watched zookeepers using enrichment materials, observed animals interacting with the materials, and had the opportunity to ask the zoo staff follow-up questions. Students observed the animals interact with these objects and asked questions of zoo staff. This provided them an introduction to the concept of captive animal enrichment typically done on the first or second day of their week at the zoo. On subsequent days, the habitat enrichment concept was pursued and combined with other concepts such as physical and behavioral animal adaptations. In small groups, students then designed and constructed an enrichment object for a species at the zoo, and observed the animals' interactions with the object on the very last day of the BZL week. Thus, students used their increasing knowledge to explore a concept and learned to apply and test this knowledge. In effect, they were "doing" science.

Students "Doing" Science

The current understanding of science education is that students best learn science by "doing" science (AAAS, 2010; NRC, 2012). This involves students asking questions that can be answered through designing and conducting investigations, and gathering and analyzing data to form conclusions that answer these questions (AAAS, 2010; NRC, 2012).

Students were observed "doing" science on numerous occasions during their zoo week. These lessons generally utilized *structured inquiry* by providing students with a research question and data collection procedure, while the results and conclusions were unknown (Banchi & Bell, 2008).

In the *Mammalian Skull Lesson*, students were provided with the question "Can you determine what an animal eats by observing the characteristics of its skull?" Students then collected visual data through drawings, analyzed the data by comparing features of several skulls with one another, and then formed conclusions based upon the data. The *Bird Beak Adaptations, Horns, Antlers, and Tusks,* and *Pelts* lessons all involved a similar pedagogy through which students were provided with the question and the investigative procedure, and then carried out the data collection, analysis, and conclusions on their own or in small groups.

The structured inquiry format of these lessons limited the number of applicable *Science and Engineering Practices* present in these lessons. Having been provided with guiding questions and data collection procedures, students were precluded from practicing *Science Practice 1: Asking Questions,* and limited in *Science Practice 3: Planning and Carrying Out Investigations to Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon* (NGSS, 2013). Students did implement *Science Practice 4: Analyzing and Interpreting Data*, *Science Practice 6: Constructing Explanations*, and *Science Practice 7: Engaging in Argument from Evidence* during these structured inquiry lessons on two or three occasions during each BZL week, depending on a classes' curriculum.

The animal enrichment lessons, which encompassed several activities, were a good example of students "doing" science and were the only examples of engineering practices incorporated into lesson design. Students first observed numerous animals using enrichments meant to stimulate natural behaviors. Groups of students then worked together to develop an investigation and test their hypothesis regarding what type of enrichment, within the constraints of the materials available, would stimulate a natural feeding behavior and make it most difficult for the animal to access the food reward. They tested these designs and interpreted their data to form conclusions. During the animal enrichment lesson activities, all eight classes of students were observed using Science and Engineering Practices, including *Practice 1: Asking Questions and Defining Problems*, *Practice 3: Planning and Carrying Out Investigations*, and *Practice 6: Design Solutions*. The lesson design used by all eight classes for the animal enrichment lesson activities did not include any formal data collection procedures, preventing students from *Analyzing and*

Interpreting Data, and *Engaging in Argument from Evidence* regarding the effectiveness of their animal enrichment devices, an apparently missed learning opportunity.

For most students, however, daily animal observations did not meet the criteria for “doing” science, likely because of lack of knowledge regarding how to conduct scientific investigations through live animal observations. This shortcoming also appeared to be true for many, particularly teachers in Round 1. While the “How to Do Live Animal Research Like a Scientist” lesson significantly increased the time spent observing assigned animals, few students utilized Science Practices during their daily animal observations. Student journals provided limited evidence of students using the following Science Practices: *Asking Questions, Planning and Carrying Out Investigations, Analyzing and Interpreting Data,* and *Constructing Explanations*. There was no evidence that any Round 1 or Round 2 students completed an investigation during their animal observations. However, none of the students had initially been tasked with developing and conducting their own investigation.

Daily animal observation tasks varied by teacher; however, there was some commonality observed. On day 1, students were generally tasked with making full body sketches of their animals and recording details or facts about their animals (obtained through exhibit signage). Some teachers also tasked student with beginning a list of questions they would add to throughout the week about their animal. On day 2, students were generally tasked with isolating and sketching specific body parts of their animal. Some teachers specifically requested these be adaptations while others left this more open ended. From day 3 on there was much more variation in the tasks assigned to students during their daily animal observations. These tasks included: sketching the exhibit, designing a new exhibit, writing a poem, creating a story, planning a party, conducting an interview, writing a narrative from the animal’s point of view, listing all behaviors observed, estimating size of animal and enclosure, and tracking their animal's movement through exhibit. While some of these tasks required data collection (listing observed behaviors and tracking movements) there was no evidence that students utilized this data following that observation.

Most animal observation time was spent completing activities that were decidedly not "doing" science. All participating classes included sketching the entire body of the animal and/or specific body parts as examples of adaptations. While this activity appeared to be engaging for many students, these sketches were not analyzed, interpreted, or used to engage in argument, and therefore not were not used as data. Other activities, such as writing a letter from your animal's perspective, planning a party for your animal, or planning your *Junior Docent Presentation* also lacked implementation of Science Practices and thus could not be described as "doing science." It is unclear why scientific investigations were not done during daily one-hour animal observations, but there are several possible explanations.

It was obvious that most students did not have the skills necessary to conduct investigations using live animal observations. Additionally, most teachers appeared to not have the background or confidence to train students how to conduct scientific investigations using observations of live animals. Many teachers stated that teaching science was not their typical focus and that very little time was devoted to teaching science in their curriculum. However, these teachers expressed a desire to learn to teach their students to conduct these types of observations in the future.

When Round 2 students were taught investigation skills, significant increases in engagement and time spent observing assigned animals resulted. Few students conducted investigations in Round 2, probably because teachers in Round 2 did not alter the assigned tasks for students during these daily one-hour observations and retained the activities utilized by previous teachers. The timing of implementation of the “How to do Live Animal Research like a Scientist” lesson, one to two weeks prior to each class’s zoo week, likely meant that lessons were already planned and student journals were already constructed, making changes to these lessons nearly impossible for teachers.

Another factor contributing to the lack of scientific investigations during daily animal observations may be the set of suggested activities presented in the BIG Zoo Lesson Training Manual. While most of the activities suggested in the training manual required students to observe their animal to successfully complete the activity, no activities that satisfied the requirements for scientific inquiry were included. To satisfy the requirements for scientific inquiry, an investigation must occur whereby a question is asked, an investigation is designed, data are collected and analyzed, and a conclusion is developed based on analysis of the data (Banchi & Bell 2008). Observations of animal behavior, including behavior frequency and duration, use of exhibit space, and interactions between exhibited animals, were all potential topics of investigation. Some of the Round 2 students demonstrated the ability to conduct such investigations during the “How to Do Live Animal Research Like a Scientist” lesson. This suggests that if BZL students were taught how to use scientific practices during live animal observations more than 2 weeks prior to their zoo week, they would be capable of conducting these investigations at the structured and guided inquiry levels, and teachers could plan their lessons accordingly.

Teacher interviews indicated that most teachers lacked the background and experience to develop investigations themselves. When teachers lack the background, confidence, and experience in teaching science, they seek resources to meet their needs. This is particularly true when teachers are concerned about the potential engagement of students during an independent student activity with limited teacher contact for an extended period such as the daily one-hour animal observations. The BZL-suggested activities fulfilled the need of high student engagement for teachers, and included observation, a component of the scientific process. However, teachers' limited background, confidence, and experience in teaching science caused teachers to misinterpret these activities as students "doing" science.

For several reasons, elementary teachers often struggle with teaching science. The focus of elementary education is predominantly on building literacy and math skills and knowledge, with far less time devoted to science (Blase, 1986; Mansour, 2007; Banilower *et al.*, 2013; Blank, 2013). This results in less experience teaching science and less confidence in their abilities to teach science (Roehrig & Luft, 2004). This lack of confidence is often warranted because many elementary teachers lack the content knowledge necessary to teach science (Appleton, 2007). Further compounding this issue, many elementary teachers also lack the pedagogical knowledge to successfully teach science through inquiry-based methods (Roehrig & Luft, 2004), knowledge arguably critical to effective science education with the consistent implementation of Next Generation Science Standards.

It is easy to understand why teachers would misinterpret the BZL-suggested activities as science activities. These teachers likely lacked both the content and pedagogical knowledge to recognize that these activities were not meeting the requirements for students to "do science." The relatively high engagement level of students likely reinforced that these activities were effective, giving teachers no reason to make changes in subsequent years. Ultimately, this misunderstanding led to missed opportunities for students to carry out scientific investigations through observations of animals.

Student Perceptions of What They Learned

When students were asked what they had learned during their animal observations, they focused on knowledge-level information such as the animal's habitat, predator-prey relationships, size, and lifespan. Most information was taken directly from interpretive materials (signage) near the exhibit. Students rarely recalled information that they had learned from their observations. Many students did very little data collection or analysis during or after their daily animal observations. The students were not actually "doing" science; rather, they were making observations visually without recording them and, therefore, there were no data to be analyzed. Several students, although they had clearly collected data in their journals, did not refer to them in post-interviews as something they had learned. It is unclear why these students did not recognize data collection as learning. Once NGSS standards and teaching methods are fully incorporated into K-12 science education, students' perception of what constitutes learning science should change from collection of science facts to self-directed learning experiences. As these changes occur in the BZL program and K-12 science education, more research including student observations and interviews is needed to determine how these changes alter student perceptions of learning.

One explanation for why students did not recognize their data collection as learning is that students did not go beyond the data collection step and therefore failed to analyze their data and draw conclusions from that analysis. The *Experiential Learning Theory* of Fry & Kolb (1979) explained why the lack of analysis and drawing conclusions from data would lead to a lack of perceived learning. Learning in the experiential learning model involves a cyclical relationship between concrete experiences, reflective observation, abstract conceptualization, and active experimentation. Most students in the current study did not move beyond the concrete experience component of this cycle during daily animal observation lessons. By not progressing through this cycle, the students were, therefore, not constructing new knowledge and understanding (Fry & Kolb, 1979). Data from observations of students, post-interviews, and post-BZL student artifacts indicated that students who collected observational data during daily animal observations ultimately did not utilize these data beyond the data collection.

The debriefing sessions mandated by BZL program design could provide opportunities for students to progress beyond their concrete experiences during reflective observation; however, the debriefing sessions often were significantly reduced or omitted by teachers. If these debriefing sessions were more heavily emphasized, and if student-collected data were given more importance during these debriefing sessions, it could increase students' perceived value of their observational data.

Because this critical component of the experiential learning cycle was removed, students failed to internalize concrete experiences and organize them into their existing schema. Students were prevented from progressing further into abstract conceptualization and active experimentation, which are necessary to internalize new learning and continue through the experiential learning cycle (Fry & Kolb, 1979).

Constructivism also explains how the reduction or absence of reflection by limiting debriefing sessions would reduce student learning, and therefore their perception of what they learned. Piaget (1952) argued that greater understanding is achieved as the learner reconciles newly attained knowledge with existing understanding through the process of accommodation. This reconciliation of new knowledge with existing understanding would most likely occur during reflections when students are actively recalling what they had just learned. Without the opportunity to reconcile new learning with existing understanding, students did not perceive new information from observations as learned information.

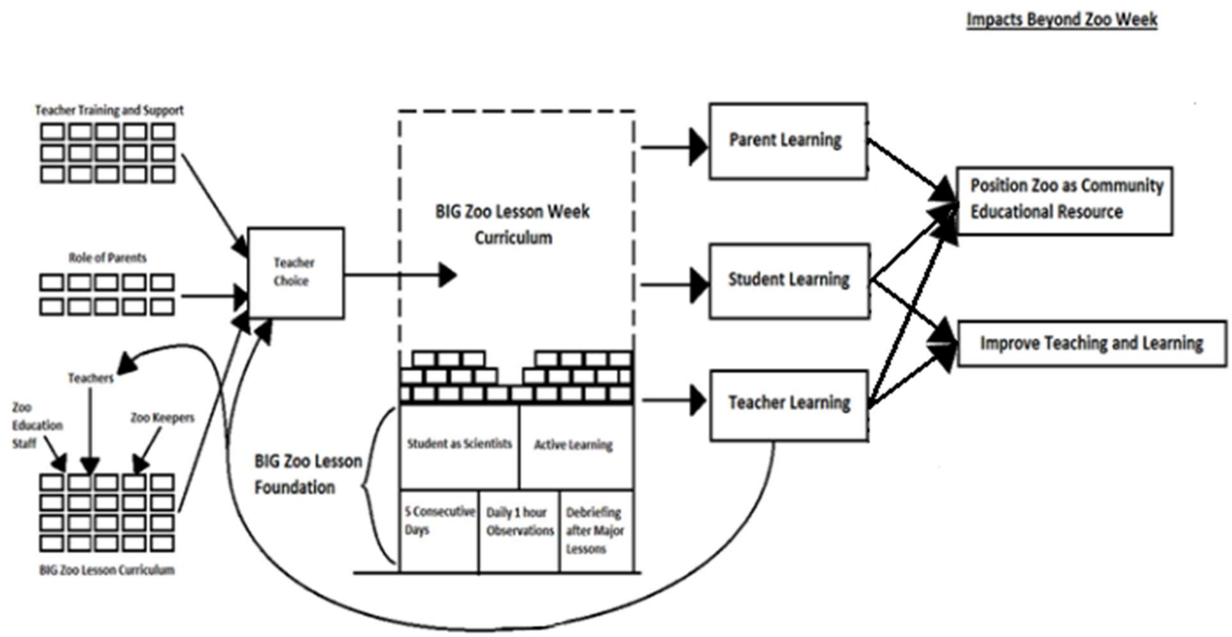
Another explanation could be that students did not trust their own observations as formal learning of science and therefore did not consider their conclusions as something learned. This attitude could be explained by the students' previous experiences. When asked how they previously learned science, students generally cited lessons during which they observed someone else "doing" science through either "Mystery Doug" videos or teacher demonstrations. This pattern suggested that students had little experience in conducting their own student-centered scientific investigations to create their own understanding, because the implementation of NGSS and the pedagogy associated with three-dimensional learning (NRC, 2012) was in the early stages at their schools. Students' experience learning science would therefore align with more traditional science learning during which teachers disseminate scientific knowledge to students rather than facilitating learning experiences that help students discover knowledge through their own investigations (AAAS, 2010; NRC, 2012). This could cause students to prioritize information that came from their teacher, zoo staff, or exhibit signage as what they learned rather than their independent discoveries.

It is clear from this research that most students did not consider information they attained during daily animal observations as learning. More research is needed to understand why this occurred and what can be done to remedy the problem.

When BZL's Foundational Design Components Are Not Followed

The BIG Zoo Lesson promotes learning through the interactions of several different components working together. Much like a building, the foundational components of the BZL form a stable base for learning. Upon this foundation, a BZL week is built by the classroom teacher, utilizing the building blocks available to form a structure that promotes learning. This learning then influences further learning, some of which adds more building blocks for future teachers to choose from. These ideas were used to construct the conceptual framework represented in Figure 2.

Figure 2 *Conceptual Framework of the BIG Zoo Lesson*



As with any building, the impact of the BZL on learning is only as strong as its foundation. When the foundation is strong, teachers can shape the upper levels as they see fit, to meet the needs of their students and their goals for their week at the zoo. Each lesson can build upon previous lessons, progressively adding to student learning. However, when the foundation is weakened, the stability of the program and the heights that student learning can attain are threatened. This investigation demonstrated that the foundation was commonly weakened due to severe reduction or omission of debriefing activities, depriving students of import reflection periods critical to learning. While all classes were observed conducting guided inquiry lessons where students were “doing” science, the missed opportunity for students to conduct independent investigations during daily animal observations reduced the height of learning possible.

The recommendations below were developed to help future BZL participating teachers and zoo staff proactively address these potential issues and ensure that learning opportunities are fully realized for future BZL participants.

Recommendations for Practice

Implementation of Student Training for Conducting Investigations through Live Animal Observations

Participation in the “How to Do Live Animal Research Like a Scientist” lesson by Round 2 students significantly increased the occurrence of on-task behaviors compared to Round 1 students. Student journal entries also demonstrated that only students who had received training in collecting observational data of live animals collected data. This evidence strongly indicates that presenting this lesson to all students prior to their BZL week can positively affect learning outcomes by providing the skills needed to “do” science during daily animal observations.

Revision of Live Animal Observation Activities

While training students to conduct scientific live animal investigations will provide them with the necessary skills, these investigations are unlikely to occur without a revision of the BZL Training Manual for teachers. Suggested student activities required to be completed should include student-led investigations at various levels of inquiry. Similar to the *Mammals Skulls*, *Bird Beaks*, and *Animal Pelts* lessons, a structured inquiry or guided inquiry format could be provided to differentiate lessons according to student proficiency with science practices (Banchi & Bell, 2008; Benedis-Grab *et al.*, 2009; Snodgrass *et al.*, 2011). Teachers could also scaffold these activities from confirmation inquiry through open inquiry as students ’proficiency with science practices (Bell *et al.*, 2005; Bianchi & Bell, 2008, van der Valk & Jong, 2009) progressively increases during the zoo week. An example of how this curriculum could be structured is shown in Appendix K.

Formalized Parent Chaperone Training Program

This research suggested that training parent chaperones regarding their role as co-learners and co-teachers during the BIG Zoo Lesson could increase both student on-task behaviors and completion of activities during daily animal observations. This research also suggested that inadequate training of parent chaperones before participation in the BZL decreased student on-task behavior and may have decreased the educational focus of the BZL program for some students. One teacher found past parent chaperone behavior such a negative influence on student learning that he chose not to use any parent chaperones. On-task behavior observed in this class was the highest of all eight classes, which suggested that this decision was correct for this group of students.

A mandatory parent chaperone training program could help prevent the negative impact of student learning observed, and provide parents with the guidance and tools needed to fulfill their role as co-learners and co-teachers as intended by the BZL program design.

This training could be done in several formats. An online training program could be created by the BZL and provided for parents to become a certified BIG Lesson Chaperone. Several in-person training sessions could be conducted throughout the school year in the evenings or on weekends and staffed by zoo education personnel. These trainings could also serve as community outreach, reinforcing the role of the zoo as an educational resource for the community. Mandatory training programs also could be held at participating schools and conducted by teachers with the assistance of zoo education staff. Evidence from this research indicated that these programs can be successful. More research is required to determine which of these formats is most successful.

Revise Scheduling and Design of Debriefing Sessions Following Major Lessons

Overscheduling appeared to be an issue for a few participating teachers. Most teachers discussed how they wished they had more time at the zoo, but that their time was limited primarily due to busing issues. Busing issues limited time at the zoo to as little as four hours for some classes, while others were at the zoo for six hours or more each day. Proximity to the zoo also had some effect, with some schools being as close as a 10-minute drive and others over 30 minutes away. Some teachers responded to decreased time at the zoo by providing short lunch periods and few, if any, scheduled breaks. While not scheduled, bathroom breaks still were needed, and lunch times were not always strictly adhered to, which impacted many individual lessons during the day. By referencing daily scripted observations timestamps, it was determined that this problem resulted in shorter time for some teacher-led lessons and for some daily animal observations for the affected classes. Scripted observations also showed that reflection periods after major lessons (animal observations, docent-led lessons, and live animal experiences) were often limited or absent as well. Shortened or absent reflection periods occurred in numerous classes regardless of total time at the zoo. It appeared that many teachers did not value reflection time when they determined that time was needed for other purposes.

The last recommendation is that the design and scheduling of debriefing sessions following major lessons be revised. This research made clear that many teachers did not value the debriefing sessions as highly as they should, and did not understand their impact on knowledge acquisition and retention by students. Limiting or omitting debriefing sessions decreased the potential for meaningful and focused student reflection. Both the Contextual Model of Learning

(Fry & Kolb, 1978) and the constructivist learning theory (Piaget, 1952) suggest that this reflection time is critical to the development of knowledge and understanding in learners and to retention of learning. As discussed earlier, the reduction or omission of debriefing sessions may have contributed to students not recognizing information obtained through their observation of animals as learning. Greater effort must be made to ensure that students are provided these reflection opportunities during debriefing sessions.

One suggestion would be to formalize debriefing sessions as part of the activities themselves. In this way they would not be seen as an extra block of time outside of the lesson, but instead as the final component of the lesson. Students could debrief by discussing what they had learned from the previous lesson with a small group of peers, making journal entries summarizing what they learned in the previous lesson, constructing a concept map visually displaying their learning and connecting that learning to previous lessons, etc. Regardless of how this reflection occurs, it is important that students are provided with time and proper guidance to focus their reflection on what they had just learned.

Conclusion

This research indicates that the BIG Zoo Lesson was an engaging zoo education program valued by teachers and their students, and provided learning opportunities otherwise unavailable to most students. Active learning through experiences with live animals and animal artifacts had the greatest impact on student learning. While the BZL was highly effective overall, several learning opportunities were missed during its implementation. Program revision aimed at correcting these mistakes should improve student learning. Modifications to daily animal observation lessons and protocols, and training teachers and students in the science skills and practices used to conduct live animal investigations will allow students to “act like scientists” as the BZL program promises.

This study increased our knowledge of how elementary students learn during zoo field trips and identified factors that influenced that learning. The variety of observations and data collected resulted in the most comprehensive evaluation of an elementary-level zoo education program available to date. Results also led to recommendations for improving the implementation of the BIG Zoo Lesson, and similar programs.

Lastly, the findings detailed herein should be useful for the zoo education programming industry. They also reaffirm that the Potter Park Zoo, and other zoos committed to active participation in the BZL, are important and effective educational resources for their communities.

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APPENDIX A: PRE-BZL STUDENT INTERVIEW GUIDE

1. Tell me about what you have been learning in science this year.
2. What do you like about learning science?
3. Is there anything you do not like about science?
    - If yes, what?
4. What do you do to learn science?
5. Have you ever been on a field trip before?
    - If yes, where? What do you remember about that field trip?
6. Have you ever been to a zoo before?
    - If yes, who did you go with? Tell me about it.
7. Are you excited for the BIG Zoo Lesson with your class?
    - Why (not)?
8. What do think you will see at the zoo?
9. What do you think you will learn at the zoo?
10. What animal are you going to observe for your daily animal observations at the zoo?
    - Tell me what you know about your animal.

APPENDIX B: POST-BZL STUDENT INTERVIEW GUIDE

1. Tell me what you remember from the zoo.
2. What was your favorite part of the BIG Zoo Lesson?
    - Why?
3. Was there anything about the BIG Zoo Lesson you did not enjoy?
    - Why not?
4. What did you learn about the animal you observed at the zoo?
5. What did you like about learning science at the zoo?
6. What was your favorite activity?
    - Why?
7. Was there anything you wanted to spend more time doing at the zoo?
    - Why?
8. Did your trip to the zoo help you learn science?
    - Why or why not?
9. How was the zoo different from learning at your school?
    - How is it the same?
10. Would you like to go back to the zoo?
    - Why/not?

APPENDIX C: PRE-BZL TEACHER INTERVIEW GUIDE

1. Why did you decide to participate in the BIG Zoo Lesson?
2. Have you participated in the BIG Zoo Lesson before this year?
    - If so, when?
3. Do you have previous experiences with field trips as a teacher?
    - If so, please explain.
4. Please describe how you planned your BIG Zoo Lesson week at the zoo.
5. How did you integrate other disciplines into your week at the zoo?
6. How would you describe your teaching style?
7. Is teaching science part of your regular teaching duties?
8. How do you believe students best learn science?
9. What science curriculum did you incorporate into your week at the zoo?
10. How were your students prepared for their week at the zoo?
11. What skills do you hope your students will develop or strengthen because of their week at the zoo?
12. Which skills will you be focusing on beyond your week at the zoo?
13. How do you believe your students will benefit from participating in the BIG Zoo Lesson?
14. Do you believe that participating in the BIG Zoo Lesson will help you improve your teaching?
    - If so, how?

APPENDIX D: POST-BZL TEACHER INTERVIEW GUIDE

1. What do you think went well during your week at the zoo?
2. What lessons or activities do you believe were student favorites?
    - Why?
3. What lessons or activities do you believe were most effective during your BZL week?
    - Why?
4. How do you believe the daily animal observations worked for your students?
    - Were students provided feedback on their animal observations? When and how?
5. Was there anything that did not go as planned?
    - Why?
6. What do you think you could do to prevent this for next year?
7. Can you describe student engagement in their learning during your week at the zoo?
8. How did your role during the week at the zoo differ from your normal role as a teacher?
    - How did you feel about your role change?
9. How did the week at the zoo compare to your expectations?
10. Are your students doing a closure activity following their BZL week? If so, please describe it to me?
11. Do you believe that the benefits for the students outweighed the time out of the classroom and financial costs?
    - Why or why not?
12. Would you like to participate in the BZL again next year?
    - Why or why not?

13. If you participated in the BZL again next year, what would you do differently?

- Why?

APPENDIX E: INFORMED CONSENT FOR PARTICIPATION IN ZOO PROGRAM RESEARCH PROJECT: TEACHER

Explanation of Research

You are being asked to participate in research focused on your participation in the BIG Zoo Lesson program. The pre- and post-BIG Zoo Lesson interview will last about one hour in length each. Notes will be taken by the interviewer during the interview and the interview will be recorded digitally on a recording device. The recording will only be used for data collection and will not be shared with any other parties or used in any other ways outside of this research project. The data collected in this study is to be used for the investigator's dissertation research. As such it may be published in part or in whole in the future. The identities of all participants will be kept confidential, and pseudonyms will be used for all participants during data collection, data analysis, and any written materials published or unpublished. The data collected will not be shared with anyone outside of the investigator's dissertation committee. All data will be digitally protected on a password protected computer, and any physical materials will be secured in a locked file cabinet. You must be at least 18 years of age to participate in this study.

Potential Risks and Benefits

The subject of the interview involves your participation in the BIG Zoo Lesson and the development of lessons and activities for your students related to the BIG Zoo Lesson. As such, there is minimal potential risk personally and professionally for your participation in this research. You are not likely to have any direct benefit for participation in this study.

Your Rights to Participate, Withdraw, or Say No

Participation in this research project is completely voluntary. You have the right to say no. You may change your mind at any time and withdraw. You may choose not to answer specific questions or to stop participating at any time. If you choose to not participate or withdraw from participation at any time, it will not be shared with anyone that you have chosen to do so.

Cost and Compensation

The only cost to you will be that of approximately one hour of your time. You will receive no compensation for participation in this research project.

Contact Information for Questions or Concerns

If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher (Shannon Niceley, 288 Farm Lane Room 3, East Lansing, MI 48824 Cell (504) 232-4395).

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail irb@msu.edu or regular mail at 4000 Collins Rd, Suite 136, Lansing, MI 48910.

Your confidentiality will be protected to the maximum extent allowable by law.

Your signature below means that you voluntarily agree to participate in this research study.

____ _______________________________

Signature Date

APPENDIX F: INORMED CONSENT FOR PARTICIPATION IN ZOO PROGRAM RESEARCH PROJECT: PARENTAL PERMISSION

Explanation of Research

Your child is being asked to participate in research focused on their participation in the BIG Zoo Lesson program. The data collected in this study is to be used for the investigators' dissertation research and may be published in part or in whole in the future. Your child's class may be selected to be taught a lesson on collecting and analyzing data through live animal observations by the investigator. The data collections for this research may include direct observations of your child while participating in the BIG Zoo Lesson, interviews of approximately 30 minutes in length prior to and following their week at the zoo focused on your child's experiences in learning science prior to and during their week at the zoo, and daily digital scans of their written work from their week at the zoo. Notes will be taken by the interviewer during the interviews and observations and the interviews will be voice recorded digitally. The recordings, digital scans of your child's work, and observation transcripts will only be used for data collection and will not be shared with any other parties or used in any other ways outside of this research project. The identities of all participants will be kept confidential, and pseudonyms will be used for all participants during data collection, data analysis, and any written materials published or unpublished. The data collected will not be shared with anyone outside of the investigator's dissertation committee. All data will be digitally protected on a password-protected computer, and any physical materials will be secured in a locked file cabinet.

Potential Risks and Benefits

Your child's participation in this study does not involve any physical or emotional risk to your child beyond that of everyday life.

Your child is not likely to have any direct benefit from being in this research study. This study is designed to learn more about how participation in the BIG Zoo Lesson influences student learning. The study results may be used to help other people in the future.

Your Rights to Participate, Withdraw, or Say No

Participation in this research project is completely voluntary. You and your child have the right to say no. You or your child may change your mind at any time and withdraw. Your child may choose not to answer specific questions or to stop participating at any time. If you or your child choose to not participate or withdraw from participation at any time, it will not be shared with anyone that you have chosen to do so.

Cost and Compensation

The only cost to your child will be that of approximately one hour of their time during their regular school day. You will receive no compensation for participation in this research project. Interviews will be conducted during regular instructional times during the typical school day. If you would like your child's interviews to be conducted outside of regular instructional times (i.e. during recess or after regular school hours), please indicate that below.

Select one of the following options:

____ My child may be pulled from regular instruction activities to participate in interviews

____ I prefer that my child's interviews are conducted outside of regular instruction activities

Contact Information for Questions or Concerns

If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher (Shannon Niceley, 288 Farm Lane Room 3, East Lansing, MI 48824, *Cell* (504) 232-4395, *Email* niceleys@msu.edu).

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail irb@msu.edu or regular mail at 4000 Collins Rd, Suite 136, Lansing, MI 48910.

Your confidentiality will be protected to the maximum extent allowable by law.

Parents, please be aware that under the Protection of Pupils Rights Act (20 U.S.C. Section 1232(c)(1)(A)), you have the right to review a copy of the questions asked of or materials that will be used with students. If you would like to do so, you should contact Shannon Niceley to obtain a copy of the questions or materials.

Your signature below means that you voluntarily agree to allow your child to participate in this research study.

____ ______________________________

Parent's Name Printed Child's Name Printed

____ ______________________________

Parent's Signature Date

APPENDIX G: CHILD ASSENT FORM

You are being asked to participate in a research project about your experiences in learning science at school and during your week at the zoo for the BIG Zoo Lesson. If you agree to participate, you may be taught a lesson by the researcher about how to collect and analyze data by making observations of live animals. You also may be interviewed for about 30 minutes at school both before and after your week at the zoo. The interviews will be about your experiences in learning science both at your school and at the zoo. The interviews will be recorded on a voice recorder and notes will be taken by the researcher during the interview. You may also be observed by the researcher during your week at the zoo and your one-hour daily animal observations recorded in your notebook may be copied for the researcher to use later.

The purpose of this research is to better understand how training students to collect and analyze data by making observations of live animals along with their participation in the BIG Zoo Lesson helps students learn science.

If you choose not to participate in this research, you will not be penalized in any way.

By signing your name below, you are saying that you agree to participate in this research.

____

Student Name Printed

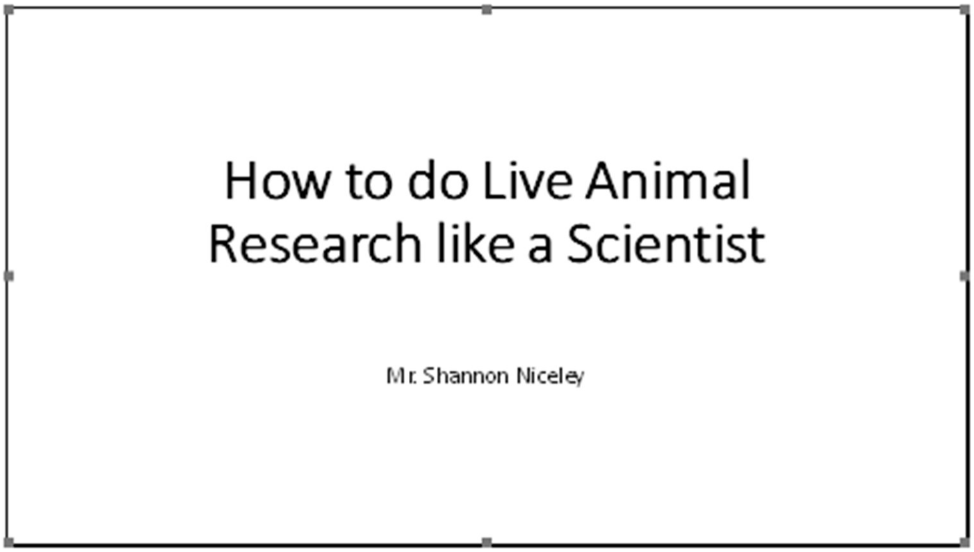
____ ________________

Student Signature Date

APPENDIX H: FIGURE 4 HOW TO DO LIVE ANIMAL RESEARCH LIKE A SCIENTIST LESSON SLIDES

Figure 3 *How to do Live Animal Research Like a Scientist Lesson Slides*

Slide 1



Slide 2

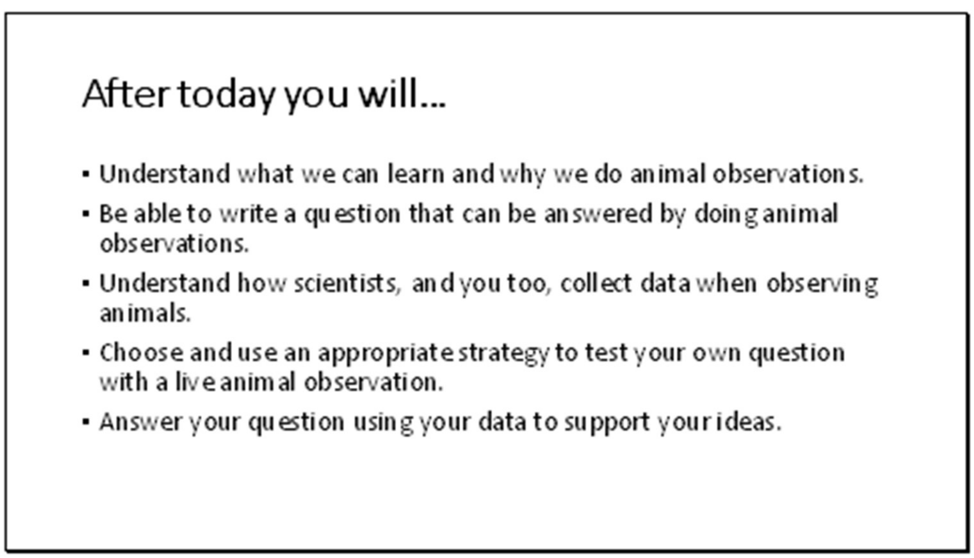
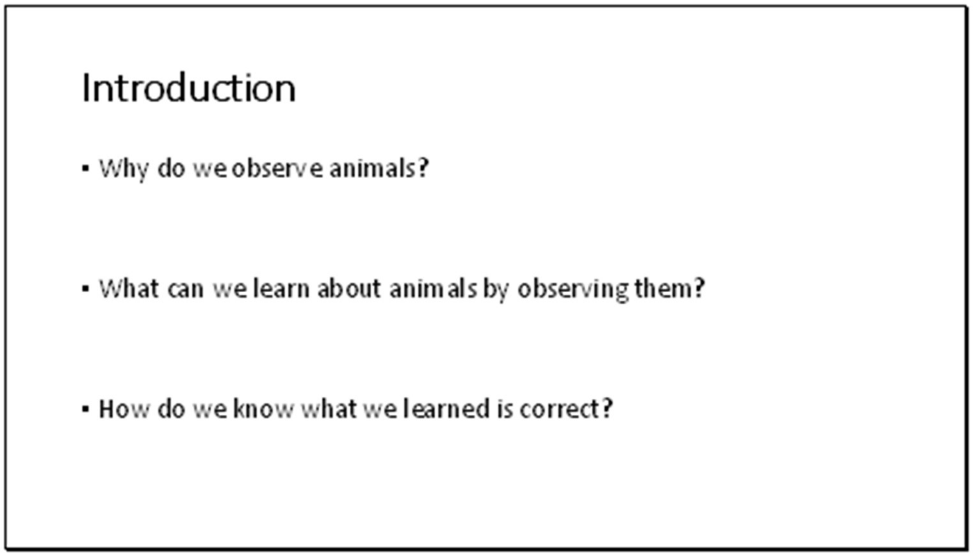


Figure 3 (cont'd)

Slide 3



Slide 4

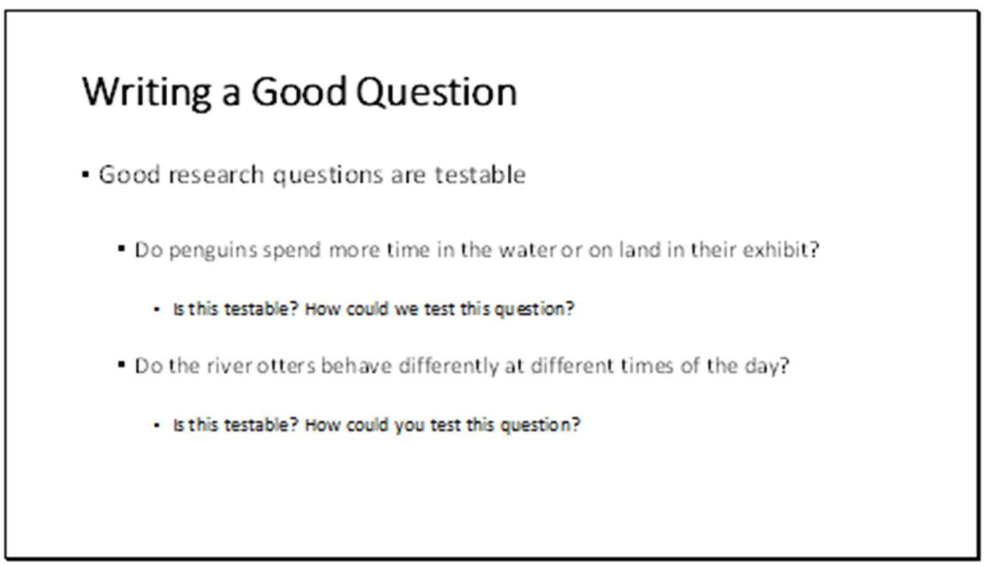
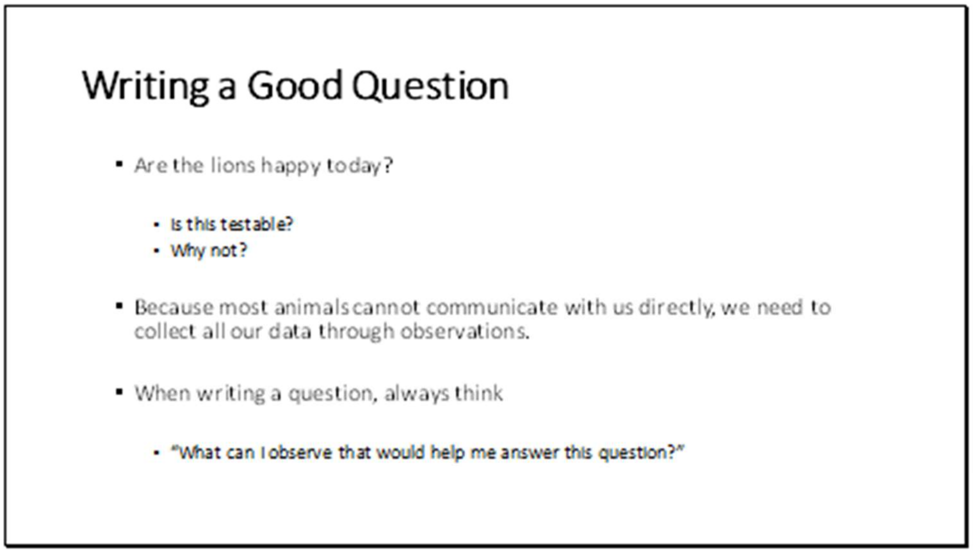


Figure 3 (cont'd)

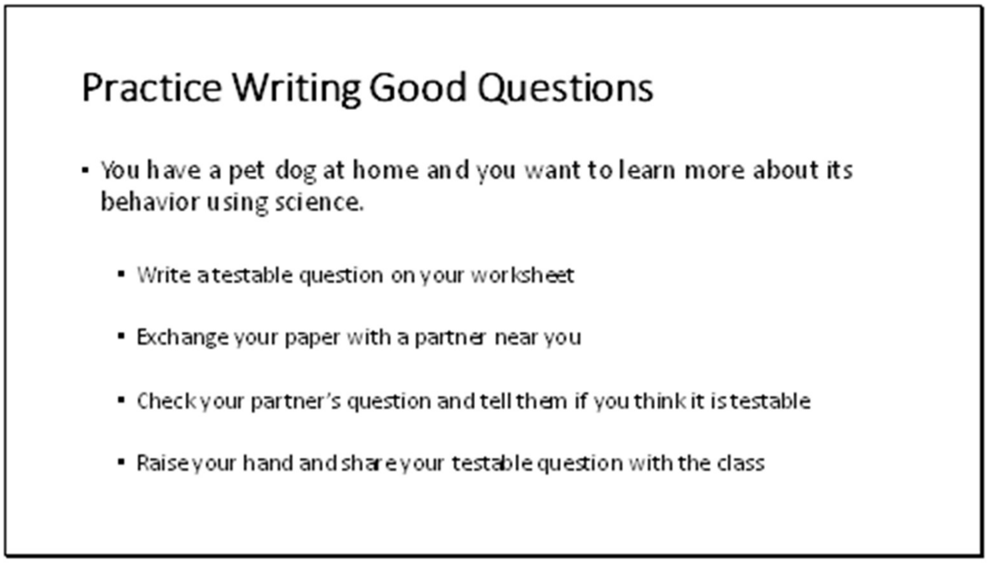
Slide 5



Slide 6

Figure 3 (cont'd)

Slide 7



Slide 8

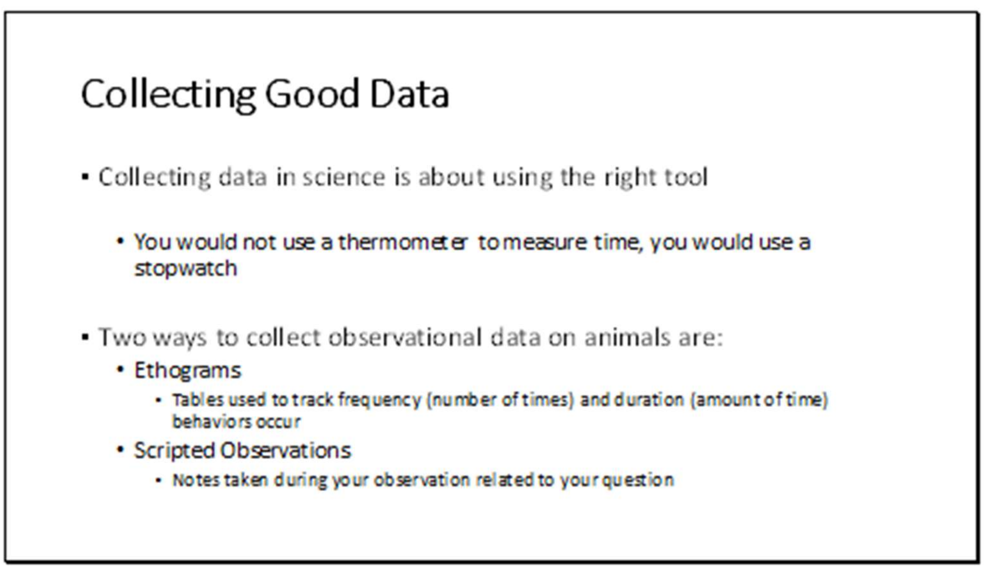
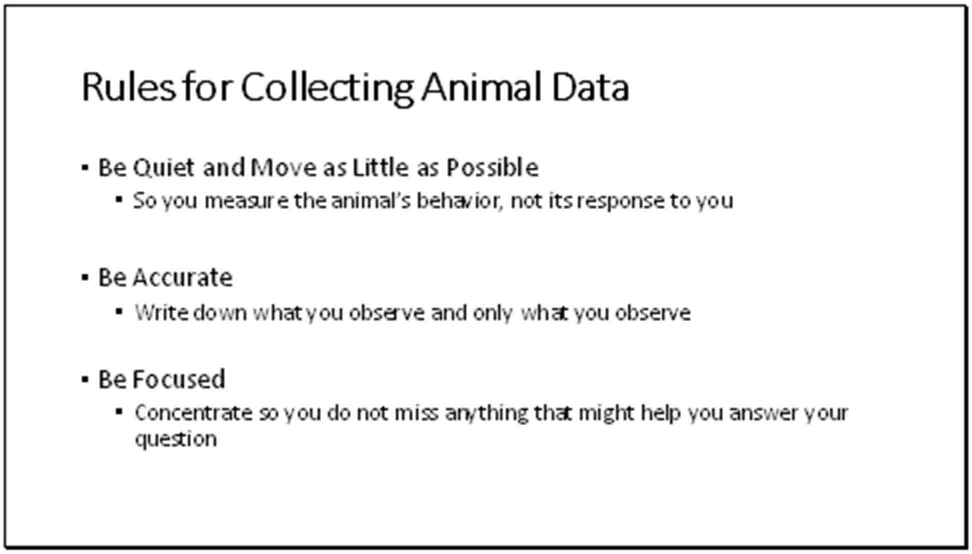


Figure 3 (cont'd)

Slide 9



Slide 10

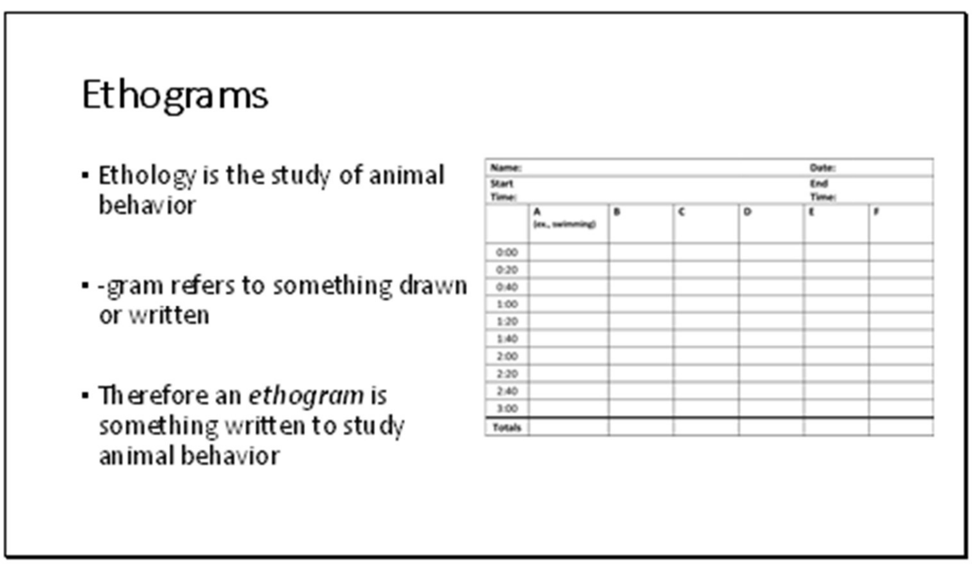


Figure 3 (cont'd)

Slide 11

Ethograms

- There are many types of ethograms depending on what data is being collected.
- Two basic types are
  - Instantaneous- collect data at fixed time intervals (every 30 seconds)
  - Continuous – record every time a behavior is observed

Slide 12

Instantaneous Ethograms

Do penguins spend more time on land or in water?

Time (min:sec)	Land	Water
0:00	x	
0:15	x	
0:30		x
0:45		x
1:00		x
1:15	x	
1:30	x	

Figure 3 (cont'd)

Slide 13

Instantaneous Ethograms

Do river otters behave differently at different times of the day? *Data collected every minute*

Day	Time	Swimming	Eating	Resting	Playing
Monday	10:00am-10:30am	𝍸 𝍸 𝍸	IIII	III	𝍸 III
Tuesday	1:00 pm - 1:30 pm	𝍸 𝍸 II		𝍸 𝍸	𝍸 III
Wednesday	1:30 pm - 2:00 pm	𝍸 II		𝍸 𝍸 𝍸 III	𝍸
Thursday	9:00 am - 9:30 am	𝍸 𝍸			𝍸 𝍸 𝍸 𝍸
Friday	11:30 am - 12:00pm	𝍸 𝍸 𝍸	III		𝍸 𝍸 II

Slide 14

Continuous Ethograms

Do penguins spend more time on land or in water?

Land	Water
:21	
	:53
5:20	
	2:07
1:19	

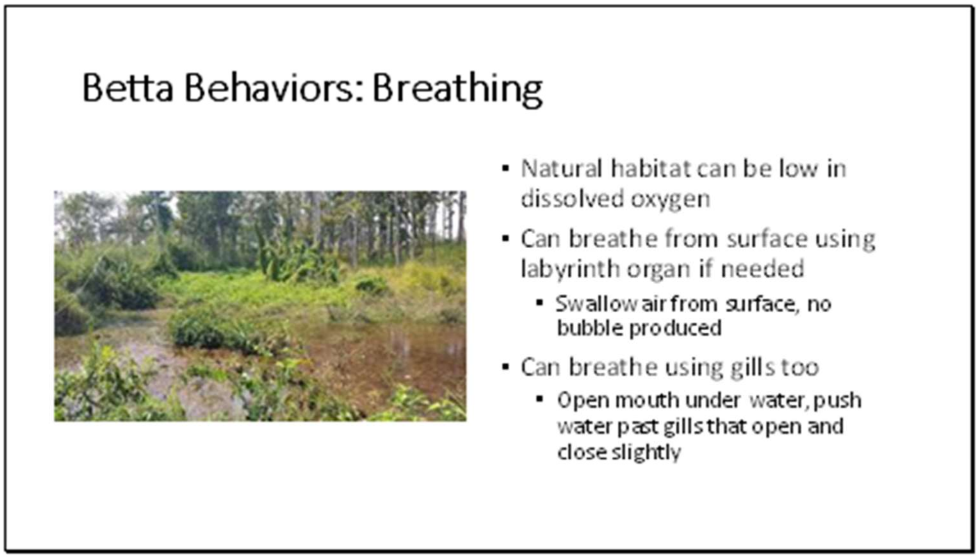
Do river otters behave differently at different times of the day?

1:00 pm – 1:30 pm	
III	Swimming
	Eating
II	Resting
III	Playing

1:00 pm – 1:30 pm	
1:00	resting
1:11	swimming
1:15	resting
1:18	playing
1:21	swimming
1:23	playing
1:25	swimming
1:28	playing

Figure 3 (cont’d)

Slide 15



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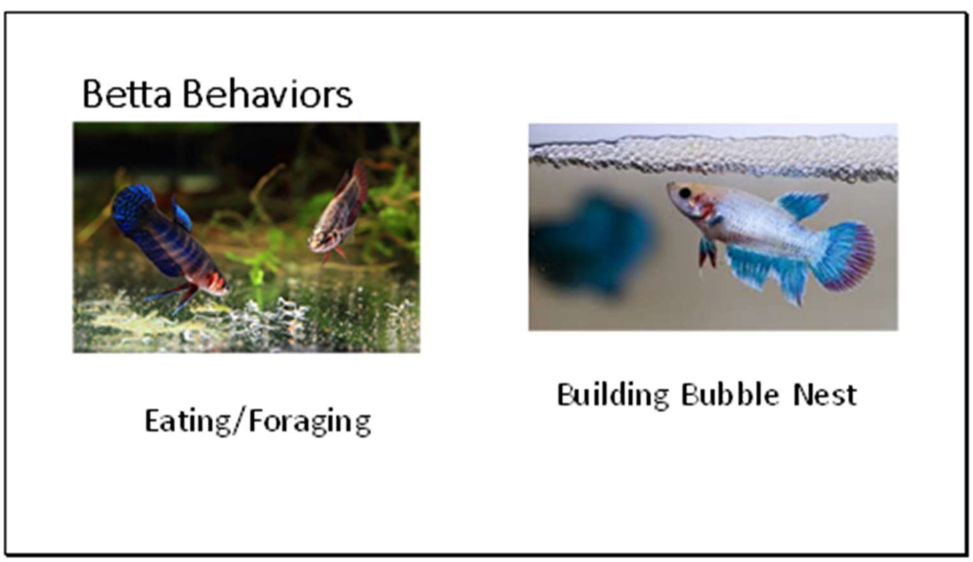
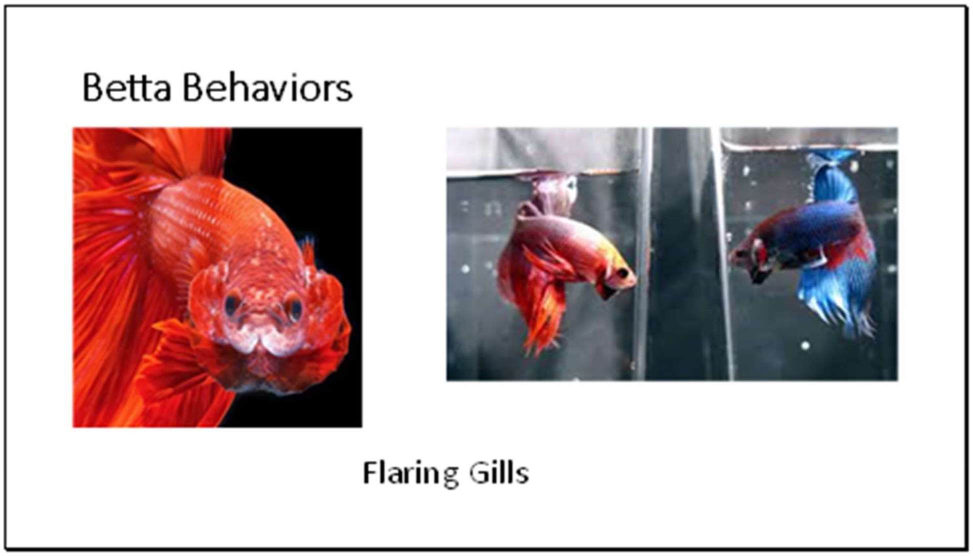


Figure 3 (cont'd)

Slide 17



Slide 18

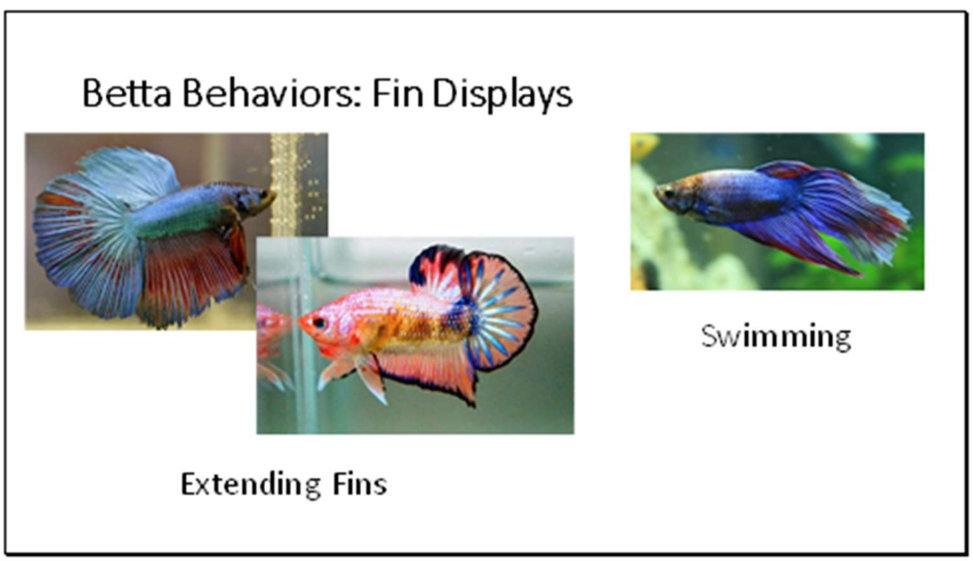
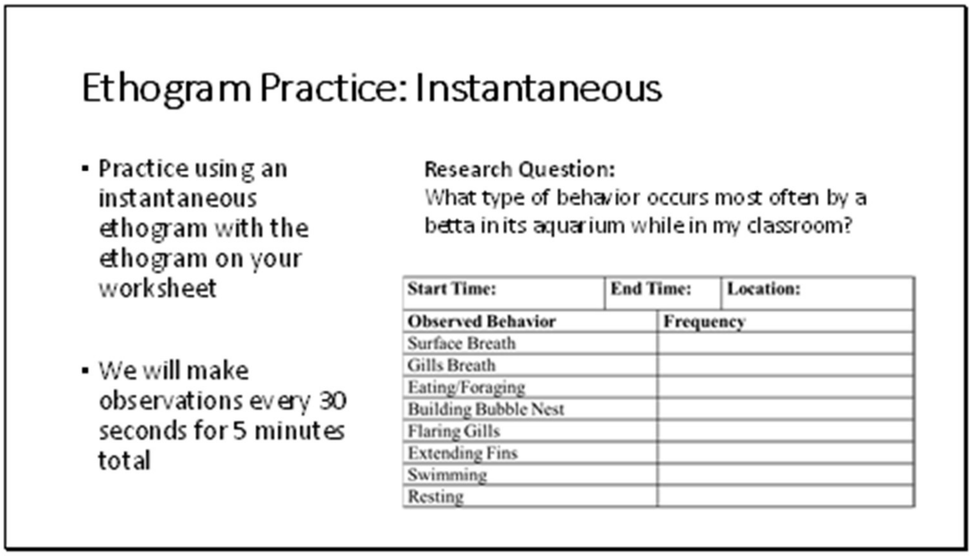


Figure 3 (cont'd)

Slide 19



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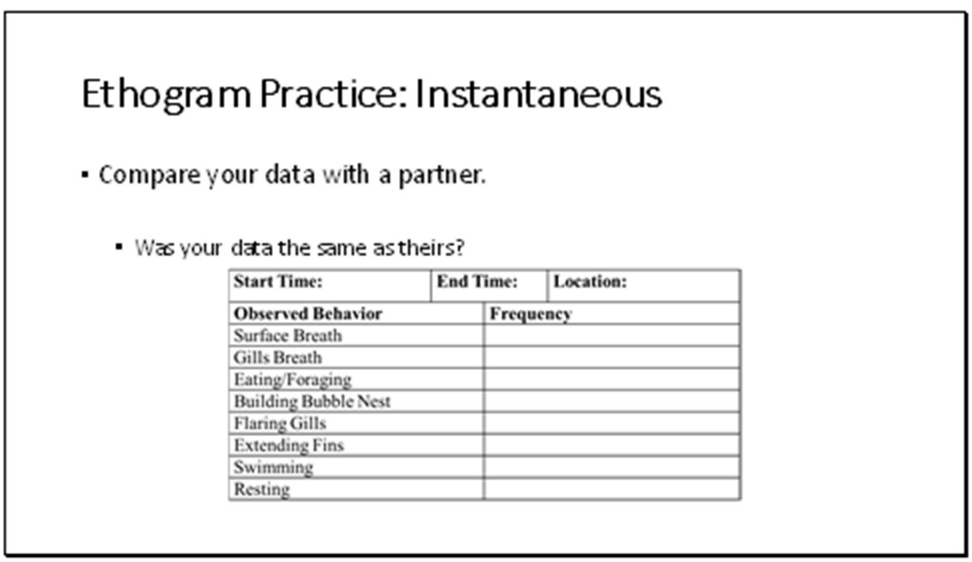
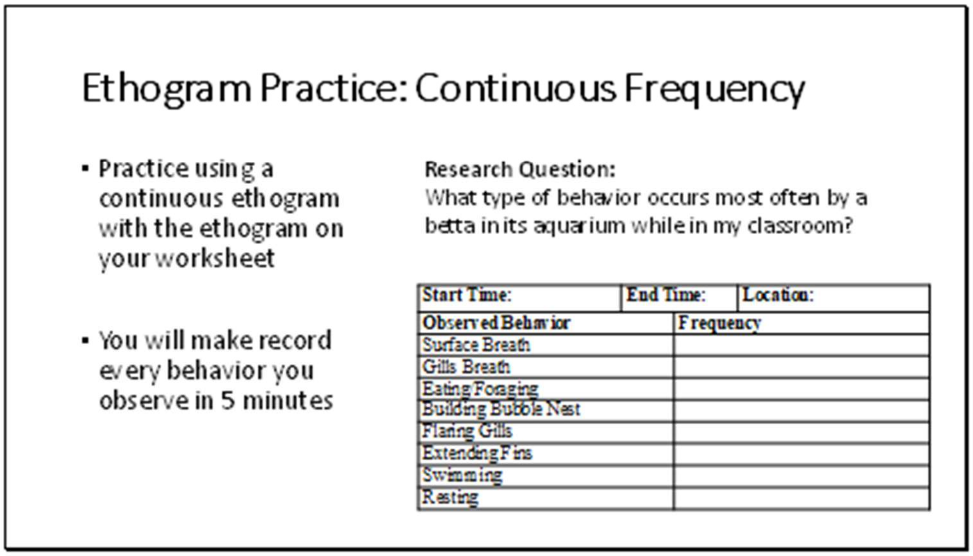


Figure 3 (cont'd)

Slide 21



Slide 22

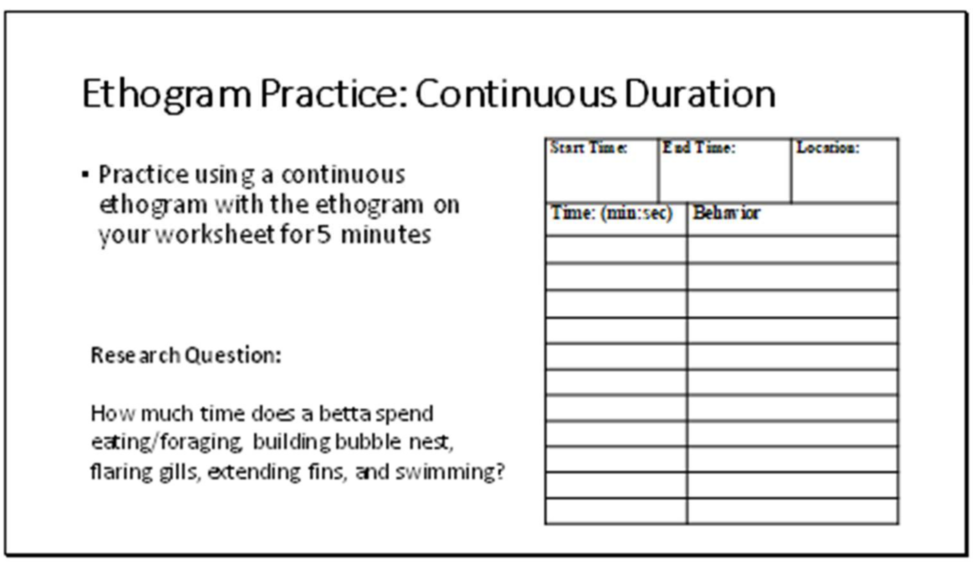


Figure 3 (cont'd)

Slide 23

Ethogram Practice

- Compare the data from your three ethograms.
- Which one do you think gave you better data? Why?

Start Time:	End Time:	Location:
Time: (min:sec)	**Behavior**	

Start Time:	End Time:	Location:
Observed Behavior	**Frequency**	
Surface Breath		
Gills Breath		
Eating/Foraging		
Building Bubble Nest		
Flaring Gills		
Extending Fins		
Swimming		
Resting		

Slide 24

Scripted Observations

- Used most commonly when you want to describe in detail what you are observing
- Use notes or full sentences to describe in as much detail as possible what is being observed
- Every few minutes or at major events make note of the time if possible

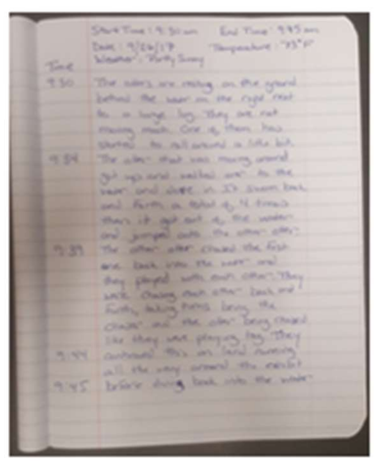
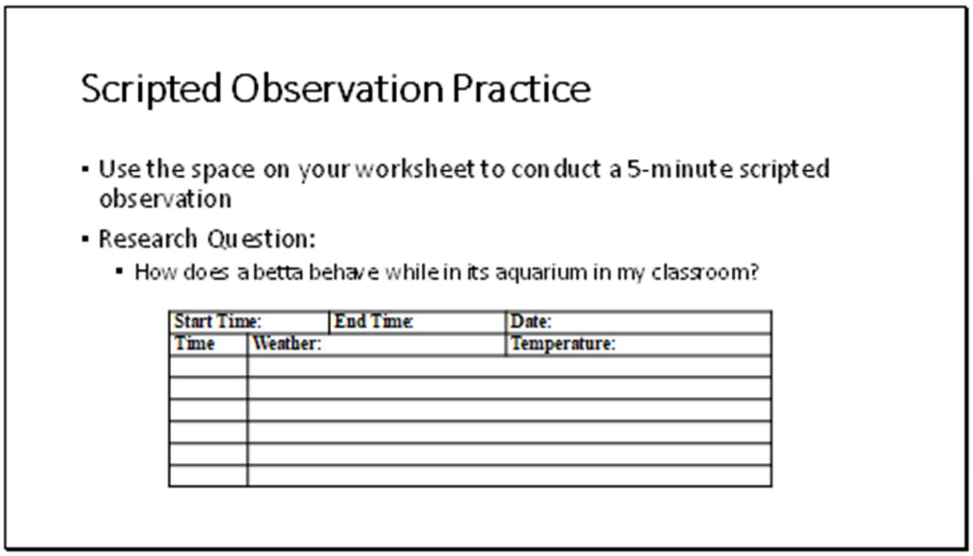


Figure 3 (cont'd)

Slide 25



Slide 26

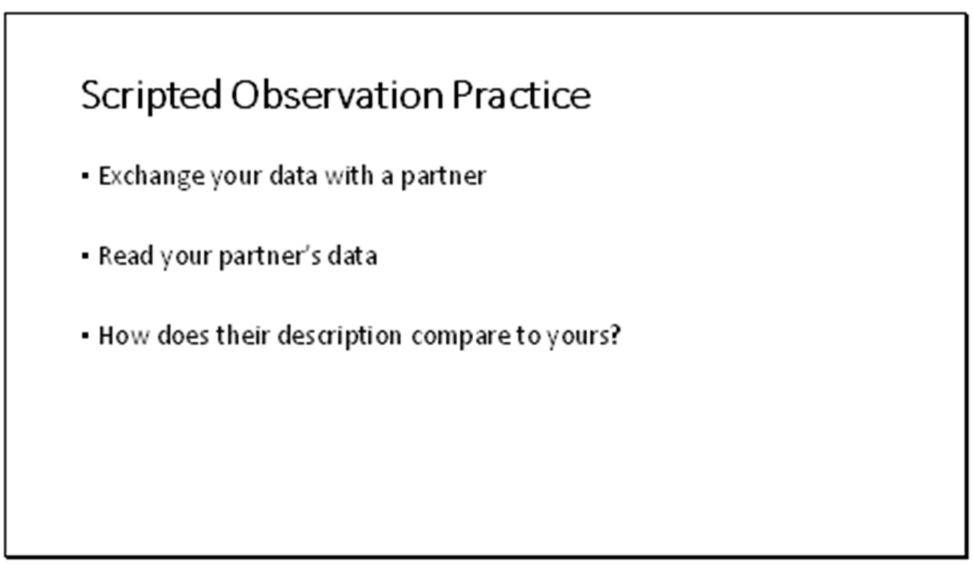


Figure 3 (cont'd)

Slide 27

Choose Your Data Collection Method

- We are going to put two betta aquariums next to each other and see how this affects their behavior.
- Write a testable question for this observation
- What method will you choose to collect your data?
- Why?

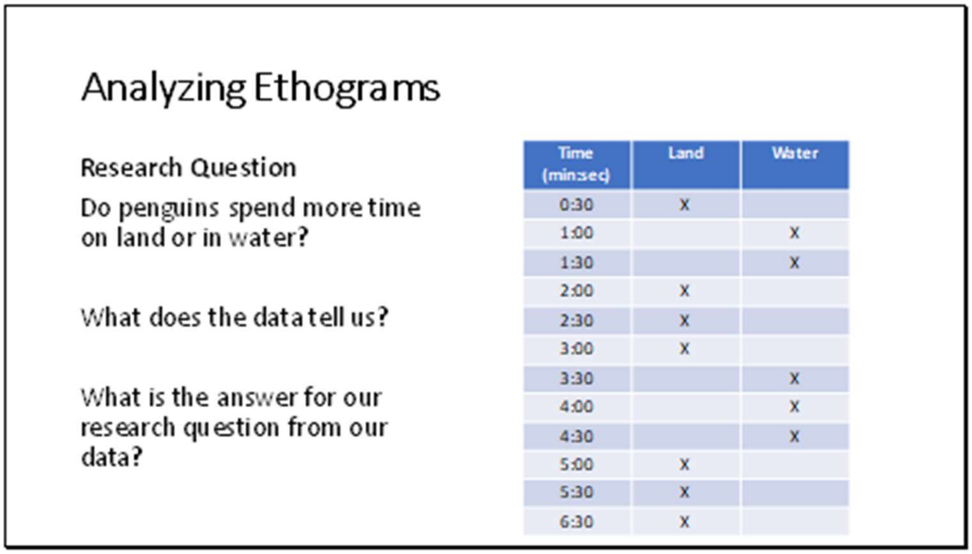
Slide 28

Analyzing Your Data

- The purpose of analyzing data is to answer your question
- Your answer should always be supported by your data
  - People answer questions by what they think
  - Scientists answer questions by what the data says

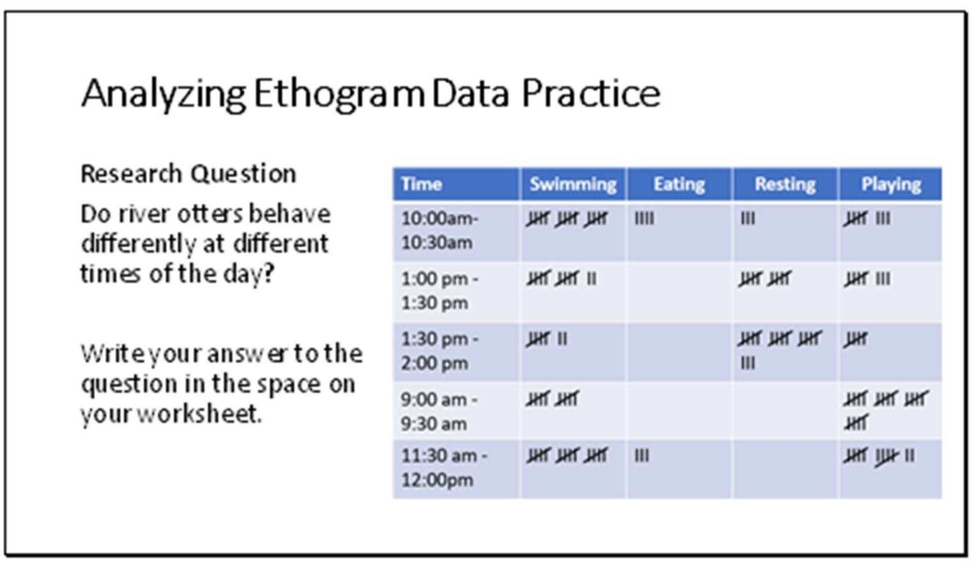
Figure 3 (cont’d)

Slide 29



Time (min:sec)	Land	Water
0:30	X	
1:00		X
1:30		X
2:00	X	
2:30	X	
3:00	X	
3:30		X
4:00		X
4:30		X
5:00	X	
5:30	X	
6:30	X	

Slide 30



Time	Swimming	Eating	Resting	Playing
10:00am-10:30am	𝍸 𝍸 𝍸	IIII	III	𝍸 III
1:00 pm - 1:30 pm	𝍸 𝍸 II		𝍸 𝍸	𝍸 III
1:30 pm - 2:00 pm	𝍸 II		𝍸 𝍸 𝍸 III	𝍸
9:00 am - 9:30 am	𝍸 𝍸			𝍸 𝍸 𝍸 𝍸
11:30 am - 12:00pm	𝍸 𝍸 𝍸	III		𝍸 𝍸 II

Figure 3 (cont'd)

Slide 31

Analyzing Scripted Observations

- Analyzing scripted observations involves reading your observation notes and writing a short summary of them

- Did you observe the same behavior a lot?
- Did you observe one behavior always happening after another?
- Do you notice any patterns?

Slide 32

Analyzing Scripted Observations Practice

Research Question:

How do the penguins interact with each other?

Start Time: 9:30 am	End Time: 9:45 am	Date: 9/25/17
Weather: Sunny	Temperature: 71°F	

9:30 All the penguins are in one group together in the back of the exhibit. A few of them are yelling at each other. The penguin with the yellow band walked over to the penguin with the blue band and began bobbing his head up and down.

9:36 Blue band bobbed its head up and down once, and then yellow band yelled loudly and blue band hopped away and into the water. Yellow band hopped over to red band and began bobbing its head up and down.

9:41 Purple band hopped over, and yellow band turned to purple band and began bobbing his head. Purple band bobbed its head up and down once, and then yellow band yelled loudly, and purple band hopped away to the other side of the exhibit. Yellow band moved back over to red band and began bobbing its head again.

9:43 Red band began bobbing its head and yellow band kept bobbing its head. Red band and yellow band hopped over to the far right together.

Figure 3 (cont'd)

Slide 33

Analyzing Scripted Observations Practice

- Write a summary sentence for the scripted observation
- My summary sentence
  - The yellow banded penguin is trying to be friends with the red banded penguin and is chasing away the other penguins

Slide 34

Analyzing Scripted Observations Practice

- Go back to your scripted observation of the betta you made earlier.
- Read your scripted observation of the betta and write a summary sentence that answers the research question
- Raise your hand if you would like to share your summary sentence

Figure 3 (cont'd)

Slide 35

Questions

- Are there any final questions about what we did today?

Slide 36

Closure Activity

- At the end of your worksheet in the space provided, write:
  - A good testable research question about the animal you are observing during your week at the zoo
  - A description of the tool you would use to collect data to answer this question
- Raise your hand if you would like to share what you wrote

APPENDIX I: FIGURE 4 HOW TO DO LIVE ANIMAL RESEARCH LIKE A SCIENTIST

Figure 4 *How to do Live Animal Research like a Scientist*

Name ____ Date _______________

How to do Live Animal Research like a Scientist

Writing a Good Question

Good Research Questions are testable

"What can I observe that would help me answer this question?"

Guided Practice

I bought a new aquarium for my pet betta fish and I want to see if he behaves differently in his new home.

How would you write a testable question for this idea?

____
____
____

Practice Writing Good Questions

You have a pet dog at home and you want to learn more about its behavior using science.

Write a testable question for this

____
____
____

Figure 4 (cont'd)

Collecting Good Data

Ethograms- tables used to track frequency (number or times) or duration (amount of time) behaviors occur

Scripted Observations- notes taken during your observation related to your question

Rules for Collecting Animal Data

- Be Quiet and Move as Little as Possible
- Be Accurate
- Be Focused

Ethograms

Instantaneous- collect data at fixed time intervals

(example: every 30 seconds)

Continuous- record every time a behavior is observed

<u>Betta Behaviors</u>

Surface breath- take a gulp of air from the surface

Gills breath- open mouth under water and open and close gills slightly

Eating/Foraging- taking bites on plants, gravel, or other objects in the aquarium searching for food

Building Bubble Nest- blowing tiny air bubbles into a pile on the surface of the water

Flaring Gills- threat display males do, usually to other males

Extending Fins- display done by both males and females, males to other males to show who is bigger, males and females to each other to show off

Swimming- moving from one place to another in the aquarium

Figure 4 (cont'd)

Ethogram Practice: Instantaneous

Research Question:

What type of behavior occurs most often by a betta in its aquarium while in my classroom?

Start Time:	End Time:	Location:
Observed Behavior	Frequency	
Surface Breath		
Gills Breath		
Eating/Foraging		
Building Bubble Nest		
Flaring Gills		
Extending Fins		
Swimming		
Resting		

Ethogram Practice: Continuous Frequency

Research Question:

What type of behavior occurs most often by a betta in its aquarium while in my classroom?

Start Time:	End Time:	Location:
Observed Behavior	Frequency	
Surface Breath		
Gills Breath		
Eating/Foraging		
Building Bubble Nest		
Flaring Gills		
Extending Fins		
Swimming		
Resting		

Figure 4 (cont'd)

Ethogram Practice: Continuous Duration

Research Question:

What type of behavior occurs most often by a betta in its aquarium while in my classroom?

Start Time:	End Time:	Location:

Time: (min:sec)	Behavior

Figure 4 (cont'd)

Scripted Observation Practice

Research Question:

How does a betta behave while in its aquarium in my classroom?

Start Time:	End Time:	Date:
Time	Location:	Temperature:

Write a summary sentence for the scripted observation.

____

____

____

Figure 4 (cont'd)

Choose Your Own Data Collection

We are going to put two betta aquariums next to each other and see how this affects their behavior.

Write a testable question for this observation

____
____
____

What method will you choose to collect your data?

____

Why? Explain to your partner why you chose this method.

Use the space below for your data collection.

Figure 4 (cont'd)

Analyzing Data

What does the data tell you?

- People answer questions by what they think
- Scientists answer questions by what the data says

Analyzing Ethogram Data Practice

Research Question:

Do river otters behave differently at different times of the day?

Use the ethogram below to answer your research question.

Time	Swimming	Eating	Resting	Playing
10:00am-10:30am	卌 卌 卌	IIII	III	卌 III
1:00 pm - 1:30 pm	卌 卌 II		卌 卌	卌 III
1:30 pm - 2:00 pm	卌 II		卌 卌 卌 III	卌
9:00 am - 9:30 am	卌 卌			卌 卌 卌 卌
11:30 am - 12:00pm	卌 卌 卌	III		卌 卌 II

Figure 4 (cont'd)

Analyzing Scripted Observations Practice

Research Question:

How do the penguins interact with each other?

Start Time: 9:30 am		End Time: 9:45 am	Date: 9/25/17
Time	Weather: Partly Sunny		Temperature: 71°F
9:30	All the penguins are in one group together in the back of		
	the exhibit. A few of them are yelling at each other. The		
	penguin with the yellow band walked over to the penguin		
	with the blue band and began bobbing his head up and down.		
9:36	Blue band bobbed its head up and down once, and then		
	yellow band yelled loudly, and blue band hopped away and		
	into the water. Yellow band hopped over to red band and		
	began bobbing its head up and down.		
9:41	Purple band hopped over, and yellow band turned to purple		
	band and began bobbing his head. Purple band bobbed its		
	head up and down once, and then yellow band yelled loudly		
	and purple band hopped away to the other side of the exhibit.		
	Yellow band moved back over to red band and began bobbing		
	its head again.		
9:43	Red band began bobbing its head and yellow band kept		
	bobbing its head. Red band and yellow band hopped over to		
	the far right together.		

Write a summary sentence for the scripted observation.

____

Figure 4 (cont'd)

Closure Activity

What animal are you observing during your week at the zoo?

____

Write a good testable question about the animal you are observing during your week at the zoo.

____
____
____
____

Write a description of the tool you would used to collect your data to answer this question. You can also draw your data collection tool below.

____
____
____
____

APPENDIX J: FIGURE 5 MAP OF POTTER PARK ZOO STUDY SITE

Figure 5 *Map of Potter Park Zoo Study Site*

APPENDIX K: FIGURE 6 PROPOSED LESSON FOR STUDYING ANIMALS THROUGH OBSERVATIONS

Figure 6 *Proposed Lesson for Studying Animal Through Observations*

Day 1: Predatory animals often rest for much of the day to conserve energy in the wild. As a scientist you would like to test whether the _______________ is displaying this same behavior in captivity. Collect data using a stopwatch and the *continuous duration ethogram* below to answer the research question:

How much time does the _____________ spend resting during a 30-minute observation?

Possible Behaviors Observed:

Active Behaviors: Eating, Walking, Running

Inactive Behaviors: Resting, Sleeping

Start Time:	End Time :	Location:
Time: (minutes :seconds)	Behavior	

Data Analysis: Find the total active behavior time by adding the minutes and seconds you observed your animal eating, walking, or running and write this in the blank below labeled Active behavior time observed. Next total the inactive behavior time by adding the minutes and seconds you observed your animal resting or sleeping and write this in the blank below labeled Inactive behavior time observed.

Figure 6 (cont'd)

Active behavior time observed: _______minutes: _________ seconds

Inactive behavior time observed: _______minutes: _________ seconds

Use the data above to aswer your research question: How much time does ______________ spend resting during a 30-minute observation? ____

Day 2: The behavior of a zoo animal can tell us a lot about its health. In order to better understand how your observation animal behaves in its exhibit, you need to answer the research question:

How often does the __________________ display each observed behavior?

Use the *continuous frequency ethogram* below to collect your data for a total of 30 minutes. There is a list of behaviors you may observe provided and blank spaces below them to add behaviors that might be specific for your animal (ex:. for penguins, you could add swimming).

Start Time:	End Time :	Location:
Observed Behavior	Frequency (use tally marks each time you observe a behavior)	
Eating/Foraging		
Walking		
Running		
Resting		
Sleeping		
Defecating (pooping)		
Urinating (peeing)		

Figure 6 (cont'd)

Data Analysis: Which behavior(s) did your animal display most often during your 30 minute observation?

Which behavior(s) did your animal display the least during your 30-minute observation?

Using your data above, write up to three sentences to answer your research question:

How often does the __________________ display each observed behavior?

Day 3: As we learned today, animals have two types of adaptations--physical adaptations and behavioral adaptations. Physical adaptations are parts of their body that allow them to better survive in their environment, such as the thick fur of a snow leopard, the stripes of a zebra, or the quills of a porcupine. Sketch one physical adaptation of your observation animal below and describe in one sentence what that physical adaptation is and how it helps your observation animal survive.

Figure 6 (cont'd)

Behavioral adaptations are behaviors that animals display that help them survive in their environment, such as when a snow leapard wraps its long fluffy tail across its face to protect its nose and face from frostbite, how zebras form tight herds to blend in with each other, or how a procupine stands its quills up and turns around to point its quills at a potential predator when it is threatened. Use the ethogram below to answer the following research question:

How often does the ____________________________ display behavioral adaptations during a 30-minute observation?

From what you have learned about your animal from reading and your own previous observations, make a list of up to 5 behavioral adaptations you think you may observe.

Collect your behavioral adaptation data using the continuous frequency ethogram below.

Start Time:	End Time :	Location:
Behavioral Adaptation	Frequency (use tally marks each time you observe a behavior)	

Use the data you collected above to answer your research question:

How often does the ___________________________ display behavioral adaptaions during a 30-minute observation?

____

____

____

Figure 6 (cont'd)

Day 4: As we learned today during our exhibit design lesson, zoo exhibits are designed to meet the specific needs of the animal they house. The zoo is considering designing a new exhibit for your observation animal, but they need to better understand how that species uses the old exhibit to inform their new design. Today, you are going to design your own investigation to answer the research question:

How does the _________________________ use the space in its exhibit?

First, make a sketch of the exhibit in your research journal. Be sure to add as much detail as possible and any appropriate labels that you may need.

Now that you have sketched your exhibit, develop a plan for your scientific investigation.

What data are you going to collect to tell you how that animal uses the space in its exhibit?

____

____

What is the best way to collect these data?

____

____

Discuss your plan with a peer in your group and/or an adult chaperone for your group. Make changes to your plan, if needed.

Conduct your investigation and collect your data below during a 30-minute observation.

Analyze your data to answer your research question.

How does the _____________ use the space in its exhibit?

Figure 6 (cont'd)

Now that you have formed your conclusions, what recommendations do you have for the new exhibit design? Explain what these changes to the exhibit design will accomplish. Do you think that your data is complete or should you conduct more observations and collect more data? Why?

Day 5: You have now observed your animal for 4 days. During these observations you have learned many things about your animal, but you likely also have other questions about your animal that you would like to answer using science. Develop a research question about your animal that you can answer using a 30-minute observation. Write your question in the space below.

Figure 6 (cont'd)

Discuss your question with a peer in your group and/or an adult for your group. Can you answer your question through data collected during a 30-minute animal observation? Do you need to modify your question so it can be answered through data collected during your animal observation?

____

____

Now that you have your question, you need to develop an investigation that can collect the data needed to answer that question. Make a plan for your investigation below, including the type of data collection you are going to use (instantaneous ethogram, continuous ethogram, or scripted observation) and the specific animal behaviors you are focusing on that will help you answer your question.

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Conduct your investigation.

Now that you have conducted your investigation, analyze your data. What is your data telling you?

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Figure 6 (cont'd)

Now use what you learned from the analysis of your data to answer your research question below.

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Are you confident that your one data collection accurately answered your research question? Why? What would you do to improve your confidence in your answer?

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APPENDIX L: EXAMPLE OF CODE FROM CODEBOOK

Tag	Code	Definition	Rule	Example	Near Miss	Explanation of Near Miss
Obs Learning	Learning through observation of animals	Student learning that was attained through the act of observing their daily-observation animal	Student explicitly states a behavior that could have been observed while the animal was on exhibit.	"the girl peacocks spent most of their time near the reptile house while the boy peacocks were found all over the zoo."	*"I remember that the arctic fox likes to hide if they hear something coming then they just start to hide just in case it is a predator because in the arctic in the snow the arctic fox blends in with the snow when it starts to lie down, puts the tail over its face so it won't see the black on it and in the summer for other predators it camouflage's it turns to brown so it can blend in with the trees and the mud so other predators won't see it."*	The behavior of hiding and wrapping tail around face to cover up black nose and eyes could not have been observed by this student because there was no snow on ground during the week of observation. The learning the student describes was from a combination of information on the signage and from lesson on camouflage (Pelts Lesson)

APPENDIX M: FIGURE 7 STUDENT ANIMAL OBSERVATION JOURNAL EXAMPLES

Figure 7 *Student Animal Observation Journal Examples*

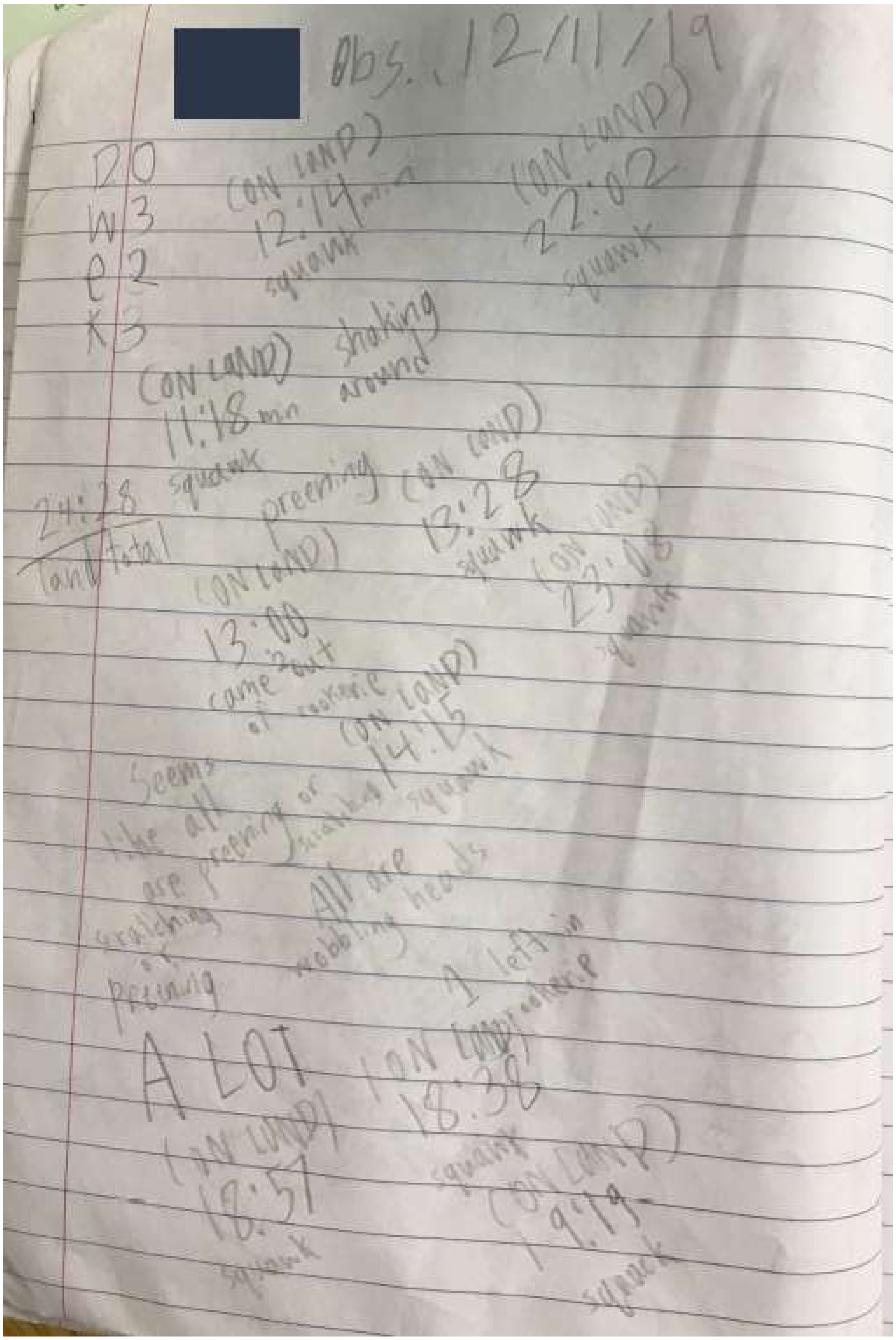
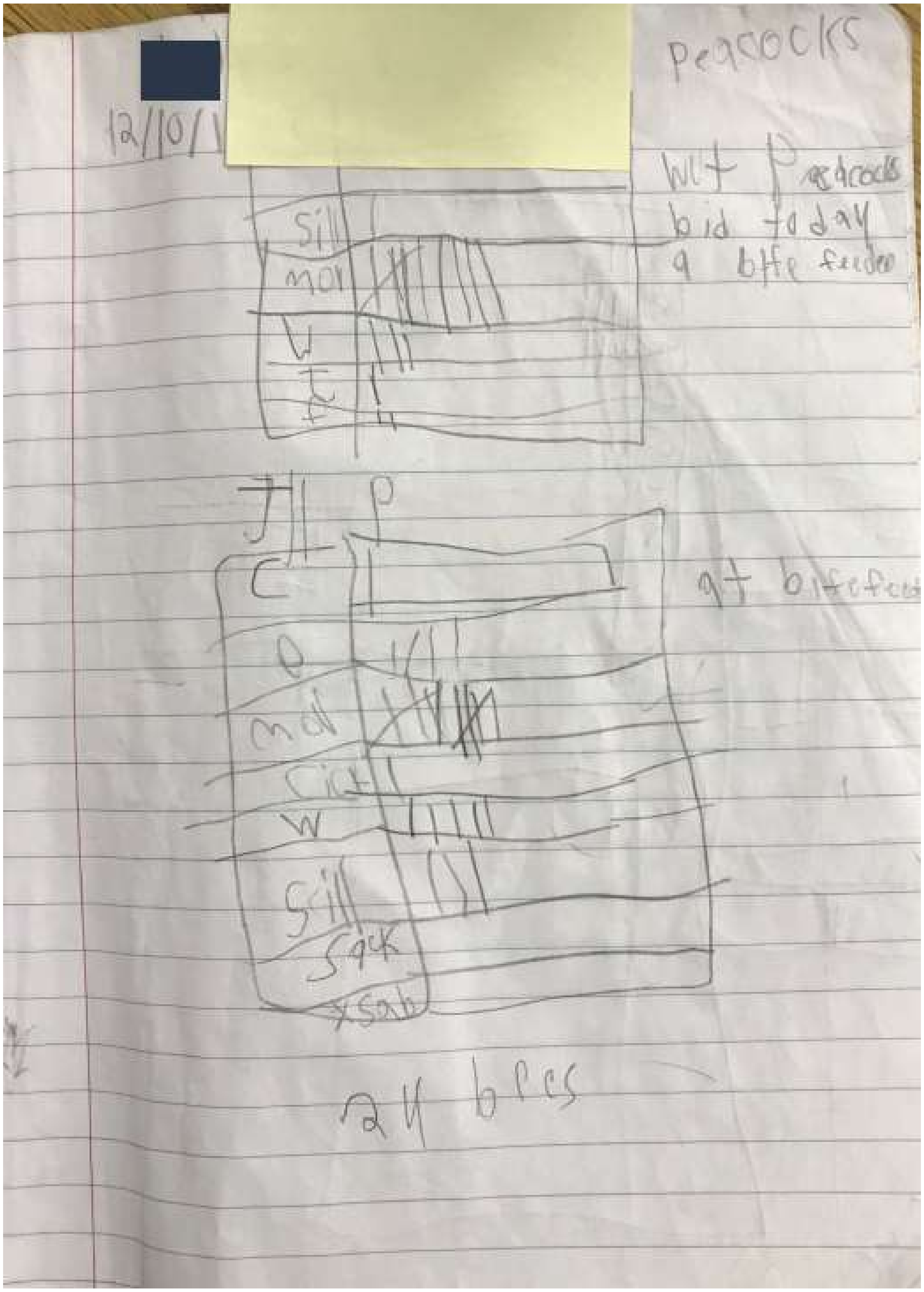


Figure 7 (cont'd)



APPENDIX N: OBSERVED BZL LESSONS AND ACTIVITIES

Lesson Type	Title	Objectives	Lesson Subtype(s)
Docent-led Lessons	What's for Lunch (Tour)	Compare and contrast herbivores, carnivores, omnivores including eye and ear placement, differences in dentition, explain beak adaptations for food eaten by different birds, discuss how prey and predators avoid detection, discuss relationships with food chain, including photosynthesis and importance of scavengers.	Live Animals
	Animal Adaptations (Tour or Encounter w/educational animals)	Understand the concept of animal adaptations and how those adaptations give them a better chance of surviving in the wild. They should be able to differentiate between physical and behavioral adaptations and understand that animals typically have adaptive behaviors that correspond to each physical adaption. In addition, students should understand that by observing physical adaptations of a species we can often predict/deduce many of their	Live Animals

		behaviors and habitat use.	
	Exhibit Design (Tour)	List 7 needs of animals in captivity List 7 basic considerations of exhibit design based on the needs of the animals to be housed Describe 3 different barrier designs to prevent animals from escaping Design an exhibit which incorporates what they have learned	Live Animals
	Rhino Encounter	Identify adaptations (senses, short-stout limbs, prehensile lip, horn, wallowing) Identify features (indoor and outdoor) of the black rhino exhibit at Potter Park Identify conservation concerns and actions taken to improve the situation	Live Animals
	Wolf Lesson	Identify the role wolves play in the food chain Identify prey species of wolves Identify physical adaptations that make wolves good predators (senses, teeth, claws, camouflage) Identify behavioral adaptations that make wolves good predators (group living and hunting,	Live Animals

		communication, nocturnal) Identify ways that wolves can indicate with each other Identify other wild species of canids found in Michigan Explain how wolves came to be endangered in the United States and their current status	
	Species Survival Plan	Explain what a Species Survival Plan is Define endangered and extinct Identify the major cause of animals becoming endangered Discuss the difference in regulated hunting and poaching Identify some of the different kinds of experts needed on a Species Survival Plan committee Explain what scientific captive breeding is and how it helps animals in the wild Identify some of the problems that can occur once to animals are matched for scientific captive breeding	
	Enrichment-Making Lesson	Define enrichment Describe examples seen around the zoo Work any group to make enrichment	Live Animals Active Learning

		Evaluate the animals' reaction to the enrichment	
Teacher-led Lessons	Monday Discovery Tour	Become acquainted with the zoo Students orient themselves within the space of the zoo Opportunity to see all of the animals at the zoo	Live Animals
	Antlers, Horns, & Tusks	Focus on similarities and differences between antlers and horns and tusks and what kind of animals have each Students can gently touch artifacts	Active Learning
	Pelts	Students observe pelts of gray Wolf, Arctic Fox, snow Leopard, a murder Tiger, seal, sea turtle, river otter, Whitetail deer, bongo, zebra, hare and identify adaptations including types of camouflage (counter shading, cryptic, disruptive) and warning colors Students attempt to use deductive skills to determine species of animal	Active Learning
	Skulls	Students observe and sketch mammalian skulls including Tiger, Wolf, otter, dear, horse, porcupine, pronghorn, bear, spider monkey, and red panda Students attempt to classify the organism	Active Learning

		as a carnivore, herbivore, or omnivore Identify types of teeth (canine, incisors, molars) and how features of the skull (eye size and placement, mandible size and orientation)	
	Bird Beaks	Students observe and sketch birds skulls and beaks and identify the type of feeding behavior associated with the beak structure.	Active learning
	Magellan Penguins	Students observe the Magellan Penguins and participate in a teacher-led presentation on the Penguins. Several artifacts including Penguin bones, skulls, wings, and feathers are used to demonstrate adaptations of Penguins.	Live Animals
	Bird and Reptile House Scavenger Hunt	Students use the signage to complete a scavenger hunt. Scavenger hunt is separated into several graphic organizers including animal classification, nocturnal or diurnal, carnivore omnivore herbivore, conservation status, continent found, those that live in Michigan, and a challenge sheet where students	

		identify a singular species with an interesting ability or trait.	
	Big Zoo Lesson Scavenger Hunt	Students are provided with a set of clues that are separated in place and envelope. Each clue is pulled out wanted time and students work as a group to identify the animal that fits the clues.	