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The purpose of this study was to examine the knowledge, skills, and dispositions enabled for elementary school participants in two summer herpetology programs, one in North Carolina and one in Florida. An additional purpose of this study was to examine the normative scientific practices in which participants engaged and to describe how these experiences differed across each of the herpetology programs. Finally, the program structures of *Herpetology* and *Reptiles* were compared to determine how each herpetology program's activities and methodologies impacted participants' perceptions of authentic science.

A goal of this study was to expand and broaden the understanding of how authentic science program structure impacts what is enabled for participants in terms of knowledge, skills, and dispositions gained. This study built on previous research of contextually authentic science practices (Buxton, 2006). This study was conducted and the data analyzed using an interpretative case study, mixed methods approach. Data collected included: video and audio data from classroom and field sessions, participant focus group interviews, photographs, and photo elicitation interviews. Participants' science journals were collected and analyzed. Pre- and post-assessments and surveys were administered and analyzed for twenty-four participants, twelve participants from the *Herpetology* program and twelve participants from the *Reptiles* program.

CONTEXTUALLY AUTHENTIC SCIENCE FOR YOUNG CHILDREN: A STUDY OF TWO SUMMER HERPETOLOGY PROGRAMS

by

Catherine Marie Scott

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the Faculty of The Graduate School at
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Approved by

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APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

> It has been said that the primary function of schools is to impart enough facts to make children stop asking questions. Some, with whom the schools do not succeed, become scientists. - Knut Schmidt-Nielsen

Van Eijck and Roth (2009) frame authentic science experiences as “forms of engagement with nature and data collection instruments that bear family resemblance with those forms of engagement scientists normally exhibit” (p. 614). These experiences impact the community at large in their outcomes. Van Eijck and Roth (2009) assert that in order for science to be authentic, participation, and not just observation, is crucial.

In addition to providing opportunities to engage in the practices of scientists, a canonical view of authentic science, researchers have also found it is important to keep a youth-centered view in authentic science and to ensure that the goals, interests, and ideologies of the participants are included when conducting scientific investigations (Buxton, 2006; Rahm, Miller, Hartley, & Moore, 2003). Although engaging students in authentic science is valuable because it exposes students to how science is done, enabling students to define what makes science relevant, valuable, and applicable to their own lives addresses the concern that exposure alone is not enough to have students affiliate with science. Buxton (2006), in describing an authentic science that combines canonical views and youth-centered views, defines these practices as contextually authentic science.

Participation in authentic science experiences is important for students because it enables them to see scientific work in practice. In addition, authentic science presents opportunities to learn and understand scientific language in context, giving meaning to unfamiliar concepts and language. Also, authentic science introduces students to the tools that scientists use and since authentic science involves participation (van Eijck & Roth, 2009), it offers opportunities for students to use those tools (or perhaps tools that resemble the tools) that scientists use. Authentic science provides participants opportunities to engage in normative scientific practices (Carlone, Haun-Frank, & Webb, 2011) that enable the growth of knowledge, skills, and dispositions in the field of science. While knowledge may refer to knowing both the content and practices associated with science, in the context of this study, knowledge is defined as scientific content, and practices are defined as the skills of doing science. Each of these components of science is valuable in developing scientifically literate citizens.

If participation in authentic science experiences provides participants with a true opportunity to engage in scientific practices, then perhaps it is valuable to examine the affordances that summer science programs offer participants in terms of knowledge, skills, and dispositions gained. Therefore, this study was designed to examine the practices participants engaged in while attending two summer herpetology programs. Two different week-long herpetology programs located in two different states, both on the Atlantic coast, were examined. The purpose of this study was to determine how each herpetology program enabled the development of knowledge, skills, and dispositions related to normative scientific practices, such as fieldwork and tool use. Further details about each of the herpetology programs, fieldwork, and tool use are provided later in this chapter.

This study was situated within the context of an international research agenda focused on authentic science opportunities for students (Braund & Reiss, 2006; Buxton, 2006; Chinn, 2009; Chinn & Malhotra, 2002; Hsu & Roth, 2010; Hsu, van Eijck, & Roth, 2010; Lee & Songer, 2003; Markowitz, 2004; van Eijck & Roth, 2009; Waight & Abd-el-Khalick, 2011). The goals of the larger research agenda are to determine what makes science authentic for students (Braund & Reiss, 2006; Buxton, 2006; Chinn & Malhotra, 2002; Hsu & Roth, 2010; Hsu et al., 2010; Lee & Songer, 2003), to explore the associated outcomes related to student interest in scientific careers (Chinn, 2009; Markowitz, 2004; van Eijck & Roth, 2009) and to understand the practices of scientific communities (Waight & Abd-el-Khalick, 2011).

Previous studies, from 2002 to 2012, examined the role of authentic science with respect to how participants determined that science is authentic, how authentic science impacted career orientations, and how the practices of authentic science aligned or did not align with participant ideology. These studies primarily targeted high school students, college students, and teachers. Only one study during this time period (Buxton, 2006) addressed authenticity from the perspective of elementary school students. Buxton’s three-year study of teachers and students in a struggling Louisiana school found that while activities that engage students in authentic science (that is, allow opportunities for students to *be* scientists) are valuable, students also found it more engaging and relevant to have activities focused on topics that affected their lives. Buxton (2006) noted the need for both canonical and youth-centered views of authentic science to create a contextually authentic science program.

However, we still do not know how contextually authentic science experiences impact the knowledge, skills, and dispositions of students in elementary school, or the role that scientific practices play in the development of knowledge, skills, and dispositions. Previous studies do not examine the development of scientific knowledge, skills, and dispositions in elementary school with respect to authentic science. Some studies (Charney et al., 2007; Hsu et al., 2010; van Eijck & Roth, 2009) address the role of internship experiences in creating authentic science opportunities for students. Other studies (Brossard, Lewenstein, & Bonney, 2005; Fields, 2009; Hay & Barab, 2001; Williams, Ma, Prejean, Ford, & Lai, 2007) examine the role that informal education may provide in creating authentic science experiences. None of these studies focus on elementary school children. In addition, few studies (Jones et al., 2000; Waight & Abd-el-Khalick, 2011) exist that examine student tool use in scientific contexts.

Therefore, for purposes of this study, knowledge, skills, dispositions, and normative scientific practices were examined in depth in two different informal education environments (that is, out-of-school, summer programs), two week-long herpetology programs for seven to eleven year olds. This study provided a systematic analysis of knowledge, skills, and dispositions children gained at each of the herpetology programs. Comparisons were made between and within programs. Additionally, a systematic analysis of each program was conducted to determine how well each program aligned with the premises of contextually authentic science. This dissertation describes the nature of the experiences that young children had in each herpetology program with respect to the content, the activities, the tools, and interactions with other students and instructors.

Importance of the Study

The struggle to interest students in pursuing scientific careers continues (Jacobs, 2005). Science is still a least favorite subject of K-12 students (Fensham, 2006; Schreiner & Sjøberg, 2004). One critique of science education is that the kinds of school science that students are exposed to are not authentic science experiences (Fensham, 2006; Rahm et al., 2003; Schreiner & Sjøberg, 2004).

The purpose of this study was to expand on previous studies focused on authentic science (Barton, 1998; Brickhouse, 2001; Buxton, 2006; Hay & Barab, 2001; Markowitz, 2004; Roth & Roychoudhury, 1993). Previous studies of authentic science have been conducted primarily in high school settings and they examined broader, more traditional science fields such as biology, chemistry, and astronomy (Hay & Barab, 2001; Markowitz, 2004; Roth & Roychoudhury, 1993; Waight & Abd-el-Khalick, 2011).

Bowen and Roth (2007) suggested that field ecology appeals to a more diverse student population than some of the traditional sciences and that field ecology might be an avenue for interesting students, particularly females, in science. Furthermore, Bowen and Roth make the argument that field ecology studies appeal to students, at least partially because they are more authentic than the experiences that students traditionally have in schools.

Research design in field ecology is highly emergent, and tools and methodologies are often developed in context. In addition, the social interactions between members of the field ecology community are an important, and an often attractive component of field ecology as a profession (Bowen & Roth, 2007). In this study, young children's' participation in two different herpetology programs (field ecology sciences) is examined for contextual authenticity.

Although previous research has been informative in examining how science is deemed authentic, researchers have not spent enough time examining the role of authentic science in the development of knowledge, skills, and dispositions associated with scientific studies. Additionally, further examination of the use of contextually authentic science with elementary school aged children may provide new insights not captured in studies of older participants or in studies that relied only on a canonical view of authentic science. While previous studies have helped to show the benefits of authentic science in developing student understanding of the nature of science and in increasing student interests in science-related careers, more must be done to examine the specific affordances that informal, contextually authentic science programs can offer participants in terms of scientific knowledge, skills, and dispositions.

Additionally, an analysis of the two programs and a determination of their alignment with contextually authentic science add to limited research on contextually authentic practices. This study also has implications for formal classroom science teaching practices that may aid science teacher educators in identifying appropriate tool use and effective methods for implementing fieldwork in the elementary school classroom. The implications of this study on the field of science teacher education will be discussed in Chapter V.

Research Questions

Building on previous studies of authentic science practices and their impact on student learning, this study aimed to add to the existing knowledge on authentic science experiences and the importance of such experiences in young children's development of scientific knowledge, skills and dispositions and was guided by the following questions:

1. What opportunities for broadening and deepening scientific knowledge, skills, and dispositions were enabled in elementary school children in two different herpetology programs?
2. What were the ways in which elementary students engaged in scientific practices, in two different one-week long summer herpetology programs?
3. What was the relationship between the students' engagement in practices and the camp structures of each herpetology program and the knowledge, skills, and dispositions enabled in each program?

Rationale for the Study

According to the American Association for the Advancement of Science (AAAS, 2009):

> The most serious problems that humans now face are global: unchecked population growth in many parts of the world, acid rain, the shrinking of tropical rain forests and other great sources of species diversity, the pollution of the environment, disease, social strife, the extreme inequities in the distribution of the earth's wealth, the huge investment of human intellect and scarce resources in preparing for and conducting war, the ominous shadow of nuclear holocaust—the list is long, and it is alarming.
>
> What the future holds in store for individual human beings, the nation, and the world depends largely on the wisdom with which humans use science and technology. And that, in turn, depends on the character, distribution, and

> effectiveness of the education that people receive. (AAAS, 2009, *Project 2061, Introduction*)

For individuals to be competent in making decisions related to science, they must have the abilities to reason scientifically (AAAS, 2009; National Research Council, 1996). These abilities are developed through participation in authentic science experiences, where students engage in inquiry, tool use, and data collection and analysis. Bruce Alberts, President of the National Academy of Sciences, advocates that “students need to learn the principles and concepts of science, acquire the reasoning and procedural skills of scientists, and understand the nature of science as a particular form of human endeavor” (Olson & Loucks-Horsley, 2000, p. xiii).

The *National Science Education Standards* call for students to have opportunities to learn both the processes and knowledge needed to conduct scientific inquiry through asking questions, planning investigations, and using tools to gather data (NRC, 1996). For students to better develop the skills needed to collect data and engage in future scientific careers, they must be provided ample opportunities to work with tools in an authentic, real world context, as tools are a main resource for data collection in the scientific world.

Although extensive research has been completed to determine what student engagement in authentic science should look like, few articles focus specifically on students’ use of tools to gather a better understanding of scientific inquiry and data collection (Jones et al., 2000). Through engagement in scientific practices, students are provided with the opportunities to use tools and concepts that are contextually situated and demonstrate the real-world application of scientific practices (Bransford, Brown, & Cocking, 2000).

Research Design

This study was guided by a mixed-methods strategy for data collection and data analysis. A multiple case study strategy was used to examine the scientific knowledge, skills, dispositions, and scientific practices that develop as a result of participation in each herpetology program. The two programs were examined to determine their alignment with contextually authentic science practices. The multiple cases were two week-long herpetology programs located on the Atlantic coast, the *Herpetology* program at a residential and day camp facility in the Carolina Piedmont and the *Reptiles* program held at a nature preserve in Central Florida (program names, cities, and camp facility names are all pseudonyms). Data were compared both within and across cases. A detailed description of each case can be found in Chapter III.

Qualitative data collected included focus group interviews, audio and video recordings as participants engaged in program activities, participant photographs and photo elicitation interviews, field notes, participant science journals, and curriculum materials. Quantitative data were collected from participants in the form of pre- and post-assessments and surveys.

Data were analyzed in a continuous comparative method. Quantitative data were analyzed using *Statistical Package for the Social Sciences*. Qualitative data from focus group interviews, field notes, observations, participant photographs and photo elicitation interviews, and recordings were analyzed by segmentation into coding categories.

Segmentation was completed both by hand and through IBM's jStart Natural Language Processing Software. These categories were developed using common themes found across each data source (Yin, 2003).

Multiple steps were taken to determine the themes by which data were sorted; these steps included sorting data into arrays and tabulating frequencies of different events (Yin, 2003). The themes were expected to emerge from the literature base supporting this study related to participant knowledge, skills, dispositions, and practices. Scientific knowledge was examined through evidence of facts and concepts. Process skills were examined using the five coding categories (acquisitive, organizational, manipulative, creative, and communicative) developed by Trowbridge, Bybee, and Powell (2000). Both scientific knowledge and process skills are described briefly later in this chapter and in more detail in Chapter II.

Specific attributes, such as curiosity and collaboration, are often used to describe scientists (AAAS, 2009; Etkina et al., 2010). Based on an analysis of previous research on scientific dispositions and findings from my study, data were sorted by the following four attributes: curiosity, collaboration, ethics, and bravery.

Limitations of the Study

The scope of this study was limited to two different herpetology programs designed for elementary school children (ages 7-11). Although herpetology programs for elementary-aged children are not numerous, these two programs represent a small percentage of informal science education programs that currently exist. Although the study population was limited, the knowledge gained from this study is informative.

A limitation of this study was the short duration of each program; each of the programs was only one week long. Although focusing on herpetology programs allows the opportunity to see how program structure impacts the knowledge, skills, and dispositional development of participants, it also limits the ability to generalize the findings to a larger population because only two short programs from a distinctive branch of biology were examined.

Terms Defined

The literature defining and describing the terms used in this study is explored in detail in Chapter II. The following are operational definitions for terms that are used in this study.

Canonical science, or traditional science, is participation in science (most often laboratory science) using an *a priori* prescribed scientific method, to guide the scientific investigation. Canonical science is often perceived as using costly equipment, precise training, and a linear format of investigation.

Contextually authentic science, (referred to henceforth in this study as “authentic science”), is defined as participation in science activities and research that reflects what actually occurs in real scientific practices. Science is made authentic by incorporating the use of tools, language, fieldwork, and research methods employed by scientists, and by encouraging the application of higher order thinking skills such as reasoning, and analyzing data. In addition, contextually authentic science is also youth-focused in that it looks at topics of interest to participants. Participants’ meaning-making of experiences is valued as they aid colleagues and scientists in determining what are valued and acceptable scientific practices (Buxton, 2006).

Dispositions, as described by Carr and Claxton (2002), are "a tendency to edit, select, adapt and respond to the environment in a recurrent, characteristic kind of way (p. 13)." Dispositions are strengthened and supported by experiences and environmental responses; events and people reinforce dispositions either positively or negatively. The dispositions under examination in this study include curiosity, collaboration, and ethics. These three dispositions are dispositions most commonly associated with scientists. In addition, bravery as a disposition is also examined based on results from my study.

Herpetology refers to the study of reptiles and amphibians, including physiological characteristics, behavior, adaptations, life cycles, predator-prey relationships, and interactions with other organisms and the environment.

Informal Science is science that occurs in nontraditional (out-of-school) settings. As defined by Crane, Nicholson, Chen, and Bitgood (1994):

> Informal science learning refers to activities that occur outside of the school setting, are not developed primarily for school use, are not developed to be part of an ongoing school curriculum, and are characterized as voluntary as opposed to mandatory participation as part of a credited school experience. (p. 3)

Informal science may occur at museums, science centers, parks, and summer camp programs, as well as many other venues.

Knowledge, in the context of this study, refers to scientific facts and concepts. Scientific facts are concrete observations that have been repeatedly affirmed, such as species identification and tool identification. Concepts link scientific facts; for example, the concept of a "reptile" is comprised of many scientific facts. A reptile is an organism that is (a) ectothermic, (b) has scales, (c) and has no eyelids.

Physical tools (Carter, Westbrook, & Thompkins, 1999) are pieces of equipment used by scientists within a specific context to conduct research and collect data. In herpetology, commonly used equipment for collecting, trapping and handling specimens as well as devices to identify, measure, and weigh specimens (Tomasek & Matthews, 2008) would be considered physical tools.

Normative practices, as defined by Kelly (2005), are "a patterned set of actions, typically performed by members of a group based on common purposes and expectations, with shared cultural values, tools, and meanings" (p. 2). Carlone et al. (2011) further elaborate on Kelly's definition by describing the conformities of shared practice as normative scientific practices. These are the actions for which one is held accountable in order to be considered competent in a specific context (Carlone et al., 2011).

Scientific practices are traditionally viewed as the types of systematic research in which scientists engage. According to Chinn and Malhotra (2002), (this) "is a complex activity, employing expensive equipment, elaborate procedures and theories, highly specialized expertise, and advanced techniques for data analysis and modeling" (p. 177).

Skills are strategies used during scientific practices to gather, analyze, and share information. Also known as the scientific process skills, these abilities, which include observing, questioning, measuring, and inferring, allow the researcher to gain more information about the phenomena under investigation. The process skills examined in this study will be categorized using Trowbridge et al.'s (2000) coding scheme. Trowbridge et al.'s (2000) coding scheme groups strategies and skills into five different categories: acquisitive, organizational, creative, manipulative, and communicative process skills.

Youth-Centered Science is science that uses young participants' interests to create student-generated inquiry experiences. Youth-centered science experiences most often occur in informal settings, where participation and programming is not restricted by mandated curriculum or schedules. In these experiences, participants employ scientific and technological tools for their own purposes (Buxton, 2006).

Summary and Organization of the Dissertation

The purpose of this study was to investigate the affordances of summer science programs, specifically herpetology programs, for younger elementary school children to engage in scientific practices and gain scientific knowledge, skills, and dispositions. This mixed-methods, multiple case study approach allowed a systematic examination of the different opportunities offered to participants in each of the programs to develop knowledge, skills, and dispositions and engage in scientific practices.

This introductory chapter provides a rationale for the study and an overview of the research design. The remainder of the dissertation is organized into four chapters. Chapter II provides a review of the literature. Chapter III describes the methodology for this study and Chapter IV presents and discusses the findings. Chapter V discusses the implications of the findings for researchers and science educators. Limitations of the study are also noted in Chapter V.

CHAPTER II

LITERATURE REVIEW

The purpose of this study was to examine the opportunities that two herpetology programs provided for participants, elementary school children, to develop scientific content knowledge and skills, and to display scientific dispositions. In addition, participant opportunities for scientific practices, including tool use, were examined. This chapter begins with a review of the literature on how authentic science is best defined and implemented, assuming that an authentic science context would provide the best setting for successful enculturation into the field of science. Next, previous research on authentic science is described in terms of what it affords participants. Then, contextually authentic science is defined and an explanation of how it was used in this study is provided.

Following a review of the literature on authentic science, the concepts of knowledge, skills, dispositions, and scientific practices are discussed. In addition, the use of tools in science-related endeavors is described and examined with regards to research on tool use in classroom and authentic science contexts.

Previous Research on Authentic Science

Canonical Authentic Science

As described by Buxton (2006), views of authentic science fall along a continuum, ranging from the canonical or traditional, to youth-centered perceptions of science. Contextually authentic science falls in the middle of the continuum, combining aspects of both canonical and youth-centered views of science. Canonical views of science are often limited in their scope of what constitutes science and scientific practices. Often, these views of science describe science as having a familial resemblance to the activities in which scientists actually participate (National Research Council, 1996; Chinn & Malhotra, 2002; van Eijck & Roth, 2009). Chinn and Malhotra (2002), in a traditional view of science, describe authentic science as engaging in practices defined by and enacted by a larger scientific community. Chinn and Malhotra define these practices as "the research that scientists actually carry out" (p. 177). In completing this research, scientists use costly equipment, are highly specialized, and implement complicated and advanced procedures and theories (Chinn & Malhotra, 2002). Markowitz (2004) further supports this notion by stating that access to "modern scientific equipment, computers, and other tools . . . will provide them with an authentic experience in data collection and analysis" (p. 396).

Lee and Songer (2003) also take a canonical stance when describing authentic science, describing the prototypical scientific method where researchers ask questions, plan and conduct investigations, draw conclusions, revise theories, and communicate results. The authors argue that real-world science is not accessible to students, because it requires advanced content knowledge and scientific reasoning that are too difficult for students without extensive support. According to Lee and Songer (2003), authentic scientific tasks include real-world tasks faced by scientists, solution of real-world problems that the students face, and direct communication with scientists through data sharing and critique. Although many reform-based movements attempt to engage students in authentic science through short-term investigations, Holmes (2004) argues that authentic science should be continuous, engaging participants in research conducted over lengthy (year long or multi-year long) ranges of time.

In addition to the use of equipment, laboratory space, and work on specialized projects, Hsu and Roth (2010) note that the characteristics of the scientists and the work atmosphere contribute to a feeling of authenticity in science. The language used, interactions between members of the scientific community, and how roles are negotiated among community members all contribute to the sense of authenticity. In their study of high school students participating in a biology laboratory internship, Hsu and Roth (2010) found that as participants spent more time working alongside scientists, they were better able to recognize science as a human endeavor, felt that they were contributing to the scientific community, and were able to gain a better understanding of scientific knowledge and skills necessary to conduct investigations.

For the purposes of this study, canonical science is viewed as traditional science (most often laboratory science) using an *a priori* prescribed scientific method, to guide the scientific investigation.

Youth-centered Authentic Science

In contrast to focusing on the views and practices of only scientists in defining authentic science, other researchers have focused instead on a youth-centered view of authenticity. Barton (1998), Brickhouse (2001), and Braund and Reiss (2006) describe authentic science experiences as activities that take into account students' interests, needs, and perspectives. For example, Barton's (1998) study of sharing science with three homeless girls demonstrated the value of basing science around participants' needs and purposes; in this instance, providing the participants an opportunity to experiment with cooking (necessary when food was lacking) and cleaning up the neighborhood around the shelter where they lived. Barton found that the social and physical needs of her students shaped the science activities that they wanted to engage in and that they found valuable (Barton, 1998).

Like Barton, Brickhouse (2001) also found that using participants' interests and needs were meaningful ways to engage middle-school girls in an after-school science club. Unlike the classroom, which limited the opportunities to engage in youth-centered science due to curriculum mandates and restrictions, an informal setting enabled opportunities for participants who did not connect with science in the traditional classroom to engage in science (Brickhouse, 2001).

What is critical for youth-centered science, as described by Buxton (2006), is that science begins with youth interests and examines how these interests are negotiated in and against the traditional views of science. Criticizing canonical views for marginalizing student opportunities to engage in authentic science, Braund and Reiss (2006) purport that experience through other outlets such as visiting museums, launching rockets, and participating in other non-laboratory based activities are ways to engage students in science through personal interest. Barton (1998) and Brickhouse (2001) similarly explain that by using student interests in service of science, room can be made for cultural and community influences to have a place in the learning experience.

For the purposes of this study, youth-centered science is defined as science that places more emphasis on young people's ideas and purposes and less emphasis on learning how to be scientists by focusing on traditional scientific practices.

Contextually Authentic Science

Rather than focus on one end of the continuum or the other, many researchers instead choose to place authentic science somewhere in the middle of the spectrum, where it blends both the practices of scientists and the interests of students. Using a systems-based approach, Rahm et al. (2003) explain that science is authentic when participants, leaders, and researchers are each able to take ownership of a scientific task and each are able to make their own meaning of scientific events. It is, therefore, important to "ask what authenticity means, to whom, and according to whom" (p. 738). Authenticity is dynamic and emergent, developed and negotiated as participants, the environment, and the task interact (Rahm et al., 2003).

In their study, Rahm et al. (2003) examine two different cases that promote an emergent notion of authenticity, which allows members of the group to negotiate and make meaning of authentic science together. In the first instance, classroom teachers were promoted to participate in a nationally recognized schoolyard plot study. As the teachers were engaged in training regarding the program, they began to negotiate ways to modify the methodologies used to make the program more relevant and meaningful to their students. When students became involved, these meanings were further negotiated so that all involved felt they were contributing to a relevant, scientifically based study. In the second program, students studying fire ecology in a six-week summer program followed scientific procedures for square meter plant inventories, but negotiated with one another about the data they felt was important to collect and report. Both of these programs enabled participants to negotiate their meanings of science, while still engaging in scientific data collection and contributing as members of a scientific community (Rahm et al., 2003).

Buxton (2006) also pushes for a contextually authentic view of science meant to be inclusive of a broad range of goals and interests. Like other researchers, Buxton notes that personal interest and application is important for science to be considered authentic by participants. In addition, the opportunity to make their own meanings of events allows multiple participant perspectives on whether or not a scientific study was authentic or not. Context, both physical (location) and social (negotiations and discussions between participants), plays a large role in determining the authenticity of science for members of the given community (Buxton, 2006).

Through nearly three years of working with a struggling Louisiana elementary school, Buxton (2006) worked with school staff to develop contextually authentic science experiences for students. Helping to design curriculum that addressed teacher concerns regarding curriculum, instruction, and assessment, Buxton also worked to encourage teachers to enable opportunities to include students' interests and room for questioning. In instances where students were able to take ownership of their science experiences, they were highly engaged and expressed interest in the work. Buxton, in examining how instructional opportunities needed to blend both canonical and youth-based views of science, found that although creating these opportunities in classrooms with limited freedom from the curriculum was challenging, it was rewarding for both the students and teachers (Buxton, 2006).

Van Eijck and Roth (2009), in their critique of canonical views of science, question “whether the things scientists do in their labs provide the appropriate image for the education of *all* students” (p. 615). Instead, the researchers argue that participation in topics of personal impact, such as environmentalism and citizen science, where activities have influence on decision-making, constitute authentic science. Such activities allow participants to draw on their own experiences and backgrounds to help solve problems and apply scientific findings, allowing participants to make their own meanings of the experience. In their research focusing on an adult indigenous student, van Eijck and Roth (2009) found that observation alone was not enough for a participant to feel like a member of a scientific community (in this instance, working in a laboratory); instead, engagement in the practices of the community was also crucial in enabling the participant to feel like a meaningful contributor to the group.

Bowen and Roth (2007) describe field ecology as a unique blend of scientific methodology and vested personal interest, arguing that context plays a large role in constituting authenticity. Authenticity, in their view, is as important to the field sciences as it is to the laboratory sciences. Further, field science exposes students to the emergent nature of research, the need to develop resources, including tools, on site, the difficulty in replicating some studies, and the collaborative nature of scientific study (Bowen & Roth, 2007). Not only does each of these components align with canonical views of science by promoting the need to think critically and develop elaborate and extensive data collection techniques, but Bowen and Roth (2007) also note that field ecology often draws on the interests of students, including women, who are traditionally marginalized in laboratory sciences.

For purposes of this study, contextually authentic science is described as science that blends both youth's interests and learning how to engage in scientific inquiry. Based on a review of the literature, there is a significant difference between the principles of canonically-based and youth-centered views of science. Canonical science focuses on traditional practices and a linear view of scientific investigation, whereas youth-centered perceptions of science focus on participant purposes and interests. Contextually authentic science, in contrast, blends both views by teaching scientific skills and practices through the use of participant interests and problems (Buxton, 2006).

The differences between each view of science can best be examined along a continuum, shown in Figure 1.

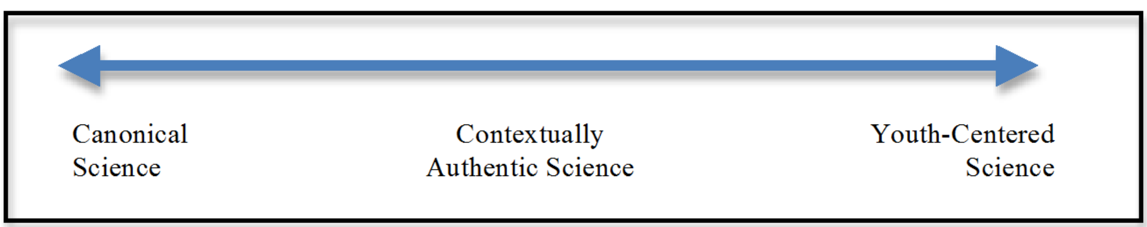


Figure 1. *Continuum of Science*

This section of the literature review provided an overview of previous research that chronicles the changing perspectives of what constitutes authentic science. The following sections of this chapter will describe scientific knowledge, skills, and dispositions, as well as review major studies examining the role of authentic science in development of scientific knowledge, skills, and dispositions.

Scientific Knowledge, Skills, and Dispositions

Scientific Knowledge

The National Research Council (1996) identifies knowledge as facts, concepts, principles or laws, models, theories, and explanations. As children participate in authentic science activities, it is expected that they will develop a conceptual body of knowledge that addresses each of these areas. In examining the role of knowledge in the herpetology programs, one can anticipate that participants will spend an extensive amount of time learning facts and concepts, rather than principles, models, and theories. This is due to the nature of the activities in which participants will engage, the short-term nature of the camp, and the age of the participants.

Facts are created based on prior knowledge and assumptions. What is considered scientific fact is actually an observation that is continually and repeatedly confirmed (National Research Council [NRC], 2007). Concepts, according to the NRC (2007), "go beyond observations and facts and reflect the larger *ideas* of science. By reducing many observations (facts) to fewer categories, concepts bring a measure of coherence and simplicity to the world" (p. 13). Understanding of concepts, for example; the concept of a reptile or an amphibian (an amphibian is a vertebrate that . . .), is best developed as participants make sense of the activities in which they participate, building on past experiences to make sense of new ideas.

When concepts are interrelated, they can be organized into principles. Theories are tentative explanations of observations and worldly events. Models may be physical, mathematical, or propositional, and are used to represent interactions between objects in a system (NRC, 2007).

The 2006 *Program for International Student Assessment* divides scientific knowledge into two domains: (a) understanding scientific content or *knowledge of science*, and (b) understanding the nature of science itself, or *knowledge about science* (Bybee, McCrae, & Laurie, 2009). In examining scientific content, the international assessment looked for student understanding of facts, concepts, and principles. The *knowledge about science* category includes understanding the purpose behind science as a field, and understanding the processes of gathering data, measuring, experimenting, and identifying types of scientific explanations (Bybee et al., 2009).

Process Skills

The *National Science Education Standards* call for students to have opportunities to learn both the processes and knowledge needed to conduct scientific inquiry through asking questions, planning investigations, and using tools to gather data (NRC, 1996). Authentic science engages participants in doing science using the scientific process skills. These skills, defined by the National Association for Research on Science Teaching as "a set of broadly transferable activities" (Padilla, 1990), enable students to learn more about their natural world. They also help students gain a better understanding of how science is done. Informal science education programs such as herpetology programs can provide opportunities for students to do science using science process skills, thus providing an authentic, realistic opportunity to do what scientists do.

The scientific process skills are frequently dichotomized into two categories, basic and integrated (Beaumont-Walters & Soyibo, 2001; DeFina, 2006; Goldston, 2004; Padilla, 1990). The basic skills, which require little training or experience to implement, include observing, inferring, measuring, classifying, predicting, and communicating (Padilla, 1990; Trowbridge et al., 2000).

Observation involves using the senses to gather information about an object or an event. This includes describing similarities and differences in specimens and identifying changes (both quantitative and qualitative) in environmental conditions (Lancour, 2004). Through inferring, participants use evidence to determine what events have already occurred. Those who use their inference skills form assumptions based upon past observations to create testable hypotheses (Lancour, 2004). Unlike observations, which describe current conditions, inferences are created based on past events (Lancour, 2004).

Measurement is one of the key process skills. Through measurement, participants collect quantitative data including length, width, and mass of organisms caught. Classification is the sorting of objects and events into different categories based on properties and criteria. Classification systems may be binary, dividing objects into two groups based on attributes, or multistage, sorting items through a hierarchy of characteristics (Bass, Contant, & Carin, 2009). For an example of a simple key for young children for reptiles see Figure 2.

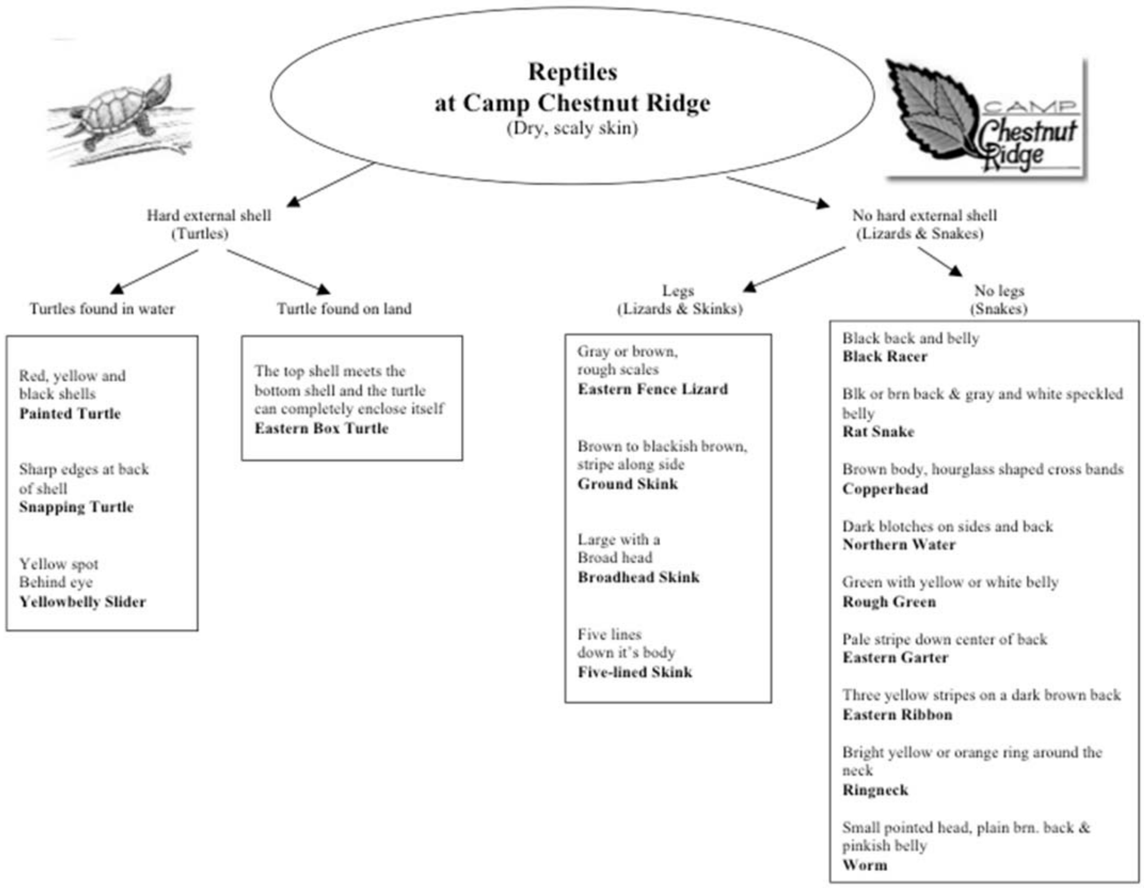


Figure 2. ***Simple Reptiles Key***

Often, scientists will make predictions of future events based on evidence. Prediction plays a crucial role as herpetologists develop a hypothesis to test. Data will then be collected as evidence to support or refute the hypothesis. Once data are collected, scientists must share their data and communicate their findings through graphs, charts, text, formal papers, and oral presentations. These modes of communication enable scientists to present their information in a clear form that is accessible to the general public.

It is thought that once students have an understanding of the basic process skills, they can use their knowledge for application of the integrated process skills. The integrated process skills are: controlling variables, defining variables operationally, formulating hypotheses, interpreting data, experimenting, formulating models, and making decisions (Lancour, 2004; Padilla, 1990).

Unlike those who dichotomize the science process skills into two distinct categories, other researchers instead divide them into five descriptive categories: acquisitive, organizational, creative, manipulative, and communicative (DeFina, 2006; Trowbridge et al., 2000). The five categories include more descriptions of the scientific process skills than those described as basic and integrative, and are categorized by the procedures that participants must use for each category. In each column, the skills progress from basic skills to more complex skills. Table 1 gives the five categories and associated process skills, which are described below.

Table 1

Five Categories of Science Process Skills (Trowbridge et al., 2000)

Acquisitive	**Organizational**	**Creative**	**Manipulative**	**Communicative**
Listening	Recording	Planning ahead	Using instruments	Questioning
Observing	Comparing	Designing	Demonstrating	Discussing
Searching	Contrasting	Inventing	Experimenting	Explaining
Inquiring	Classifying	Synthesizing	Constructing	Reporting
Investigating	Organizing		Calibrating	Writing
Gathering Data	Outlining			Criticizing
Researching	Reviewing			Graphing
	Evaluating			Teaching
	Analyzing			

The Acquisitive category of science process skills includes listening, observing, searching, inquiring, investigating, gathering data, and researching (DeFina, 2006; Trowbridge et al., 2000). These skills are operationally defined for purposes of this study to guide data collection as follows:

- Listening—Collecting aural scientific data, such as frog calling sounds
- Observing—Studying/watching to collect data, such as identifying spots on turtle scutes
- Searching—Looking for organisms, such as combing through leaf litter to find a toad
- Inquiring—Asking questions in the service of science, such as asking how to use a tool, how to identify an animal or animal characteristics, or how to design an investigation
- Investigating—Testing ideas, looking for confirmation of hypotheses, such as trying different methods to see what makes it easier to undo and refasten the clips on the minnow traps
- Gathering data—Collecting qualitative and quantitative data to answer a question, such as holding toads and counting the number of dots on the spots to determine identification of the type of toad
- Researching—Looking up information about the topic being studied, such as reading a book to learn the characteristics of a reptile

Each of these skills is used to attain new information while working in science. During and after gathering data, one must have a way to organize the data so that he or she, and others, can understand the phenomena. Process skills included in the Organizational category are recording, comparing, contrasting, classifying, organizing, outlining, reviewing, evaluating, and analyzing (DeFina, 2006; Trowbridge et al., 2000). Each of these skills enables the researcher to collect data, compare it to what is already known about a subject, and organize and analyze the data to make meaning:

- Recording—Writing down information, such as recording the qualitative and quantitative data about frogs to determine if the frog is a toad (large glands behind the eye) and what kind of toad it is (based on the number of dots in each spot of their color pattern)
- Comparing—Looking for similarities in data and organisms, such as comparing the lengths, widths, and shell patterns of two box turtles
- Contrasting—Looking for differences in data and organisms, such as examining characteristics of reptiles versus amphibians
- Classifying—Identifying species or grouping categories for organisms and data, such as identifying a Fowler’s Toad as a toad with dry skin and three or more dots in the dark spots on its back
- Organizing—Developing a system to collect and analyze data, such as using science journals as a place to write down data and then organize data
- Outlining—Creating a tentative order for data collected in order to present findings, such as grouping findings and thinking about major headings for a group presentation

- Reviewing—Checking over data and information to ensure accuracy such as looking at measurements made of animals and comparing those measurements to other known quantities
- Evaluating—Ensuring that information that is shared is correct, ethical, and takes into account multiple possibilities and perspectives such as when one is evaluating all of the information at hand to make a positive identification of a specific animal species
- Analyzing—Reflecting on the inquiry process and determining what to refine for future work

Science is a creative endeavor; creativity cannot be overlooked when students engage in doing science. Planning for investigations, designing, inventing, and synthesizing all require creativity, and thus fall into the Creative category of science process skills. The Creative process skills are described and operational definitions are provided below:

- Planning for investigations—Determining what question(s) to ask, what and how the question(s) will provide needed information such as asking which bait the turtles in the lake prefer because participants want to know how they can collect the most turtle species
- Designing—Determining what materials to use, how to collect and analyze data, and how to present information, such as setting up traps with two types of bait, and then determining how to collect data on the amount of bait eaten (for example, weighing it before and after traps are set, or counting the

number of bite marks on the bait), and designing a poster to share findings with others

- Inventing—Creating devices, methods, or models to solve a problem, such as using a stick to estimate the length of a snake when traditional measurement tools are not available
- Synthesizing—Consolidating information and explaining how it applies to the questions asked, such as presenting a brief summary of one's findings in an abstract

In addition to being creative, scientists must use tools to engage in science. Manipulative science process skills include using instruments, demonstrating, experimenting, constructing, and calibrating (DeFina, 2006; Trowbridge et al., 2000). These process skills are operationally defined as:

- Using Instruments—using tools such as calipers, Pesola scales and field guides to collect qualitative and quantitative data
- Demonstrating—Showing how a device works such as, modeling how to use a Pesola scale or how to open a minnow trap
- Experimenting—Implementing a procedure or method for gathering information, such as setting traps, collecting the traps, and recording data to determine what location in a vernal pool attracts the most organisms
- Constructing—Building a model or tool, such as reconstructing a turtle skeleton

- Calibrating—Adjusting tools to ensure accurate data collection such as setting the Pesola scales to zero before weighing frogs or salamanders

Once scientists have developed ways to acquisition information through the use of creativity and manipulation of tools, and organize their data for others to understand, it is important to communicate the findings to others in the scientific community and in the general public. The Communications category of process skills contains the following skills: questioning, discussing, explaining, reporting, writing, criticizing, graphing, and teaching (DeFina, 2006; Trowbridge et al., 2000). Each skill provides a way for scientists to share information with others, critique the information provided to them, and better understand observed phenomena. The operational definitions that guided data collection and analysis in this study are:

- Questioning—Asking questions to determine the credibility of scientific information and data collected, shared, or analyzed such as asking how a researcher came to his or her conclusions
- Discussing—Talking with colleagues or peers about a topic, such as how to go about recording data as a group
- Explaining—Sharing information about how to use a tool or gather information, such as explaining the difference between reptiles and amphibians or explaining how to calibrate a Pesola scale
- Reporting—Sharing findings with others at the end of an investigation or experiment such as when Herpetology students reported their findings in the mini-conferences

- Writing—Collecting data and writing a report or notes on the topic
- Criticizing—Critiquing a methodology for data collection and the inquiry process, or critiquing the findings of a colleague, such as suggesting that another method of data collection might be more efficient or less intrusive to organisms
- Graphing—Creating a graph (for example, a bar graph displaying the turtle species found in a lake or a line graph charting a turtle's carapace growth) using data collected in the field
- Teaching—Sharing both acquisitional knowledge and participatory knowledge with peers, colleagues, or students, such as teaching that a turtle's top shell is called a carapace (acquisitional) or how to use calipers to measure the length and width of the carapace (participatory)

The process skills observed during each of the herpetology programs during the summer were classified using Trowbridge et al.'s (2000) five descriptive categories because this classification system offers a much larger contingent of identified process skills than other process skill frameworks provide.

Scientific process skills are crucial to the development of scientific knowledge; they enable participants to link previous knowledge and experiences with newly discovered phenomena (Harlen, 1999). The scientific process skills are not innate to students; instead, they must be directly taught so that students can understand both how to use the skills and the rationale for their use. Once the skills have been learned, it has also been found that children are able to easily transfer them to new situations (Harlen, 1999; Padilla, 1990). However, children must have multiple opportunities to practice and better develop these skills in order to use them successfully (Harlen, 1999).

Dispositions

Understanding both the content and processes of science is not enough to ensure one's success as a scientist; one must also possess dispositions that are characteristic of the behaviors of scientists. Dispositions are "frequent and voluntary habits of thinking and doing" (Katz, 1993). Similarly, Carr and Claxton (2002) describe a disposition as "a tendency to edit, select, adapt and respond to the environment in a recurrent, characteristic kind of way" (p. 13). Dispositions are strengthened and supported by experience and significant people in one's life; these events and people reinforce dispositions as either positive or negative. Unlike attitudes, described by psychologists as a mental evaluation of an object or action with favor or disfavor, dispositions characterize an attitude while performing or doing something (Rijst, Kijne, Verloop, & Van Driel, 2008). To use dispositions, a child must recognize an occasion for a particular behavior, have the ability to carry out the behavior, and have a tendency to perform the behavior (Carr & Claxton, 2002).

The development of dispositions is dependent on both the practices and intent of those in the surrounding environment and on the opportunity afforded to a person to try a disposition and recognize its value (Carr & Claxton, 2002). Dispositions, although not a permanent state of being, are strengthened or weakened as the community reinforces them positively or negatively. As stated by Carr and Claxton (2002), "we are required to pay close attention to the relationship between the learner and the 'surround' and accept that the manifestation of learning dispositions will be very closely linked to the learning opportunities, affordances and constraints available in each new setting" (p. 12). Dispositions develop as a result of interactions between an individual and the community, and can either be diminished or strengthened based on the needs of the community and context at any given time.

Researchers (Bronfenbrenner, 1979; Carr, 1999; Carr & Claxton, 2002; Goleman, 1996) identify several dispositions that are deemed important for learning; these include courage, curiosity, playfulness, perseverance, confidence and responsibility. In addition, intentionality, self-control, relatedness, resilience, reciprocity, communication and cooperation may also be considered dispositions (Carr & Claxton, 2002; Goleman, 1996).

In examining the dispositions recognized and valued through field ecology and herpetology programs, several focal areas were targeted for this study. These include a participant's exhibition of curiosity, communication, and ethics. In addition, the notion of bravery is examined as a disposition deemed valuable by participants. The notion of bravery is different from courage in that science literature describes courage as a willingness to challenge and question traditional beliefs (Zerhouni, 2007) whereas participants in this study defined bravery as being willing to handle and look for reptiles and amphibians, as well as deal with uncomfortable outdoor weather conditions. These dispositions were selected because of their recurrence as dominant dispositions in educational research (AAAS, 2009; McGee & Keller, 2007) and because assessment of these skills is attainable in a short time, compared with dispositions such as resilience and perseverance (Gresalfi & Cobb, 2006).

According to Rutherford and Ahlgren (1990), “scientists thrive on curiosity—and so do children” (pp. 185). Scientists use their curiosity to generate questions for research and develop methodologies to answer those questions. Curiosity is a driving force behind science, as it enables researchers to develop new questions, to think of plausible alternative explanations, and to determine the why of observed phenomena.

Collaboration is an important component of science; it allows researchers the opportunity to communicate with one another and critique research questions, methodologies, and findings. It seldom occurs that a scientist works alone, with no contact with other humans, yet this is the perception that many children have of scientists at work (Chambers, 2006). Often, scientists, such as field ecologists, collaborate with their colleagues to share stories and insights on their work, enabling them to problem solve and trouble-shoot ideas together (Bowen & Roth, 2007).

Being ethical is a valuable disposition in that it aids participants in both caring for organisms and accurately recording data. One must have a sense of responsibility when working with live organisms, as the welfare of the animals is in the researcher’s hands. Knowing how to handle organisms in the field, as well as knowing what signs to look for when an animal exhibits anxiety or distress, may prevent harm to both the animal and its handler.

In addition, one must be responsible for managing and maintaining tools in the field, for recording data accurately to properly reflect observations and findings, and for communicating findings to others in a forthright manner. Project 2061 (AAAS, 2009) emphasizes ethical behavior as keeping honest, accurate accounts of data collected and recording all data in a science journal.

Bravery was a disposition recognized by participants in both programs, but not one initially identified by the researcher. In this study, bravery was considered essential to participants due to fears of snakes and other reptiles. Previous research (Cardak, 2009; LoBue & DeLoache, 2011) notes that participants often find creatures such as snakes to be threatening and that many young participants have misconceptions when it comes to this group of reptiles, thinking that they may be aggressive, venomous, or attack without warning. In addition, LoBue and DeLoache (2011) found that an anxiety regarding snakes develops early on in children, even before they may be exposed to snakes, and that these animals are more quickly noticed and detected than other animals. However, no research has been done to identify bravery or courage as a scientific disposition, particularly related to work in herpetology, nor has research been done on elementary-aged participants' perceptions of bravery and herpetology.

Participants' scientific knowledge, skills, and dispositions impact their abilities to engage in scientific practices. Conversely, engagement in scientific practices enables opportunities for participants to develop scientific knowledge, learn process skills, and hone dispositions. In the following section of this review of the literature, scientific practices and normative scientific practices are identified and described, as are previous studies examining normative scientific practices.

Previous Research on Scientific Practices

According to Cobb, Stephan, McClain, and Gravemeijer (2001), practices within a local community are impacted by several sets of norms, including those of the individual (his or her beliefs and values), and those of the community (beliefs of the role of the self, of others, and the power structure within the community, among other tenets). As participants engage within the community, they help shape the expectations for how members of the community participate and negotiate meanings. These ways of being are reinforced as new members enter and participate within the community (Cobb et al., 2001). In the field of herpetology, for example, participants may be expected to assist in tool use and data collection and follow proper handling procedures for animals. Participants must determine how these expectations align with their perceptions of herpetology, determine where they fall as individuals within the community, and then decide whether to take up or reject their assigned positions within the community of practice.

Carlone et al. (2011) note that enculturation into scientific practices is both a social and cultural process. The ways to be scientific are dependent on both the expectations of the group and the meanings that participants make of their experiences. As stated by Carlone et al. (2011),

> To operationalize “practice,” we draw on Kelly’s (2005) definition: “practice is constituted by *a patterned set of actions*, typically performed by members of a group based on common purposes and expectations, with shared cultural values, tools, and meanings” (p. 2, our emphasis). We label the regularities of shared practice as normative scientific practices, which are the practices one is held accountable to in order to be considered competent in a given setting (Cobb, Gresalfi, & Hodge, 2009). (p. 464)

Normative scientific practices are the actions for which an individual is held accountable to be part of a group. These practices are reinforced by recognition from the instructor or other members of the group as one participates.

Historical perceptions of what scientists are and what they do impact the behaviors and practices reinforced in current science programs and classrooms, and are used as participants position themselves and are positioned within the given community. For example, Carlone et al. (2011) share the widely accepted model of the “geeky white-male scientist” in the laboratory as one that most people are familiar with and associate with doing science. In addition, local practices also play a role in what is considered an acceptable and expected scientific practice. For example, herpetologists in some communities may encourage mark and recapture studies of animals while others discourage handling of animals in their natural habitats.

The perception of what is viewed as competent is dependent on the context; for example, the markers of competency in a science classroom may differ greatly from those used to measure competence in a laboratory or field-based work setting. Competence is not measured as an individual’s traits, “but rather an interaction between the opportunities that a student has to participate competently and the ways that individual takes up those opportunities” (Gresalfi, Martin, Hand, & Greeno, 2008, p. 50). In the herpetology programs competence might be defined by a participant’s ability to follow procedures and share factual information, and/or a participant’s ability to use tools, collect data, and work with their peers. These practices are negotiated by the members of the community, who may choose to take up these practices when afforded the opportunities to do so. In addition, the instructors in each program also determine what practices are valued by the opportunities they present to participants and what is reinforced or discouraged (Gresalfi et al., 2008).

According to Sadler (2009), a participant's decision to take on the practices of a community is greatly impacted by his or her goals for engaging in a situation. A participant can easily learn the tasks and strategies used within a community, but that alone is not enough. In addition, a participant must actually attempt to use these strategies to solve a problem that the community has identified as significant (Hay & Barab, 2001; Sadler, 2009). The community itself is responsible for determining what matters in a given context and what scientific practices are important. As participants take on the practices of the community, they begin to become members of the community and build an understanding of the community's goals (Hay & Barab, 2001). For example, the goals of herpetology programs may be to emphasize contributions to citizen science projects on herpetology, and/or to teach young participants how to identify common reptiles and amphibians in their geographic location. Participants in these communities will learn to negotiate their position within the community, determine what they need to accomplish and why, and aim to become contributing members of the group.

In their study of two fourth-grade classrooms, Carlone et al. (2011) found that the culturally produced meaning of science and the culturally produced meaning of smart science students impacted how students perceived their own abilities and the abilities of others to do science. An examination of normative scientific practices in the classrooms, including answering scientific questions, sharing ideas, using tools, communicating scientifically, and making scientific observations found that how normative practices were reinforced and celebrated in each classroom directly contributed to participants' perceptions of what science was and how they viewed themselves as science students. In the classroom where all participants felt that they were smart science students, collaboration and working together was not only expected, but participants were also held accountable for being collaborative and working together. Participants in this classroom felt that scientists worked together and built knowledge together, whereas in the comparative classroom, where participants were recognized for individual ideas and answers, participants felt scientists were people who knew all of the answers (Carlone et al., 2011).

The use of tools was also referenced in Carlone's study as a scientific practice. In one classroom, participants took turns with tools, enabling one person to be recognized at a time. In the other classroom, participants were expected to work together using tools, further supporting the notion of science as a collaborative endeavor (Carlone et al., 2011). In the following section, literature on tool use and studies of tool use as a scientific practice are examined.

Physical Tools

Tool use has been identified in science education literature as both a scientific process skill (Trowbridge et al., 2000) and a scientific practice (Carlone et al., 2011). The scientific process skills (including inquiring, investigating, and measuring) necessary for tool use enable participants to select the appropriate tool, calibrate the tool, and use the tool correctly and accurately to gather and record data. Expectations that participants will use tools, and reinforcement of tool use by instructors and peers, enable tool use to be considered a normative scientific practice.

Science encompasses many different disciplines, including the biological sciences, the physical sciences, and the earth and space sciences as well as the technical applied fields such as engineering, but all of the sciences require the use of tools. A physical, or disciplinary tool is anything that allows a scientist to collect information (data) in a more efficient and accurate manner. According to the *National Science Standards,* "tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things that they could not otherwise see, measure, and do" (NRC, 1996, p. 138). These physical tools include laboratory and field equipment, technology programs including species index databases, data collection devices such as *Global Positioning System* (GPS) units and HOBOs, proper apparel, and instruments for data collection and communication. For instance, a chemist may require the use of beakers, Bunsen burners, digital scales, fume hoods, gloves, and goggles to conduct experiments, while a marine biologist's tools may consist of a wetsuit, snorkeling gear, and containers for collecting water, sand, plant, and animal specimens. The use of appropriate tools depends largely on the type of scientific study being conducted, the nature of the research itself, and the research site. While many tools are mass-produced, such as laboratory glassware and shovels, other tools are produced specifically for a given field, such as the squeeze boxes used by herpetologists to measure the length of snakes.

For ecologists, several tools facilitate research studies and work in the field. Field ecologists examine the interaction of plants and animals, and often the interactions of animals in terrestrial and aquatic habitats. To better understand both the physiology and behavior of animals in their environments, knowledge of how to trap these animals is often necessary. In order to determine how one would trap an animal, he or she must be familiar with geographical movements of the animal, the time of day in which the animal moves, the preferred method of locomotion, and whether the animal species moves independently or in groups.

Knowledge of what traps, trapping techniques, and other tools will be the most effective while causing minimal risk of harm to the animal and researcher is essential for successful field ecology practices. For example, one must determine, depending on the nature of the research and whether it is conducted in a terrestrial or aquatic location, whether or not to use aluminum or wooden traps, snares, pitfall traps, or cages (Bookhout, 1996). In addition to the impacts of weather and location on trapping efficiency, it is also important to consider the type of organism being caught, how long they will stay in the trap, and any adverse effects that may occur as a result of trapping (Bookhout, 1996).

Once animals are caught for study, a field ecologist must have an understanding of how to handle and collect data on these animals through minimally invasive methods. Animals caught in their natural habitat are naturally defensive, so one must be cognizant of techniques for best holding the animals without risking harm to themselves or the specimens. Often, field ecologists use tools to aid in handling animals and collecting data including length, mass, and DNA samples from specimens. Collecting all of these data require different tools; for example, mass taken on small animals may be done with digital scales or spring scales, while DNA may be taken using syringes to draw blood or scissors to collect tissue or nail samples.

Simple tools are items used for data collection that, although they require practice to use correctly, do not require extensive training or deep additional background information. Simple tools are non-invasive to the organisms being studied and pose little or no risk of harm to either the handler or the specimen. In contrast, more complex tools, such as those used for tissue sampling, require more extensive training and can pose risks to both researcher and organism if not used properly. In the field of herpetology, simple tools are used for collecting and capturing organisms, recording observations of organisms, and collecting specific data on organisms.

Collecting and Capturing Organisms

To provide students opportunities to engage with reptile and amphibian species it is essential that they have opportunities to collect these animals in the field. Cover boards, or pieces of plywood and tin sheeting, laid out in wooded areas, provide ideal artificial habitats for many reptile and amphibian species (Tomasek & Matthews, 2008). Polyvinyl chloride (PVC) pipes, stuck vertically in the ground, provide cool, damp hiding spots for tree frog species. Both cover boards and PVC pipes are simple tools for students to use that require minimal training and pose no major safety threats to students or animals.

Students may also capture aquatic turtle species with large turtle traps, made from mesh and PVC pipe. The traps hold containers for sardine bait as well as empty plastic bottles to help them float, and are tied to neighboring trees after being placed in the water (Williams, 2002).

Simple tools such as minnow traps, snake traps, drift fences, and dip nets are used to collect different reptile and amphibian species. Minnow traps and snake traps provide entryways large enough for organisms to enter, but are designed so that captured animals cannot escape. Drift fences are built as walls that animals cannot climb over or under or through. They are constructed of wooden stakes and landscaping material. As reptile and amphibian species encounter the wall, they make their way along the bottom of the fence to find an opening. As they walk along the drift fence, they fall into buckets (pitfall traps) buried along the wall's edge, allowing for capture of the organisms (Willson & Gibbons, 2009).

Radio telemetry units are used to track box turtles (Davidson College Box Turtle Study, n.d.; Somers & Matthews, 2006). Using epoxy, a radio transmitter is attached to the carapace of a box turtle. The transmitter sends a signal picked up by antennae, allowing herpetologists to track the movement and geographic location of marked turtles. GPS devices aid in recording exact locations of specimens found, both in box turtles and other herpetological species.

Recording Observations of Organisms

Students may use journals and pencils to create sketches and diagrams of species found during herpetological fieldwork. In addition, digital cameras can aid students in qualitative data collection by capturing specific images and details that may not be captured in drawings alone. Additionally, herpetologists use photographs to index and identify species found on site; for example, researchers photograph both the turtle's plastron (bottom shell) and carapace (top shell) for ongoing turtle studies. Hand lenses and magnifying boxes enable students to extend/expand their sense of sight when observing different organisms.

Herpetologists use field guides to identify different reptile and amphibian species; these guides use dichotomous keys and other tools to classify animals based on both qualitative and quantitative descriptions including color, length, weight, and other observable characteristics, such as number and location of spots. Triangular files may also be used to file patterns representing unique three-letter codes on the scutes of aquatic turtle shells and box turtles, allowing for identification should these specimens be recaptured (Hester, Price, & Dorcas, 2005). These qualitative data aid herpetologists in determining frequency of capture and monitoring long-term quantitative data collection on an individual animal. They also allow scientists to estimate the population density of specific animals by computing a population estimate based on the ratio of capture/recapture data.

Collecting Specific Data

Once animals are collected and identified, herpetologists use additional simple tools to aid in collecting quantitative data on each specimen. Journals may be used to describe and illustrate images from the field, and also to record quantifiable data collected by researchers. Pesola scales (spring scales) and digital scales are used to determine the mass of an organism; rulers, meter sticks, calipers, and squeeze boxes all enable the measurement of an organism's length, width, and height. Calipers are quantitative tools used to measure the distance between two sides of an object; this is particularly helpful when measuring the length and width of a turtle's uneven, bumpy carapace and plastron. Herpetologists measure the length of snakes using a squeeze box (Fitch, 1987; Rivas, Ascanio, & Munoz, 2008), where a snake is laid between soft padding (such as an egg crate mattress) and a sheet of Plexiglas. A line is then traced down the spine of the snake on the Plexiglas. Because it is impossible to measure the curved line of the snake's length with an inflexible ruler or measuring tape, string is instead used to trace the line, then the length of the string is measured.

In addition to collecting quantifiable data on the length, width, and mass of organisms, herpetologists may also collect data on the surrounding environment. Weather instruments including thermometers and psychrometers may be used to record temperature and humidity. These data can be critical in the study of herpetological species, as many species move only during periods of warm temperatures, rain, and high humidity. Additionally, water quality measurements such as dissolved oxygen, pH, and nitrate levels are taken to assess the conditions where many amphibian species live, as these organisms are particularly sensitive to pollutants and habitat change.

Previous Studies on Tool Use by Elementary Students

The simple tools used by herpetologists include common field instruments, such as GPS devices used to mark locations where organisms are found and weather tools for recording humidity, and temperature. Measurement tools such as rulers, scales, and calipers are frequently used in other scientific fields, as are water quality test kits. The use of such tools is not unique to herpetology or field ecology; nonetheless they play a crucial role in developing a better understanding of the roles of various herpetological species within an ecosystem.

The field of herpetology enables active use of both qualitative and quantitative data collection through the use of tools. The wide range of methodologies employed in the field provides multiple opportunities to engage students in using tools and measurement strategies. These experiences may range from basic observation strategies and descriptive data collection to more complex measurement of quantitative attributes of specimen.

Science is a field laden with tool use. Tool use is invaluable to scientists; tools allow those in the field and the lab to collect data and better understand phenomena encountered in the natural world. Tools are used to help scientists achieve a higher purpose, to carry on

> the fundamental values and goals of the community and to accomplish the jobs that define and justify the very existence of the community. Tools are badges of membership, symbols of commitment and accomplishment, frequently tinged with affects such as pride and sometimes (for beginners) embarrassment. (diSessa, 2000, p. 39)

I could only locate one study that focused explicitly on the use of tools by elementary-aged students. Jones et al. (2000) note that tool use enables participants to manipulate the meanings they make of different events, based on what tools they choose to use and the manner in which the tools are used. In examining gender differences in tool use, the researchers found that male elementary students used more commands when using tools, grabbed materials more often than females, and tinkered with tools more often than female students. In addition, males used more “I” centered language than females and were more aggressive towards their partners when working with tools. Female students were more likely to use tools as directed by the teacher, whereas male students frequently used the tools for their own purposes and investigations. Female students also were more willing to share tools when resources were limited, rather than monopolize tool usage (Jones et al., 2000).

Engagement in scientific practices, including tool use, contributes to the development of scientific knowledge, skills, and dispositions, as well as influences how authentic participants perceive their experiences to be. The authenticity of scientific experiences (canonical, youth-centered, or contextually authentic) also contributes to opportunities to develop specific scientific knowledge, skills, and dispositions. In the following section, previous studies examining authentic science and the scientific knowledge, skills, and dispositions developed through authentic science are identified and described.

Authentic Science and Scientific Knowledge, Skills, and Dispositions

While a great deal of research has been done to examine what constitutes authentic science, limited research has been completed to examine the role of authentic science in developing participants’ conceptual understanding of the scientific process skills and scientific reasoning. In a study of over 70 students’ participation in a youth-centered authentic science experience (a long term project, completed with a scientific method, but allowing students to make their own meanings), Roth and Roychoudhury (1993) found that as students participated in authentic inquiry, their abilities to develop research questions, determine and refine data collection techniques, and analyze and critique findings improved. One important tenet of this experience for participants was that process skills and data collection techniques were best understood when taught in context, rather than presented as separate from scientific investigation (Roth & Roychoudhury, 1993).

Zimmerman (2007) found that the development of scientific thinking skills in elementary and middle school-aged children also improved when students were engaged in inquiry; even students as young as first grade were able to determine how to test a hypothesis through experimentation and to evaluate their findings as conclusive or inconclusive. Students between the ages of ten and thirteen were also able to recognize the value of recordkeeping while conducting experiments, enabling them to keep careful track of their experiments, methodologies, and results (Zimmerman, 2007).

Additional studies have been completed (Hanegan & Bigler, 2009; Lustick, 2009) on the development of scientific knowledge and skills through inquiry and authentic science; these studies focus on development of knowledge, skills, and dispositions in pre-service and in-service secondary science educators, rather than on elementary-aged students. However, additional research has been completed to examine the role of authentic science on impacting career aspirations; this research is described in the following section.

Authentic Science and Career Aspirations

In a study of high school students enrolled in a summer science academy, Markowitz (2004) found that participation in the program increased student interest in science and furthered students' desires to pursue science-related careers. The program, offered by a local university, engaged high school participants for four weeks in various scientific fields (microbiology and health) and activities (field trips and scientific seminars). Of the ninety-six participants who responded to the survey, over sixty percent agreed or strongly agreed that their time in the program encouraged them to take more advanced science courses and improved their scientific content knowledge (Markowitz, 2004).

Similarly, Charney et al. (2007) found that high school students, also enrolled in a summer science program that engaged them through laboratory practices and scientific seminars, demonstrated growth in their understanding of scientific inquiry and scientific process skills such as communicating and questioning. Through the four-week university program, participants were able to construct a broader view of what science is (Charney et al., 2007).

Barab and Hay (2001), through a study of a two-week science program for middle school students, found that participants who were immersed in an apprenticeship-based program were able to learn science while simultaneously doing science. For ten days, 24 middle school students worked in a local university's biology and computer labs assisting researchers with their current studies on drug exposure (focusing on methamphetamines and hormones) and computer modeling (focusing on sonar and optical communication). Participants were engaged in activities and taught scientific knowledge as it was needed, rather than being lectured to by experts in the field. The conversations that occurred between participants and the researchers were based on scientific ideas and information, and revolved around the context of the program. As participants engaged with one another and their instructors through activity and discussion, they negotiated meanings for their work and determined what was valuable as a group, rather than as individuals. Barab and Hay (2001) also found that although participants in the program had no opportunities to deviate and develop their own procedures, methodologies, and studies, they still felt as if they were contributing worthwhile help and information within the laboratory community.

Summary of the Review of Literature

This review of the literature includes research that informs this study and describes contextually authentic science, scientific knowledge, skills, dispositions, and tool use. In doing so, a key study by Buxton (2006) is highlighted that especially informs the contextual framework of this study.

Opportunities to gain scientific knowledge, develop process skills, and hone dispositions differ based on the structure of scientific programs. What is enabled for participants in canonically-based science programs and youth-centered science programs differs due to the types of normative practices reinforced in each program, and the case is the same for contextually authentic science. Participants in canonical, youth-centered, and contextually authentic science all may gain scientific knowledge, have some experiences developing their scientific process skills, and develop scientific dispositions through their experiences. However, the extent to which each of these will occur in each type of authentic science, as well as the types of knowledge, skills, and dispositions that may be gained, are unknown.

Normative scientific practices, such as tool use, are socially constructed and reinforced by members of the community. The types of normative practices reinforced are largely dependent on the structure of the community and what is enabled for its participants. Participant opportunities to gain scientific knowledge, skills, and dispositions will greatly impact their abilities to engage in normative scientific practices. This relationship is reciprocal. Engagement in normative scientific practices enables opportunities to develop knowledge, skills and dispositions; however, some knowledge, skills, and dispositions are also necessary to engage in scientific practices.

The opportunities offered to participants in each type of science program, as well as the experiences they have participating in normative scientific practices and gaining knowledge, skills, and dispositions, impact many outcomes for participants. These experiences may shape future interests in science, career orientations in science, and overall perceptions of how science is done.

In the following chapter, Chapter III, the methodological considerations of this study are discussed.

CHAPTER III

METHODOLOGY

The purpose of this case study was to investigate the affordances of two summer herpetology programs for young children with respect to knowledge, skills, and dispositions gained by participants. Also of interest were the normative science practices reinforced in each of the herpetology programs, one located in North Carolina and one in Florida. Finally, the program structures of *Herpetology* and *Reptiles* were compared to determine how each herpetology program's activities and methodologies impacted participants' perceptions of authentic science.

This chapter begins with identification of the research questions and a description of the case study protocol. Next, the participants and herpetology programs are described. Following a description of the participants and programs, the research design is discussed, as are data collection and analysis tools. In addition, the conceptual framework, research procedures, and issues of validity are described.

This chapter highlights and details the methods that were used to answer the following research questions for the study: (a) What opportunities for broadening and deepening scientific knowledge, skills, and dispositions were enabled in elementary school children in two different herpetology programs?; (b) What were the ways in which elementary students engaged in scientific practices, in two different one-week long summer herpetology programs?; and (c) What was the relationship between the students' engagement in practices and the camp structures of each herpetology program and the knowledge, skills, and dispositions enabled in each program?

To address these questions, a multiple case study model was used that examined the activities in each of the week-long herpetology programs. A multiple case study model was selected because the research sites were bounded by time, place, and activity (Creswell, 2008). Each program was held for one week in June of 2011 in two different locations in the southeastern United States, and each program had a specific focus on reptiles and amphibians for the duration of the program. This study was exploratory in nature; the opportunities participants would have to gain scientific knowledge, skills, or dispositions at each program were unknown. Additionally, the normative scientific practices that would be emphasized by each program and how participants would view their experiences in each program were also unknown. Yin's (2003) method of case study analysis was used because the phenomena being described are exploratory; no clear, single set of outcomes were necessarily anticipated or expected.

The two herpetology programs were each considered an individual case. The programs had different activity structures and participant roles, and were led by professionals with different backgrounds and expertise in herpetology and science education. Each case was selected due to similarities in participants' ages and program subject matter as well as convenience with respect to timing and location of the programs; both programs provided easy access for the researcher and were held in two subsequent weeks over the summer of 2011. In addition to examining the two herpetology programs as separate cases, selected participants from each program were targeted and mini-case studies were written to highlight the various kinds of experiences that individuals had in each program. These participant mini-case studies are deemed as nested case studies.

The contextual event surrounding the unit of analysis was participation in each of the herpetology programs. It was thought that perhaps participation in these two field-based programs enabled students to engage in normative scientific practices that aided in developing scientific knowledge, skills, and dispositions. In addition, it was also thought that program structure would directly influence how participants perceived herpetology and how they described authentic science.

The two summer herpetology programs were examined for differences within and between cases (Yin, 2003), drawing on comparisons of the knowledge, skills, and dispositions gained by participants in each program. In addition, opportunities for participation in normative scientific practices were examined between and within cases to determine similarities and differences among programs. The structure of both programs was also examined to determine how program structure impacted participants' perceptions of authentic herpetology. Aligned with Yin's (2003) framework for a case study, sources of evidence for each of these comparisons included participant science journals, interviews, direct observation, and photographs (Tellis, 1997).

The investigation of the two herpetology programs, guided by a case study protocol, included qualitative and quantitative data collection. Data were collected to analyze the knowledge, skills, and dispositions gained by participants, as well as normative scientific practices used during each of the programs. The types of qualitative and quantitative data are described in more detail in sub-sections of this chapter.

In the following section, participants and then the herpetology programs are described.

Participants

The participants in this study were selected purposefully (Maxwell, 2005) in that they were all children who chose to attend one of two herpetology programs offered during the summer of 2011. The participants were ages seven to eleven years old. Thirteen students participated in the *Herpetology* program in the North Carolina Piedmont, and thirty students participated in the *Reptiles* program hosted by Holliday Ecological Services (a pseudonym) at a nature preserve in Central Florida.

Herpetology Participants

The participants in the *Herpetology* program were rising second through fifth grade students from the state's Piedmont. Each participant came from one of nine towns surrounding the program location, and all attended public schools with moderately large school populations (an average of 566 students) and diverse school demographics. Two of the schools were public magnet schools, one with a focus on science and technology education. A third school was a charter school. Ten of the participants were males and three were females. Ten participants were day students, traveling to and from their homes each day, spending their nights at home while three of the participants were residential campers. Participants were self-selected; when signing up for a program major for the week, all of these students chose herpetology as their area of focus. None of the participants had previously participated in any herpetological summer programs, but one participant was part of the class that participated in a pilot study for this dissertation.

Herpetology Instructors

The instructors in the *Herpetology* program have a variety of educational experiences and backgrounds. Dr. M is a science education professor at a large, local public university in the University of North Carolina (UNC) system, where she has taught pre-service and in-service teachers for nineteen years. She has experience as a summer science camp director and for the past four years has led a week-long, residential high school herpetology program on the North Carolina (NC) camp facility property. Dr. M has written several practitioner articles on herpetology and the use of reptiles and amphibians in classroom learning experiences.

Dr. T is an assistant professor of elementary and middle grades education at a local private liberal arts college, where she teaches math and science methods, as well as a summer herpetology course for high school students who are potential first generation college students. Dr. T is one of the co-founders of the high school herpetology program held at the camp facility.

Dr. A, an ecology professor at a small public university in the UNC school system, specializes in salamander research. Dr. A has spent the past two years volunteering with the high school herpetology program and conducting research with Drs. M and T.

It should be noted that I have an extensive history with each of these instructors. Drs. M and T supervised my experiences in the undergraduate elementary education program at the local university, and Dr. M has been my advisor throughout my university studies. Dr. T and I have worked together on other research projects involving herpetological education and elementary students. Dr. A and I are good acquaintances and I am a friend of his wife, also a doctoral student in science education, who also volunteered her time to assist at the *Herpetology* camp in the summer of 2011. I have assisted Drs. M and T at the high school herpetology program for the past two years and have worked with them on a number of other projects. Because of our relationships, all three instructors, as well as six additional volunteers, donated their time for the week to assist in implementing the *Herpetology* program.

Among the six volunteers, Ms. B, a fourth grade science teacher at a science and technology magnet school and a graduate student at our local university, also volunteered at the herpetology program and lead students through activities. She and I taught elementary school together for several years before I entered the doctoral program.

The five additional volunteers for this program are a doctoral student in science education (Ms. A) and four undergraduate students. Ms. A, the doctoral student, and I have worked together at the high school herpetology camp for the past two years and took several courses together in our university's doctoral program. Ms. A currently serves as a biology instructor at a smaller public university within the UNC school system. She assisted in leading participants through daily herpetology program activities. The four undergraduate research assistants are students that I supervise in our university's teacher education program and all were working at the camp to fulfill course credit requirements. While none of these volunteers led activities during the camp, they interacted with children and assisted with data collection under my direct supervision.

Reptiles Participants

Thirty children, aged seven to eleven, participated in the herpetology program offered by Holliday Ecological Services in Central Florida. Ten participants were female and twenty were male. The participants registered through the city for the program, which is a day program only. Nearly half (*N* =12) of the participants had participated in one of Mr. Holliday's summer camps before; of these participants, six had previously participated in his herpetology program. One of the participants was in his fourth year of the herpetology program. Of the fifteen participants who returned their IRB consent and assent forms, eleven were returning participants to one of Mr. Holliday's programs.

Reptiles Instructor

Mr. G. Holliday (referred to by participants as "Mr. G") is a field biologist, environmental educator, and owner of Holliday Ecological Services, a Florida-based company specializing in wildlife surveys and research, natural history programs, and nature-based tours. Mr. Holliday has worked in Florida with the local public university's diamondback terrapin research team for sixteen years. He has served on numerous councils dedicated to protecting threatened turtle and tortoise species within the state. Mr. Holliday offers two programs through his company, the *Reptiles* program and a wildlife ecology program. He has been running the *Reptiles* summer program for seven years.

Mr. Holliday's daughter, Ms. E., assisted Mr. Holliday during the *Reptiles* program. Ms. E. helped manage materials, monitor participant behavior, and helped participants complete classroom-based activities. Ms. E. has been a third grade teacher in the Florida public school system for four years, and this was her third year assisting Mr. Holiday with the *Reptiles* program.

One male high school student and another college-aged male also assisted Mr. Holliday during the week. Like Ms. E, the two gentlemen helped to hand out materials and monitor participant behavior. Both were former participants in Mr. Holliday's herpetology programs. The college-aged assistant, who was enrolled in courses in the local community college, was developing his own collection of herpetological species to share with educational groups and was mentored by Mr. Holliday in proper handling and husbandry techniques.

Unlike the *Herpetology* program assistants, I did not know any of the adults assisting in the *Reptiles* program prior to arriving at the nature preserve. The only contact I had with Mr. Holliday prior to the program was via email and a phone conversation to confirm consent for me to observe the program.

IRB Consent

All program participants were informed of the intent to study the program and provided with parent and child IRB consent/assent forms. The purpose of the study was explained verbally and in person to both parents and participants; parents signed permission forms to give consent and campers signed student assent forms to indicate willingness to participate in the study. In the *Herpetology* program, twelve of the thirteen families returned IRB consent and assent forms; in the *Reptiles* program, fifteen of the thirty families returned IRB consent and assent forms.

Program Descriptions

Herpetology

The *Herpetology* program occurred at a local environmental education facility and summer camp program in the NC Piedmont. This long running church camp facility has hosted a summer herpetology program for high school students through a partnership with our university, and I assisted as a doctoral student with this program for the previous two years. Through communication with the directors of the camp and the university faculty who ran the summer high school program, it was agreed that a herpetology session would be offered for elementary school students during June of 2011.

The environmental education facility, located in the NC Piedmont, is comprised of 362 acres of hardwood forest. Residential campers stay in cabins and meals are in a lodge. The property includes a thirteen-acre lake where aquatic turtle studies are conducted, as well as nature trails where coverboards, drift fences, and PVC transects for herpetological research have been established. In addition, a vernal pool exists on neighboring property, accessible by one of the nature trails. The facility has been running summer camp, outdoor education, and after school programs for fifty years.

The NC *Herpetology* program limited participation to thirteen elementary school children. For the duration of the program, participants engaged in herpetological field activities during the hours of 10 AM and 12 PM for their program elective experience. The camp facility recruits campers through their website and hard copy fliers that provide descriptions of each program. The *Herpetology* major description is provided below:

> **Herpetology:** Herpetology (the study of reptiles and amphibians) is for campers interested in hands-on ecological fieldwork and exploring the hardwood forest around the camp! Campers will collect, process, and learn about the salamanders, frogs, snakes, turtles, and lizards on the property. This camp is offered in partnership with professors and students at the university, and as part of a doctoral dissertation. Parents will be required to sign an additional release form allowing campers to take part in this research study (Camp website).

The herpetology program description informed participants that it was part of a doctoral study and that additional paperwork was required of participants, ensuring that participants and their families are notified before enrolling. Ten of the participants in *Herpetology* were day campers and left camp by 5 PM daily, while the remaining three campers were residential campers and spent the night at the camp. Campers who opted for the day program paid a rate of $235 per week to participate from 9 AM to 5 PM, while residential campers remained on site for a total of $505 per week. Ten of the participants enrolled in *Herpetology* were regular participants in the facility’s summer camp programs.

Herpetology engaged students in fieldwork for the duration of the program. Participants had some experiences with making hypotheses, interpreting data, and experimenting as they assisted researchers in developing questions to study and plans to collect data to help them answer their questions of interest. Participants assisted in long-term herpetological research experiences, including aquatic turtle studies, vernal pool studies, and coverboard population inventories. During the week, participants spent three days engaged in each of these field experiences, with the remaining two days spent focused on the study of their choice. In the *Herpetology* program, participants collected and interpreted data through observations and measurement. During the program, participants were exposed to both metric and English measurements; metric measurements of length and mass were collected on all species, but English measurements were also shared with participants due to their familiarity. Participants had more exposure to English measurements in school as aligned with the North Carolina Standard Course of Study for grades K through 5, so these measurements were taken so that participants had a familiar baseline with which to compare their metric measurements.

Participants created hypotheses about an area of interest, such as a population count of turtles in the lake, and determined whether or not the data they collected supported or refuted their hypotheses. Participants also carried out experiments, such as determining the best type of bait for an aquatic turtle trap, and followed procedures to set up the experiment, collect data, and analyze the data.

Participants in this program were responsible for learning to use tools and collect data during their investigations, in addition to learning about the physiology and behavior of common state reptile and amphibian species. The field of herpetology, the study of reptiles and amphibians, requires both common field ecology tools and those unique to the discipline of herpetology. The tools used by herpetologists enable scientists to gather both quantitative and qualitative data about the research site, the species found, and the environmental conditions during the research period. Scientists involved in herpetology use both simple tools to collect data, record observations including measurements, and for tracking, while more complicated tools are used for genetics studies and disease control.

Studies involving reptiles and amphibians can be both short and long-term projects; examples include monitoring population counts in a given geographical area, monitoring movement of a particular turtle species, and examining the effects of water quality on breeding populations. The North Carolina camp facility has been involved in several herpetological research projects focusing on amphibian and turtle populations. These projects include aquatic turtle studies to determine species variation in the property's lake, testing turtle trapping methods for effectiveness, monitoring the home range of radio-tagged box turtles, participating in frog call population surveys, and monitoring vernal pool salamander populations. Each of these projects required the use of simple tools to collect accurate data.

Due to the nature of the herpetology programs and the age of participants, we focused on the simple tools that participants encountered during their week-long programs, including calipers, spring scales, and science journals. These tools are commonly used in educational herpetology programs, compared with complex tools used in tightly-controlled, research-based settings, such as electron scanning microscopes or gel electrophoresis to identify DNA codes found in box turtle species in order to determine how much variability exists in a population in a specific location. Variability is a measure of health of the population of organisms.

Reptiles

An Internet search was conducted to find similar herpetology programs nationwide for comparison and a request was put on the NC Environmental Education Listserv to see if other educators could identify similar programs. Three other herpetology programs were located along the east coast, one in Delaware, one in Virginia, and one in Florida. All three facilities were contacted regarding their programs; the director of the herpetology program in Florida was the only one to respond. Mr. Holliday's herpetology program is run through contract with the city and is offered at one of their environmental education nature preserves.

The nature preserve where the program was located is a 245-acre park located along one of the largest lakes in Central Florida. Hardwood hammocks, sand pine scrub, pine flatwoods, willow marsh, and lake shore comprise the ecosystems on the property, which also contain more than three miles of nature trails. Multiple parks and nature preserves surround the 375-acre lake.

Mr. Holliday's program, offered through Holliday Ecological Services, also serves children ages 7 to 11. Campers participate for one week in a day-camp program that runs from 9 AM to 4 PM, Monday through Friday. The program description, located in the Holliday Ecological Services brochure, reads:

> Hands-on, science-based nature day camps for children (ages 7-11) with a strong interest in wildlife.

Mr. Holliday, through emails and phone conversations, consented to a program observation. He led the summer program independently and allowed thirty participants per week. Participants in the program paid $150 for the week to the city. The 2011 Holliday *Reptiles* program ran from June 20-24, the week immediately following the NC *Herpetology* program.

The *Reptiles* program combined classroom experiences and field studies to teach participants about reptiles and amphibians. When asked about the structure of the program, its director explicitly stated “The kids don’t use tools. They are only seven to eleven years old.” In the program, students learned to recognize different state reptiles and amphibians and learned about the behavior and physiology of native herpetological species. Each day of the program revolved around a theme, such as Turtle Day, Reptile and Amphibian Day, and Hiking Day. Participants assembled a turtle skeleton from a set of bones, mounted snake skins on cardstock, examined scat samples to identify species, and went on daily hikes looking for local reptiles and amphibians.

Participants completed observational field studies of anoles, gopher tortoises, and alligators. Activities such as species identification using scat and turtle skeleton reconstruction involved observation and manipulation. Students also participated in classroom activities focused on reptiles and amphibians, including coloring reptile and amphibian pictures, making turtle maracas, and watching informational reptile and amphibian movies during lunch.

Research Design

A goal of this study was to expand on the understanding of the development of scientific knowledge, skills, and dispositions in contextually authentic science programs. In examining what opportunities for tool use, and gains in knowledge, skills, and dispositions were afforded to participants in two different herpetology programs, comparisons were made between and within the two week-long programs. Of importance was the design of the programs and the experiences offered to participants. The

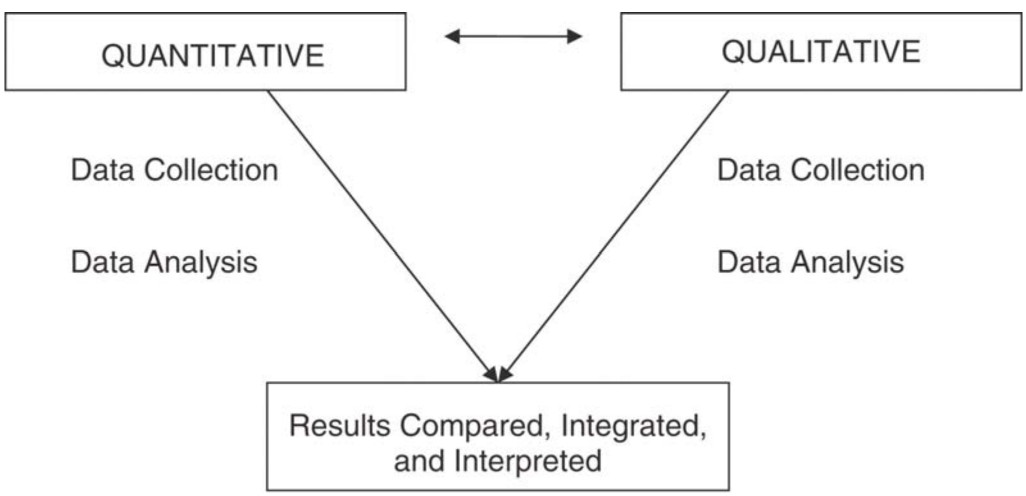
Herpetology program in North Carolina involved students in herpetological research, teaching participants how to use tools and collect data at the same time as they developed content knowledge. Conversely, the instructor of the *Reptiles* program offered in Florida described his program as an "introductory course" in herpetology. Participants in this program experienced both classroom and outdoor activities, but participated in limited tool use through the program.

While collecting data, it was important to consider the differences between the programs and how these differences affected what opportunities were presented to participants to gain scientific knowledge, skills, and dispositions, and the extent to which each program offered opportunities to participate in tool use. In addition, one must examine whether or not each program aligned with the principles of contextually authentic science. The types of scientific knowledge developed by participants in each program were compared, as were the skills and dispositional development facilitated by the programs and displayed by participants. The practices in which participants engaged were also examined across and within each program. Undoubtedly, there were differences in the practices, task structure, and role of the instructor in both programs. In addition, the differences in duration of the program and in geographical location also presented different opportunities for participants. Geographical differences impacted the biodiversity found in each environment, as well as the types of wildlife found in each state. Species variation impacted the opportunities for handling animals. Due to these differences, a rigorous approach to data collection was essential in determining what participants gained from their program experiences.

In addition to examining the differences within each program, one must also consider the role of similarities in study results. Both programs have run for several years with success. Each program is run by active herpetological educators with extensive knowledge of the reptiles and amphibians in their geographic locations. The programs both last for one week and at a similar time of year.

Data Collection and Analysis

A mixed-methods approach incorporated the use of qualitative and quantitative data collection and analysis. Qualitative and quantitative data were collected concurrently and triangulated to confirm, corroborate, and validate findings, making mixed-methods a justifiable approach for the research questions. The findings from both qualitative and quantitative data were integrated during the analysis and interpretation phases of the study; Figure 3 depicts a visualization of this strategy.



Adapted from Friedman, Goes, and Savage (n. d.)

Figure 3. ***Data Analysis and Interpretation Strategy***

Qualitative data collection is an important part of mixed-methods research; it provides detailed, thick description of events that quantitative data cannot convey (Creswell, 2008). Qualitative research also examines the context in which events take place. Unlike quantitative data alone, qualitative data provide depth in examining how context influences the events and the processes by which events take place. It also aids in understanding the meaning-making of the participants through interviews, observations, and descriptions that quantitative research may not uncover (Maxwell, 2005).

Mixed-methods research has several strengths in addition to providing strong evidence through corroboration of findings; combining narrative and written responses with numerical data provides more robust information than quantitative data alone. The use of both qualitative and quantitative techniques can answer more questions and add insights that are not visible when only one research methodology is used (Johnson & Onwuegbuzie, 2004).

Conceptual Framework

A conceptual framework, as described by Maxwell (2005) is "the system of concepts, assumptions, expectations, beliefs, and theories that supports and informs your research" (p. 33). Miles and Huberman (1994) further specify that a conceptual framework is a visual or narrative representation that describes the relationship between each of these components.

Contextually authentic science is described as science that engages participants in practices that are reflective of the work of scientists, while also considering the interests, values, and meaning-making of participants (Buxton, 2006; Rahm et al., 2003). Practices that reflect the work of scientists, such as herpetologists, include fieldwork and tool use (Bowen & Roth, 2007; van Eijck & Roth, 2009).

However, participation alone is not enough. Further research on authentic science finds that although engaging students in scientific activities does provide opportunities to learn about conducting scientific investigations, students only show so much interest when the practices do not align with their own ideologies, interests, or beliefs about science (Chinn, 2009; Hsu et al., 2010; Markowitz, 2004; van Eijck & Roth, 2009).

A gap in the previous research is the consideration of informal science education opportunities, such as the herpetology programs, as contextually authentic science. In addition, previous studies focusing on authentic science looked primarily at high school and undergraduate university classes and focused on the laboratory-based sciences such as cellular biology and chemistry, without examining the roles of field ecology or elementary school participants in creating contextually authentic science (Charney et al., 2007; Hsu & Roth, 2009, 2010; Hsu et al., 2010; Hunter, Laursen, & Seymour, 2007; Lee & Songer, 2003; Markowitz, 2004; Waight & Abd-el-Khalick, 2011).

Were the program structures of the *Herpetology* and *Reptiles* programs aligned with contextually authentic scientific practices? What similarities and differences existed between the normative scientific practices, particularly tool use, at these programs? How did the structure of each program impact the scientific knowledge, skills, and dispositions gained by each participant? Each program relied on fieldwork and study of the natural world to engage participants. Several benefits of ecological studies, specifically fieldwork, have been suggested in the literature. Fieldwork involves a greater number of participants, including females, not found in traditional laboratory-based sciences. Fieldwork also incorporates innovative creation of tools and modification of tools in situ (Bowen & Roth, 2007), enabling greater opportunities for the demonstration of creativity. Finally, fieldwork also enables participants to feel a stronger sense of community and collaboration (Bowen & Roth, 2007), allowing opportunities for youth participants to co-construct meanings and share their ideas and values alongside researchers.

Engagement in scientific practices is a key part of authentic science. Through these practices, participants develop an understanding of how to use the scientific process skills, conduct investigations, and communicate their findings. At the same time, they build an understanding of the facts and concepts that constitute scientific knowledge, and the scientific community reinforces scientific dispositions, such as creativity and curiosity.

Normative scientific practices enable participants to develop an understanding of scientific knowledge, or facts and concepts. These practices are reinforced and recognized by members of a community and are expected if participants are to be deemed competent within that community. Authentic science aids participants in developing an understanding of related science content as participants engage with tools, design investigations, and actually put their ideas, theories, and methodologies into practice (Hanegan & Bigler, 2009). In the instance of the herpetology programs, this included scientific content knowledge related to the study of reptiles and amphibians, as well as knowledge of tools, tool identification, and tool application.

Normative scientific practices also aid participants in developing an understanding of the scientific process skills. In authentic science, participants engage in activities similar to those of real scientists, employing instruments to collect data and design research studies. Tool use is a key practice of scientists, as it aids them in gathering more accurate data. As participants engage in tool use and data collection they are able to develop their understandings of scientific process skills including measurement, observation, and communication (Bell, Blair, Crawford, & Lederman, 2003). For example, through the herpetology programs participants observed various reptiles and amphibians in their natural environments. Participants handled the animals and used their sense of sight to create accurate, detailed descriptions of each specimen found and of the environment in which they were located. Participants used dichotomous keys or field guides in the *Herpetology* program and reptile information books in the *Reptiles* program to sort and classify species based on observable or measureable attributes.

Finally, authentic science practices enable participants to develop the dispositions recognized as valuable for involvement in science. These dispositions, or tendencies to act, are reinforced by those in the local environment, and include traits such as curiosity, responsibility, and an ability to communicate (Rijst et al., 2008). In the instance of authentic science, those in the local environment would include the community of scientists engaged in scientific practices.

Given this conceptual framework, this study contends that contextually authentic science engages participants in normative scientific practices, such as tool use, that aid in the development of scientific knowledge, skills, and dispositions. A visual representation of the conceptual framework for this study can be found in Figure 4.

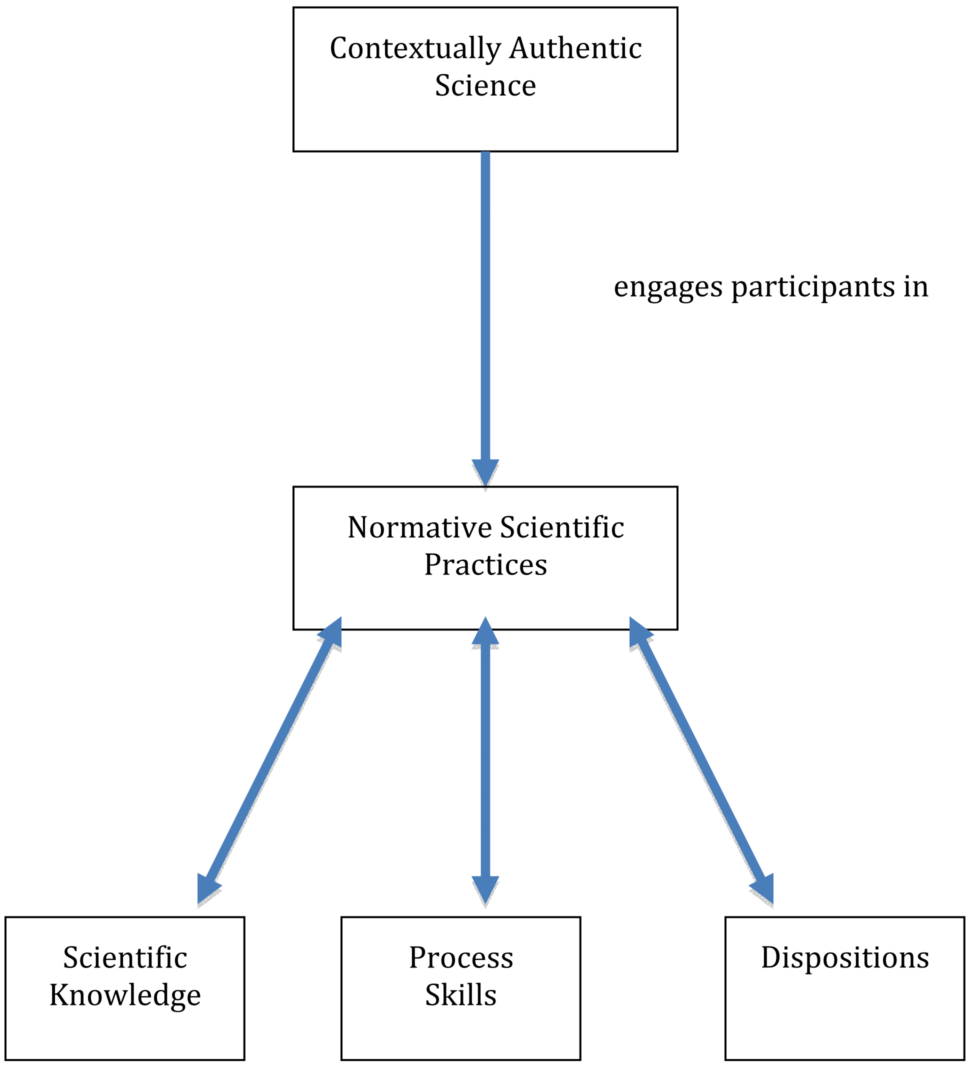


Figure 4. ***Conceptual Framework***

Research Procedures

Both qualitative and quantitative data were collected analyzed to answer research questions for this study. Multiple sources of data were triangulated to support the trustworthiness of the research. Data sources included focus group interviews, individual interviews, participant photographs and photo elicitation interviews (PEI), pre- and post-surveys and assessments, observations and field notes, audio and video recordings, participant science journals, participant drawings, and the program curricula. Table 2 provides a crosswalk between the research questions and data sources. After Table 2, a description of each data source is provided.

Table 2

Crosswalk of Research Questions and Data Sources

Research Question	Data Source	Data Type
What opportunities for broadening and deepening scientific knowledge, skills, and dispositions were afforded to elementary school children in two different herpetology programs?	Focus Group Interviews	Qualitative
	Video/Audio Recordings	Qualitative
	Participant Photographs/ PEI	Qualitative
	Field Notes	Qualitative
	Science Journals	Quantitative/Qualitative
	Survey/Assessment (Pre-Post)	Quantitative
What were the ways in which elementary students engaged in scientific practices, in two different one-week long summer herpetology programs?	Focus Group Interviews	Qualitative
	Video/Audio Recordings	Qualitative
	Student Photographs/PEI	Qualitative
	Field Notes	Qualitative
	Science Journals	Quantitative/Qualitative
	Survey/Assessment (Pre-Post)	Quantitative
What was the relationship between the students' engagement in practices and the camp structures of each herpetology program and the knowledge, skills, and dispositions enabled in each program?	Focus Group Interviews	Qualitative
	Video/Audio Recordings	Qualitative
	Student Photographs/PEI	Qualitative
	Field Notes	Qualitative
	Science Journals	Quantitative/Qualitative
	Survey/Assessment (Pre-Post)	Quantitative

Assessments and Surveys

Data collection began with pre-study surveys and assessments of all program participants (see Appendix A for protocol) who agreed to participate in the study. The purpose of the survey and assessment was to gain an understanding of what herpetology content knowledge, understanding of tool use, and views of science participants had when they entered the program. In order to address understanding of content knowledge, participants were asked multiple choice and open-ended questions on species identification and reptile and amphibian characteristics. Participants in the North Carolina program were also assessed on their knowledge of tool use and identification. In order to understand participants' views on science, participants were asked Likert-scale items on tool use, measurement, data collection, and their interests in science and the outdoors. In addition, Likert-scale items were used to identify the normative scientific practices valued by participants. The survey and assessment were re-administered upon completion of the program and results were compared to see changes within programs and differences and similarities across programs.

Focus Group Interviews

Focus group interviews occurred with the *Herpetology* and *Reptiles* program participants who agreed to participate in the study (see Appendix B for protocol). The focus groups consisted of four to six participants per group that were randomly assigned and took approximately twenty to thirty minutes per group. The groups were fairly homogenous in regards to gender and age, allowing potential for maximum disclosure (Eliot & Associates, 2005); all participants self-selected to enroll in a herpetology program, showing a common interest, and all are in elementary school, indicating a fairly small age range. The majority of participants in the *Herpetology* program (10 of 13) were male, which allowed for one group that was completely homogenous in terms of sex, but care was taken to place two of the female participants in the same group assuming that they would be more comfortable in a group together; the third female participant asked to complete the focus group with her male peers because she had previously attended camps with one of the male participants. Interviews were semi-structured to allow flexibility for participant responses and to encourage further elaboration on responses. At the *Herpetology* program the focus groups were conducted by two moderators, one to facilitate the interview and the other to tape record the interview and take notes.

At the *Reptiles* program, due to limited financial and personnel resources, I facilitated the interviews and took notes. The instructor of the *Reptiles* program did not want children to miss instruction so he suggested I interview participants as we were walking on the daily hikes. On the first and last day of the program I walked with three to four children at a time and audio taped the interviews. Due to the large number of participants at the program it was unreasonable to anticipate that all campers would be able to participate in a focus group.

The purpose of the focus group interviews was to gain an understanding of participants' views of the herpetology programs and the activities in which they were involved. Focus group interviews occurred at the beginning of the week-long programs and again at the end of each program. Questions were designed to assess content knowledge and knowledge of normative scientific practices gained during program activities. Additional questions addressed what values participants placed on the activities, their opinions of the programs, and what they determined to be the most meaningful experiences at the program, allowing the researcher to examine the programs' alignment with contextually authentic science. Data collected from focus group interviews at both programs were analyzed for evidence of knowledge, skills, and dispositions gained through the week-long herpetology programs. Data were also examined for alignment with contextually authentic science and identification of reinforced normative scientific practices. All focus group interviews were audio taped and transcribed.

Photograph Elicitation Interviews

Program participants were provided with digital cameras to document their activities during each of the program sessions. Participants were asked to take photographs of the activities they participated in each day (see Appendix C for protocol). The digital photos were printed and shared with the participant photographers; fifteen cameras were available for each of the programs. Selected participants each day were asked to identify and describe the most important photographs taken and their rationale for selecting each photo in a *Photo Elicitation Interview* (Epstein, Stevens, McKeever, & Baruchel, 2006).

Use of participant photographs allowed the participant to "make decisions about what to include in or exclude from the photographic records of their lives, thus letting them control the images that are presented in their everyday world" (Epstein et al., 2006, p. 4). The purpose of the photo elicitation interview was to enable the researcher to see what values participants placed on different program activities, and how those values aligned with the project purpose of each program activity. The researcher kept field notes and audio recorded participants as they selected and described their photographs. These photographs, along with the descriptions provided by participants, provided data for analysis of participant dispositions and knowledge of the reinforced herpetological field practices for each program. Questions for the photo elicitation interview were designed to ask participants what content knowledge and scientific practices knowledge they gained through the activities photographed.

Field Notes

Running field notes were maintained during participation in program activities and paired with audio recordings of participants to ensure accuracy (see Appendix D for protocol). The researcher took field notes, as did five undergraduate research assistants at the *Herpetology* program. Notes and audio recordings were transcribed and reviewed by the researcher and other program staff to ensure that they represented the events that took place.

The purpose of field notes was to gather descriptive information of participants engaged in scientific practices using the scientific process skills. In addition, field notes captured participants' comments and gestures that indicated an understanding of scientific content and evidence of scientific dispositions. Specifically, the field note protocol addressed the five process skill categories (acquisitive, organizational, manipulative, communicative, and creative) described by Trowbridge et al. (2000), as well as the four dispositions (curiosity, collaboration, ethics, and bravery) under examination in this study.

Through examining the activities in which participants engaged during the herpetology programs, one could assess and analyze where each activity fell within the five categories of scientific process skills. Instances where participants observed animals, asked questions to learn scientific content, and looked for animals, such as snakes under coverboards, were categorized as acquisitive process skills. The use of data sheets, comparisons between and among species, and classification of organisms fell under the organizational process skills category. As participants found the organisms and collected data on each specimen they needed to engage in tool use, including measuring the length, width, and mass of different organisms found, and calibrating scales to attain correct measurements, both of which were considered manipulative process skills.

While acquisitive, organizational, and manipulative process skills may take precedence over communicative and creative process skills, both were a part of participants' endeavors in each of the camps. Participants designed investigations to learn more about herpetological species, employing their use of the creative process skills. Discussions of what participants found each day, as well as opportunities to process information in the field and to collaborate with one another, afforded participants in the *Herpetology* program opportunities to use communicative process skills. Examples of this during the *Herpetology* program included participants questioning one another's findings, discussing what was observed or measured in the field, explaining their reasoning, reporting findings, and teaching one another how to use tools. In the *Reptiles* program, opportunities to use communicative skills included discussing observations made in the field.

Observational methods provided an opportunity to examine what dispositions participants exhibited when they encountered scientific tasks and situations. As participants engaged in these experiences, observations focused on the reactions, actions, and reasoning of the participants as they worked through the activity. For example, one would look for instances where participants display curiosity, making note of what the participant says and does that indicates curiosity. Indicators of curiosity included the participant asking questions about the content taught and skills used in the field.

Continued observation over a period of time, in similar settings, enabled the researcher to look for tendencies in dispositional displays. In the field, during observation, an observation protocol chart assisted in both tallying instances in which each of the process skills was used, along with a description of the activity that occurred and what participants said during the exchange. (See Appendix D for protocol).

Field notes also enabled a comparison of practices and activity structure between each of the two programs. In examining whether each program aligned with the goals of contextually authentic science, field notes were examined for evidence that activities aligned with both teaching scientific practices and incorporating participant interests.

Video Recording

Participants were videotaped during their participation in program activities. The purpose of video recording participants was to capture the actions, comments, and affect of participants as they engaged in scientific practices. Videotaping also enabled the researcher to record participant comments and actions more thoroughly than field notes alone. Participants in the *Herpetology* program worked in two to three small groups each day, allowing for ease of videotaping of all participants. The undergraduate research assistants taped the small groups. On average, approximately 3.5 hours of video footage was recorded and transcribed for each day. At the *Reptiles* program, various groups of participants were videotaped the first day, and then selected participants that demonstrated a range of interest in the program were followed and videotaped on subsequent days. The Florida program involved participants together in all activities, which made videotaping all activities feasible. On average, approximately four hours of video footage was recorded and transcribed for each day of the *Reptiles* program. Participants were not videotaped during lunch, free play, and snack/bathroom break activities.

Videos were transcribed and triangulated with audiotape recordings and field notes for evidence of knowledge, skills, and dispositions enabled through participation in program activities. A videotape analysis protocol (see Appendix E) enabled the researcher to look for evidence of process skills, to look for evidence of scientific content knowledge shared during activities, and to identify characteristics of scientific dispositions displayed through participation in program activities. In addition, videotapes enabled the researcher to identify reinforced normative scientific practices within each program. Videotapes allowed a more thorough comparison of activity structures and participant opportunities to engage in scientific practices in both herpetology programs. Videotapes were analyzed for evidence of alignment with contextually authentic science practices, activities, events, and conversations (that combined learning alongside scientists tempered by participants' ideologies and interests).

Audio Recording

As participants engaged in activities in each herpetology program they were audio recorded. The purpose in audio recording participants was to capture statements, comments, and questions made by participants that might otherwise not be captured in field notes or video recordings. The audio recordings of participants were transcribed and triangulated with videotapes and field note data to ensure that activities that took place during each program were accurately represented.

During each program all instructors, volunteers, and program staff were asked to wear one of the audio recorders. This allowed conversations between participants and staff to be captured and compared between programs. Participants carried any additional recorders attained as they participated in the group activities. The data collected, once triangulated with field notes and video tape transcriptions, were examined for evidence of content knowledge and scientific process skills displayed, scientific dispositions exhibited during each program, and for similarities and differences in the knowledge, skills, and dispositions evidenced through each herpetology camp program. On average, four audio recorders were used each day during program activities. Audio recordings from focus groups and casual conversations between instructors and participants were transcribed and analyzed.

Science Journals

As participants engaged in program-related activities at the *Herpetology* program, including aquatic turtle study, vernal pool study, and cover board study, they were asked to collect and record data on the organisms found at each location in science journals. The data completed by participants were collected daily and analyzed for participant knowledge and skill use as it related to identification of herpetological species and understanding of and accuracy of tool use. Data sheets contained in the science journals (see Appendix F) asked participants for species identification and measurements including mass and length. Participants in the *Reptiles* program did not keep science journals during the week.

Program Curricula

The program curricula for both the *Herpetology* program and the *Reptiles* program were collected and analyzed (see Appendices G and H) for alignment with the principles of contextually authentic science, which incorporates both learning the processes of "doing" science and builds upon interests and meanings created by participants in the program. The programs were compared in several ways. First, each program was analyzed for planning and intent to involve participants in scientific practices, such as the use of tools and explicit instruction on scientific content, skills, and dispositions. The programs were analyzed for opportunities for participant input, opinions, and interests. Next, the programs were examined to compare how opportunities differed for participants between each program.

Data Collection Instruments

All data collection instruments and protocols are provided in the Appendices of this proposal.

Data Analysis

Quantitative survey responses were analyzed using *t*-tests with the *Statistical Package for Social Sciences* software. These included the pre- and post-assessment and survey scores, which were compared within and between summer programs. The use of a *t*-test was selected because the data tool was a repeated measures assessment on each student, where the same assessment was administered before and after each program. The intent was to look for statistical differences between each participant's pre- and post-assessments and surveys.

Qualitative data from focus group interviews, field notes, observations, student photographs and photo elicitation interviews, and program curricula were analyzed by segmentation into coding categories. These categories were developed using common themes found across each data source (Yin, 2003).

Multiple steps were taken to determine the themes by which data was sorted; these included sorting data into arrays and tabulating frequencies of different events (Yin, 2003). The themes emerged from the theoretical propositions supporting this study related to participant knowledge, skills, dispositions, and tool use. Data were coded by hand using typed transcriptions, video taped footage, and field notes. The undergraduate research assistants also coded the same data and met with the researcher to verify patterns in coding schemes. In addition, the researcher used IBM's jStart Natural Language

Processing Software to develop text analytics coding. Using the software, definitions for key themes in coding, such as "practices," "knowledge," and "skills" were developed and typed transcriptions were scanned in the program. The jStart software used the defining themes to highlight and identify codes within the transcriptions. Multiple codes could use used simultaneously to identify practices by participants; for example, "tools" and "participant" definitions, when combined, would allow the researcher to identify who used tools and when they used them. After the transcriptions were coded by hand, the codes identified by the jStart software were compared to those found by the researcher to triangulate data and ensure accuracy. For example, using the jStart program, a definition was established for process skills that included key words such as "observe," "listen," "measure," and other terms from Trowbridge et al.'s (2000) coding scheme. Transcriptions were entered into the program and scanned for key words. The jStart program highlighted and identified each instance where terminology referencing process skills were used. These data were matched with the data coded by hand to verify the researcher's own findings.

Field notes, videotape, and audio recordings were examined for evidence of participant use of scientific knowledge (Bass et al., 2009; NRC, 1996), process skills (Trowbridge et al., 2000), and dispositions (AAAS, 2009; McGee & Keller, 2007). The frequency of these events and rich description of what took place, who was involved, and what knowledge, skills, and dispositions were evidenced were categorized and analyzed in the data to provide robust evidence of the affordances of each herpetology program.

Scientific Knowledge

In examining data for evidence of scientific knowledge, conversations were coded for participants' sharing of both correct scientific information and misconceptions. The types of misconceptions held by participants were identified and described, and changes in the number of misconceptions shared over the week were examined. Nested case studies were analyzed to show how these experiences impacted selected participants from each program to demonstrate the types of knowledge gained by participants in each program. In addition, participant scores on pre- and post-assessments were examined for statistically significant changes in scores. Programs are first described individually then compared with respect to the types of knowledge gained by participants.

Process Skills

Trowbridge et al.'s (2000) five categories of process skills (acquisitive, organizational, creative, manipulative, and communicative) were used to tabulate the number of opportunities enabled for participants in each program to use scientific process skills. Transcripts and videotapes were analyzed for evidence of process skill use. As process skills were witnessed they were marked on the data analysis sheet in the corresponding categories. Once tabulated, relevant examples were provided to demonstrate the types of opportunities enabled for participants to use scientific process skills and to show how participants used those process skills. The programs were examined first individually and then compared to look for similarities and differences in the number and types of opportunities to use process skills.

Dispositions

Four dispositions were examined in each of the herpetology programs. The first disposition, curiosity, was identified as a disposition considered essential for scientists based on the literature review (AAAS, 2009; Etkina et al., 2010). In each program, the number and types of questions asked by participants were listed and categorized as one example of participants' exhibition of curiosity. Participant focus group interviews were examined for discussion of curiosity and pre- and post-survey questions were analyzed for changes in ratings regarding curiosity-focused questions.

The second disposition also identified in the literature was collaboration (AAAS, 2009; Etkina et al., 2010). Evidence of participant collaboration was cited from video transcriptions and field note data. In addition, the researcher looked for examples of collaboration in participant discourse, examining the "we" versus "I" language (Carlone et al., 2011) used by participants and instructors that reinforced or discouraged collaboration. Finally, participant ratings on pre- and post-survey questions regarding collaboration were analyzed, as were focus group conversations regarding the value of collaboration to scientists and their work.

Ethics, the third disposition identified in the literature as important for scientists (National Academy of Sciences, 1996) was analyzed using participant pre- and post-survey data on questions regarding ethical behavior. Relevant examples from videotape data were used to support evidence of participants' ethical behavior. Ethical behavior was examined from multiple perspectives; first, ethics were examined by analyzing participant honesty and thoroughness in data collection, and second, ethics were analyzed by examining how participants handled, cared for, and oversaw animal collection.

The final disposition, bravery, was examined not because it was cited as an important disposition in relevant science education literature, but instead because bravery was a disposition repeatedly discussed by participants in both programs. Focus group interviews, field notes, and videotape transcriptions were all analyzed for examples of participant bravery and discussions of bravery.

All of the dispositions were identified and described first for each individual program. Then, comparisons were made between the two programs to demonstrate similarities and differences in the dispositions reinforced in each program.

Practices

The normative scientific practices (for example, tool use and data collection) were identified in each program. The practices were identified and described using program descriptions, field note analysis, participant science journal analysis, videotape transcriptions, and interview transcription analysis. Frequency of occurrence for each practice was tabulated and analyzed for changes in frequency across each week-long program. Relevant examples from video footage and transcriptions were cited as supporting evidence for the practices identified in each program.

Scientific practices identified in the literature include tool use (Carlone et al., 2011; Chinn & Malhotra, 2002), laboratory work (Hsu & Roth, 2010), and empirical research (Hsu & Roth, 2010; NRC, 2011). Due to the nature of the different herpetology programs, a particular interest was the different practices highlighted in each program and what practices were considered normative within each of the herpetology programs.

Program Structure and Impact on Participant Experiences

Photograph elicitation interviews were used to determine what events during the week made participants feel like scientists. Participant photographs and rationales for photograph selection were categorized by themes. Participants were also interviewed in focus groups to determine what knowledge, skills, and dispositions participants felt were essential for success as a herpetologist and to see how they felt that the program aligned with their views of herpetology. Participant responses were categorized by knowledge, skills, and dispositions, and emergent themes were identified, as were normative scientific practices that participants felt were an important part of herpetology.

After determining the markers of each program that participants thought were important for successful herpetological work, program structures were analyzed to determine how experiences impacted participant responses. Activities in each program were themed and compared; for example, coverboards work in the *Herpetology* program was similar to trail hikes in the *Reptiles* program, so these experiences were compared and contrasted using Venn Diagrams. Similarly, wetlands activities and individual learning opportunities in each program were compared and contrasted for similarities and differences. After comparing each program, participant responses to questions about herpetology were examined to determine how they aligned with the differences in each program's structure.

Validity

According to Creswell (2008), validity is “an attempt to address the ‘accuracy’ of the findings, as best described by the researcher and the participants” (p. 206). In qualitative research, validity is a process, unlike positivistic research that may view it as “verification” (Creswell, 2008; Maxwell, 1996). For this study, the researcher used a qualitative perspective on validity, viewing it as a process rather than as verification of assumptions.

Validity is a central issue in research design in ensuring that there is a correlation between the test instruments and concepts they intend to measure. For this purpose, focus group interview questions and student surveys were reviewed and revised by professors with familiarity of the tools used in herpetological investigations and understanding of the processes of inquiry, aiding in establishing validity for the project.

Data triangulation, peer review, and rich, thick description also aided in establishing validity (Creswell, 2008; Yin, 2003). Data from participant interviews, videotapes, field notes, and participant surveys were examined together as data were collected. Those assisting in the collection of research data also assisted in reviewing data analysis for accuracy; the undergraduate research assistants met with the researcher for regular meetings to compare data analysis and look for common findings among research group members. Data included rich, thick descriptions of participant engagement with tool use and were examined both between and within each of the cases, allowing for careful review of the findings and opportunities to establish internal validity. The researcher has also spent extensive time working with participants in herpetological programs, aiding in familiarity with the procedures and processes of conducting herpetological research. In addition, the use of multiple data sources provided opportunities to triangulate and corroborate findings (Yin, 2003).

This chapter has provided the methodological considerations for this study. The research participants, programs, and design of the study were described. The conceptual framework, research procedures, and data analysis processes to be used were identified and discussed. Issues of validity were also addressed. Chapter IV will present a discussion of the findings and implications of the findings for this study.

CHAPTER IV

FINDINGS AND DISCUSSION

The purpose of this study was to examine the knowledge, skills, and dispositions enabled for elementary school participants in two summer herpetology programs. An additional purpose of this study was to examine the normative scientific practices in which participants engaged and to describe how these experiences differed across each of the herpetology programs.

This study was conducted and the data analyzed using an interpretative case study, mixed methods approach. Data collected included: video and audio data from classroom and field sessions, participant focus group interviews, photographs, and photo elicitation interviews. Participants' science journals were collected and analyzed. Pre- and post-assessments and surveys were administered and analyzed for twenty-four participants, twelve participants from the *Herpetology* program and twelve participants from the *Reptiles* program.

This chapter details and discusses the findings of the study. Each of the programs is presented as a case with nested cases focusing on specific representative participants, selected to demonstrate the range of participants in each of these programs to clearly see how the two herpetology programs offered opportunities for participants to develop and enhance their scientific knowledge, skills and dispositions and to participate in authentic scientific practices. First, program descriptions are shared to provide an overview of each week-long program. Then, the overall findings with respect to evidence of knowledge, skills, and dispositions gained by participants in each program are presented. This is followed by a discussion of the normative scientific practices in which participants engaged in each program. After information about each program, or case, is presented and discussed, a comparison of experiences and program structure are provided. The chapter concludes with a summary of the major findings of this study.

Program Descriptions

There are several summer programs on the East Coast of the United States that focus on herpetology for elementary school students. I have been involved for the past two years with a local herpetology program for high school students and my involvement in this program triggered my interest in offering a similar program for elementary students and then looking to see how our program compared with others offered nearby. This program was called *Herpetology*.

I searched for other nearby herpetology camps for elementary school children and found several weeklong programs in different states. The *Reptiles* program that I attended and participated in was a program that I initially located via a herpetological society website. This program had been offered for the past six summers and the high school version of my program had been offered for the past four summers. Both programs had a clear emphasis on herpetology, and both were situated in ‘natural areas’, with one in an environmental education camp facility and one in a nature preserve. The first program, *Herpetology*, was offered to campers in a residential and day camp setting and the second, *Reptiles*, was offered to day campers only.

Herpetology

Participants in the *Herpetology* program assisted in long-term herpetological research experiences, including (a) coverboard population inventories, (b) vernal pool studies, and (c) aquatic turtle studies. During the week, the participants spent the first three days rotating in small groups through each of these field experiences. Students then selected one of these three areas to study more intensely for the remaining two days of the program.

Coverboard studies introduced participants to artificial habitat of plywood and tin, which resemble natural downed logs, and various species of reptiles and amphibians that utilized this artificial habitat. Participants found several reptiles and amphibians under coverboards including marbled salamanders, worm snakes, and Fowler's Toads (see Figure 5). Participants were taught how to safely lift and replace coverboards when looking for animals. All participants kept science journals and recorded data from each field experience throughout the week.

Figure 5. ***Participants Use Snake Hooks to Lift Coverboards***

Participants collected data including snake and salamander mass and length and used dichotomous keys to identify frog and toad species. Participants who chose to conduct a mini-research projects on coverboards for their final two days of the program developed the research question, “Which coverboards attract more reptiles and amphibians, metal or wood?”

In the Vernal Pool Study, participants used minnow traps to collect organisms (see Figures 6 and 7) including newts, other salamanders, salamander larvae, frogs, and tadpoles. Participants used keys to identify various species of reptiles and amphibians found at the vernal pool. Participants were introduced to the concept of vernal pools and practiced tool use, including setting and retrieving minnow traps, wearing waders, and using aquatic dip nets, calipers, and spring scales. Data collected on newts and other salamanders included mass and length. Participants in the vernal pool group asked two different questions that they hoped to be able to answer at the end of the week, “Can we catch more organisms at the middle of the vernal pool or along the perimeter?” and “Can I catch the turtles that are hiding in the middle of the vernal pool?” (a 7-year-old).

The Aquatic Turtle Study introduced participants to aquatic turtle collection, including how to assemble and bait traps and how to remove turtles from traps (See Figure 8). Participants set and retrieved aquatic turtles traps from four locations around the perimeter of the 13-acre lake. Participants also practiced tool use in the aquatic turtles group, using calipers and spring scales to collect plastron length and width, carapace length and width, and mass. Species were identified using keys and field guides.

Participants who chose to study aquatic turtles at the end of the week developed the question, “Which bait do aquatic turtles in the lake prefer, hot dogs or chicken?”

Figure 6. ***Participants Use Minnow Traps***

Figure 7. ***Participants Collect Specimens in Vernal Pool***

Figure 8. ***Participants Collect Aquatic Turtle Traps***

Overall, the *Herpetology* program emphasized outdoor experiences and fieldwork for participants; all activities were conducted in the outdoors. Participants were responsible for collecting data and handling animals and learned about local reptile and amphibian species. In the following section the second program, *Reptiles*, is described.

Reptiles

The *Reptiles* program was a traditional classroom-based summer camp program involving arts and crafts, hikes, and time spent handling captive-bred animals. Each day of the camp followed a theme; themes included alligators, snakes, turtles, ecology, and a day hike. Participants went on daily morning walks looking for evidence of reptiles and amphibians. Although campers encountered a variety of lizards and some tortoise and turtle species, the only animals held were those that were raised in captivity and owned by the program leader. In the afternoons, campers completed arts activities, such as making a turtle music shaker (a maraca), completing coloring pages on reptiles and amphibians, and listening to the program leader talk about the common reptiles and amphibians in their area. The program followed a more school-like schedule with bathroom and snack breaks in the morning, a movie during lunch, and structured indoor activities. Participants walked in lines on hikes, similar to walking in lines at school.

The first day of the *Reptiles* program served as an introduction to the field of herpetology. Participants learned the characteristics of reptiles and amphibians in the classroom and went on a morning hike through the nature preserve to look for herpetological species. In the afternoon, captive snakes were presented to the participants, who learned about the characteristics of each snake species. No animals were held during the first day of the program. The second day of the program was “Turtle Day.” Participants were able to hold the captive snakes if they were not wearing sunscreen, bug spray, or perfumes. Participants again went on a morning hike to look for reptiles and amphibians. In the afternoon they reconstructed turtle skeletons in groups of four, “met” an alligator snapping turtle, and learned about different turtle species in the state.

Ecological relationships were the focus for the third day of the *Reptiles* program. Participants again went on a hike, looking for evidence of alligators. They discussed alligator behavior and size and made observations of a rotting alligator carcass (see Figure 9). In the afternoon, participants helped clean out the nature preserve’s box turtle pen and some campers were able to use calipers to measure the turtles’ carapace lengths and widths. The afternoon finished with participants playing a board game focused on

Diamondback Terrapins, which featured questions on habitat protection, predator-prey relationships, and ecosystems that support the life of the terrapin.

Figure 9. ***Participants Observe Alligator Carcass***

Day 4 was 'Habitat Conservation Day.' Participants watched a non-native species presentation, where the instructor showed marine toads, brown anoles, and Cuban frogs, all species that were not indigenous to the state. The instructor explained how each animal was thought to have arrived in the area and their impact on native plants and other vegetation. During the afternoon hike, the instructor pointed out non-native brown anoles to the participants. After catching a brown anole, the instructor threw the anole into a chicken coop and several participants watched as the chickens killed and ate the anole. The day ended with arts and crafts, where participants made a turtle maraca using beans, paper turtle cutouts, and paper bowls.

The final day of the program culminated with a three hour, three-mile hike from one end of the nature preserve to the other. Participants looked for wildlife and signs of wildlife, collected apple snail shells and watched gopher tortoises. The instructor led a mini-lesson on scat identification during the hike, where he dissected scat and identified parts of the scat as participants watched. In the afternoon, participants grouped around a laptop to watch a PowerPoint created by the instructor on species identified in the nature preserve.

Participants engaged in watching movies, coloring pictures of reptiles and amphibians and assembling puzzles of reptiles and amphibians during lunch and free time. Movies with a herpetological theme, such as *Life in Cold Blood* (2008) were shown every day during lunch. Participants had snake-themed puzzles and animal coloring sheets to complete during transitions. In free time, participants also read *Florida's Fabulous Reptiles and Amphibians* (1991) by Winston Williams (see Figure 10).

Figure 10. *Participants Read during Transition Times*

Comparison of Programs

The *Herpetology* and *Reptiles* programs did exhibit several similarities. Participants were able to engage with and handle animals in both programs. Participants were led by experts with extensive herpetological knowledge in both programs and learned about animal behavior and physiology and ecology.

The *Herpetology* and *Reptiles* programs were significantly different in their program structure. All of the activities in the Herpetology program were conducted in the outdoors. Reptiles and amphibians were found in their natural habitats and observed each day. Participants engaged in frequent tool use on each day of the program, collecting scientific data, including trap and coverboard location, kinds and number of animals caught, gender, lengths and weights of individual organisms.

In contrast, the *Reptiles* program was a largely classroom-based program; children spent only 1.5 out of seven hours (21%) outdoors on Days 1-4, and three out of seven hours (42%) outdoors on Day 5. Animals that were handled came only from tanks and were handled in a tightly controlled environment. Children were introduced to different amphibian species only once during the program and this was through a lecture on nonnative animals. General information on herpetology was presented to participants through lecture, rather than through exploration. Figure 11 displays the similarities and differences between the two different herpetology programs.

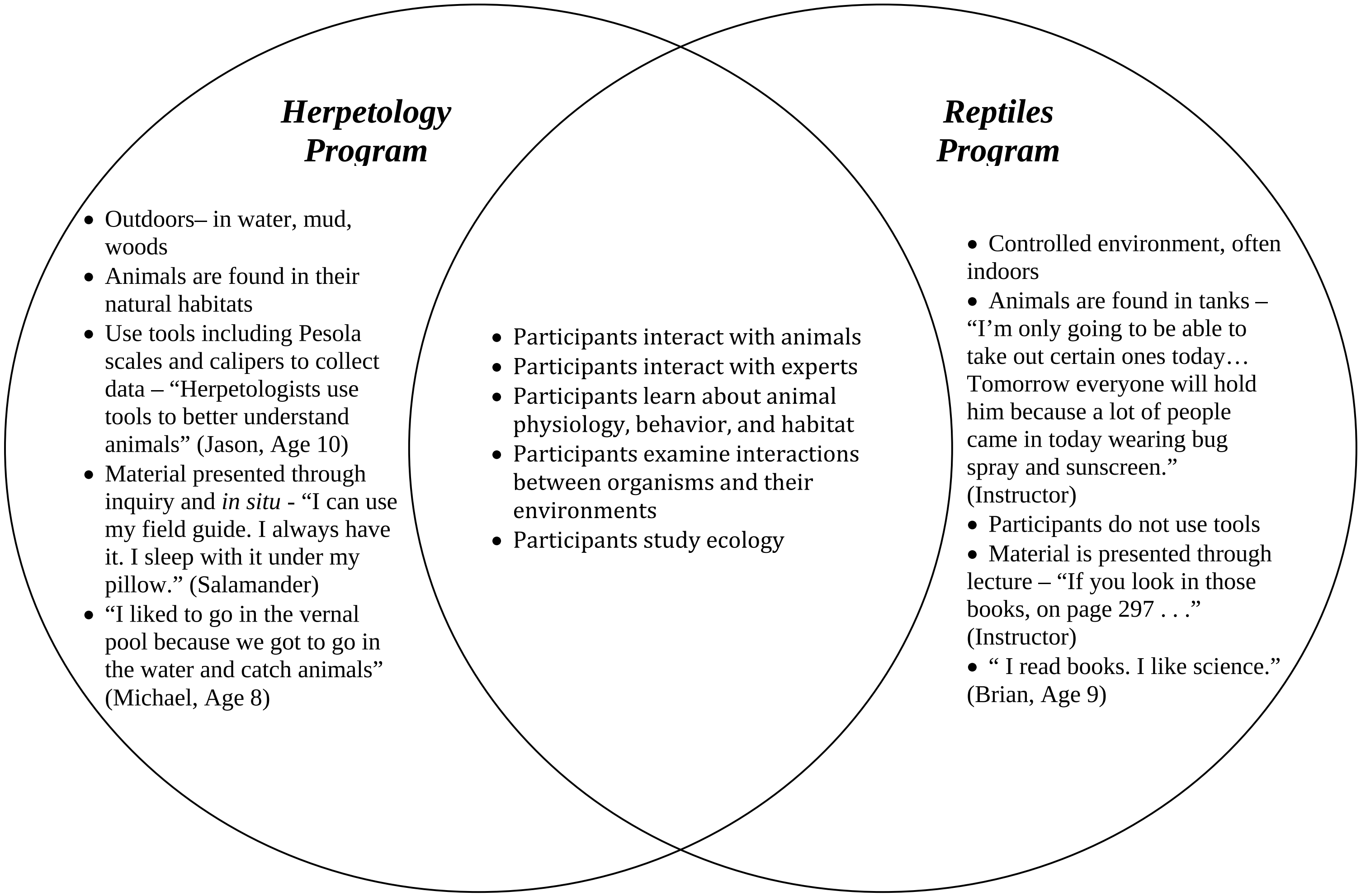


Figure 11. ***Venn Diagram Comparing Herpetology and Reptiles***

Overall Findings

This section of Chapter IV presents evidence of student gains in content knowledge, including the ability to identify reptile and amphibian species and the ability to identify tools used in herpetological studies, and the ability to explain animal anatomy. Student gains in process skills, such as using instruments, making observations, and demonstrating tool use to one another are also detailed. Finally, gains in scientific dispositions, such as responsibility and ethics, are discussed.

Research Question 1

What opportunities for broadening and deepening scientific knowledge, skills, and dispositions were enabled in elementary school children in two different herpetology programs?

Scientific Knowledge

Herpetology. Participants had multiple opportunities to display their scientific knowledge in both summer herpetology programs. Table 3 displays the knowledge gained by participants in the *Herpetology* program as indicated by pre- and post-assessment scores. Overall, participants in the *Herpetology* program (*N* = 12) showed a significant increase in content knowledge at the end of the program. The twelve participants who completed the tools assessment also showed a significant increase in content knowledge of tools based on their scores on a pre- and post-assessment of their knowledge of tools.

Table 3

Participant Assessment Scores, Herpetology

Assessment	*M*	*N*	*SD*	Significance Level
Pre-Knowledge Assessment	9.45	12	4.09	
Post-Knowledge Assessment	14.5	12	2.89	
Pre-Post Knowledge		12		.000 (t = 5.53)
Pre-Tools Assessment	10.83	12	3.18	
Post-Tools Assessment	15.83	12	2.73	
Pre-Post Tools		12		.000 (t = 5.12)

Participants in the *Herpetology* program, in addition to significant increases on post-assessments, demonstrated a growth of scientific knowledge as the week-long program progressed. This scientific knowledge was displayed as participants identified reptile and amphibian species and correctly identified and referred to anatomical features, identified herpetological tools, and communicated their understanding to their peers and adults involved in the program. The example below of a participant identifying the difference between amphibians and reptiles demonstrates an example of scientific knowledge:

> Child: A box turtle is a reptile and a salamander is an amphibian.
>
> Instructor: Amphibian and reptile. Okay, so what’s an amphibian?
>
> Child: An amphibian is usually a slimy skinned creature. It’s cold blooded. And it spends most of their [sic] life in or near water. (Aquatic Turtles Video 1, 6/14/11, 05:00)

Table 4 shows the frequency of participants' displays of knowledge and misunderstandings, such as when they misidentify an animal or provide incorrect information about the physiology, anatomy, or behavior of an animal (for example, stating that turtles and other reptiles have gills) during the herpetology program.

Table 4

Frequency Count of Displays of Participants' Knowledge and Misunderstandings during Fieldwork

Displays	Day 1	Day 2	Day 3	Day 4	Day 5
Knowledge	28	29	16	20	14
Misunderstanding	7	3	4	3	0

On the first day of the program, participant displays of knowledge related to identification of species, habitat and characteristics of organisms. Participant responses to conversations and questions regarding herptofauna were correct twenty eight out of thirty five times (80%) Most often, participants incorrectly identified genetic characteristics of species (N = 5), such as sharing that female box turtles have red eyes (seen in male turtles), or that box turtles lay their eggs in water; the remaining two incidences involved the misidentification of reptile and amphibian species.

On Day 2, participant responses were consistent with Day 1, with 29 out of 32 (91%) correct responses. For Day 3, participants again had a majority of correct responses, with 16 out of 20 (80%) correct answers. On Day 3, two of the incorrect responses related to species identification and two more related to determining the sex of turtles. One of these instances related to the Day 1 argument over the eye color of the box turtles and determining whether male or female box turtles had red eyes.

Participants began their own student-generated research studies on Day 4 of the *Herpetology* program. During this time, participants developed, with program staff assistance, research questions focusing on topics of interest at the vernal pool, aquatic turtle, and coverboards areas. Participants were able to explain their questions and interests, but had greater difficulty determining methodologies for their studies and what types of data to collect (as well as how much data to collect). Overall, participants displayed scientific knowledge 20 times (such as when they explained why they felt their hypotheses would be correct), and were witnessed displaying misinformation about how to collect data three times.

On the final day of the *Herpetology* program, participants had multiple opportunities to share their scientific knowledge as they presented their research studies and findings to their peers. Fourteen instances occurred in which participants shared scientific knowledge, and none occurred where participants presented misinformation. All participants shared their projects with their peers, and all correctly relayed their research questions, hypotheses, methodologies, findings, and areas for further research:

> Kaitlyn: My question was, do I find more salamanders in the middle of the vernal pool, or on the outside? My method was to first set traps in the middle of the pool and on the outside. Then we checked the traps in the middle and outside and counted how many salamanders were in both. The results were that in the middle we first caught nothing and in the second one we caught nine salamanders. On the edge I only checked one and there were four salamanders. On average, in the middle, there were 4½ salamanders in each trap and on the outside there were four in each trap (once all traps were checked). My conclusion is that there were more

> salamanders in the middle. We need to do this study a lot of times to see if we are right. (Research Presentations 1, 6/24/2011, 02:03)

Participants in each program came with a variety of previous experiences in summer programs, herpetology, and educational experiences. The following nested case studies, examining two participants in *the Herpetology* program, demonstrate the growth of content knowledge in selected participants to provide a more robust example of participant growth.

"Salamander." Salamander was a rising fifth-grade participant in the *Herpetology* program. She is self-assured and confident; the first day, as participants introduced themselves to one another and the counselors, she insisted that everyone call her "Salamander." Salamander comes in with strong herpetological content knowledge, scoring 100% (20 out of 20 possible points) on her pre-assessment. She also scored six out of 16 points on her tools pre-assessment.

On Day 1 Salamander dominates conversations, displaying correct scientific knowledge five of the 28 noted times. Salamander provides 18% of all correct answers shared during the day (out of the 12 participants for whom IRB consent was attained). Although Salamander has a strong educational background and is highly interested in herpetology, she makes several noticeable errors her first day in the program. Salamander is involved in the collection of three different animals on Day 1 and is only able to correctly identify one animal by its distinguishing characteristics. In one instance, when she sees a newt caught by another participant, she insists that the species is a palmate newt, a species found only in Western Europe.

In the second incident, Salamander helps a peer correctly identify a box turtle, but she is incorrect in insisting that the sex of the box turtle is female because it has red eyes and an indentation in the plastron, both characteristics of male box turtles. When asked to check her field guide to verify her findings, Salamander states, “I’m going to. I’ve got my field guide under my pillow. Yeah, because I was reading it last night and it was under my pillow. I have the Audubon Society one” (Group Share Video, 6/13/11, 04:26). However, when asked the following day, Salamander shares that she did not check her field guide to find out if she was correct.

On the third day of the *Herpetology* program, Salamander displays several strategies and evidence of dispositions not seen at the onset of the program. In one instance, for example, Salamander finds a Fowler’s Toad during the coverboard study. When asked to verify her findings, she leads the group through the use of a dichotomous key to identify the toad:

> Salamander: (as she chases it) Oh my gosh. This is a...smart toad. (She picks it up)
>
> Adult voice off camera: You remember how to hold him?
>
> Salamander: Yes, I do. You’ve got to get his legs first. Cause they always flail. (To group) I found a toad!
>
> Instructor (off camera): In the leaves? Oh, on the ground? Oh, Good. Can you ID it?
>
> Salamander: I think it’s a Fowler’s Toad.
>
> Instructor: Okay. You know what I think I’ve got in one of our backpacks this morning? I think we have some keys. So let’s stop and use those for just a minute. Okay - let’s start on the top. Give us our first choice, Salamander.

> Salamander: ‘Smooth, moist, scaleless skin—amphibians, go to number two. Or dry, scaly skin—reptiles, go to number eleven.’
>
> . . . (break in recording)
>
> Instructor: Dry, warty. He’s a toad. Go to nine. Okay. Back to Salamander. You’ve got to be the defining person.
>
> Salamander: ‘Black spots’ . . . wait . . . Black spots on the back contain only one or two warts . . . he’s an American Toad. Several, he’s a Fowler’s Toad.’ He’s a Fowler’s Toad. He’s got . . . most of the black dots have four or five.
>
> Instructor: So, you used a key to identify a Fowler’s Toad. Fowler’s Toad! If you want to get a good look at it, let’s have Salamander either share that or let you hold it. And you can keep your keys. You can put them in your pockets, if you have pockets. If you don’t maybe an adult can put yours in a pocket for you.
>
> Alex: Can I touch it? (reaching in)
>
> Male voice off camera: Salamander, show him the black dots.
>
> Salamander (showing toad): You see, those are the black dots. And they have little bumps in them.
>
> Instructor: Count those, Alex. See if you got the same thing Salamander got.
>
> Salamander: About four on that one (touching spots). (Day 3 Video 1, 6/15/11, 23:41)

Salamander not only correctly identifies the Fowler’s Toad, but she uses her dichotomous key to verify her prediction, showing use of scientific process skills. She holds the toad as previously directed by the instructors, showing responsibility for properly handling the animals and an application of strategies taught during the program. Salamander takes turns with her peers reading through the key and allows others the opportunity to speak, as well as allowing a peer to verify her findings without criticism. Salamander’s performance on Day 3 greatly contrasts with her performance on Day 1, where she refused to use tools to verify her findings, disagreed with peers who questioned her findings, and incorrectly identified species.

On Day 5, Salamander shows further use of scientific process skills and a growth in her knowledge and dispositions towards science. Salamander works on a team with three other participants to create a research question and develop a method for data collection. Salamander and her peers decide to examine whether wood or aluminum coverboards attract more reptiles and amphibians. In their group presentation, Salamander can correctly explain her group's method of data collection and how their research questions changed as they began to collect data. Rather than correct everyone, as was her initial inclination, she allows other group members to share information:

> Salamander: Our two questions was (sic) which coverboard is preferred by more animals, wood or metal, and do they—and where are they more often located, close to the trail or far away? Our hypothesis was three of us said that it was wood because metal can get hot, and one chose metal because it is not normally in the woods and animals might get curious.
>
> Tim: So, um, what we found was a salamander under wood coverboards—two salamanders under the wood. Um, we found a toad under the wood, we found ants under the wood, we found a black widow under the wood, and we found two beehives under the wood coverboards.
>
> Salamander: We checked 29 coverboards and three were metal. And the discussion is we need an equal amount of wood and metal traps, and we need to test a lot of times. We only- we only found one snake, so we changed our question because it was originally which coverboard attracts more snakes, and our hypothesis was supported, animals preferred wood coverboards, because then we found a beetle, a spider, the salamanders, and a black widow under the wood coverboards. (Day 5 Group Presentation Video, 6/17/11, 07:08)

Salamander correctly uses terminology learned throughout the week, including "hypothesis," "supported," and "discussion." She is able to explain how her group decided to change their hypothesis and shares findings that are based on evidence, rather than feelings alone.

Salamander entered the program with greater background knowledge of herpetology than many other participants; however, this program allowed her to further develop her knowledge, skills, and dispositions as they related to herpetological studies. Salamander received 13 out of 18 possible points on her post-tools assessment, and an 18 out of 20 on her post-content assessment (Salamander skipped a problem; it is unknown if this was accidental or intentional). Initially, Salamander did not engage in skills such as classifying organisms, nor did she engage in dispositions such as collaboration. However, her competence in these areas increased throughout the week as a result of participation in the *Herpetology* program.

"Tim." Tim was also a rising fifth-grade participant in the *Herpetology* program. He was highly interested in herpetological studies, signing up for the *Herpetology* program after engaging as a participant in the researcher's pilot study. Tim entered the program with some herpetological content knowledge, earning 13 out of 20 possible points on his pre-assessment. He also scored 13 out of 18 points on his tools pre-assessment.

On Day 1, Tim shows some basic content knowledge about reptiles and amphibians. He can correctly identify a turtle as a reptile, for example, but is unclear about how a turtle shell works and cannot fully explain the differences between how reptiles and amphibians breathe:

Teacher: It has a shell. And the shell is a pretty cool thing on a turtle. It does stuff that you might not even think about. What is the obvious or the pretty apparent thing that the shell does for the turtle?

(Children raise hands)

Tim: Protection.

Teacher: It protects it. Okay. That's the biggest thing. But actually the shell also helps the turtle hold its breath . . .

Tim: Because the shell holds air.

Teacher: The shell also helps the turtle maintain a body structure. What we call a shell is actually (tapping shell) . . . tap yours like this . . .

(Children tap shells)

Teacher: What we call a shell is actually bone. So our bone is on the inside of our skin. And it provides support to our body . . .

Tim: Exoskeleton (pointing).

Teacher: It's not an exoskeleton because there's something across the top of the shell and those things are called scutes. And on everybody's shell . . . did I not hand you a shell? Oh, I'm sorry. Here . . . take that one (handing child shell). On everybody's shell, most of that stuff is missing. So this is the bone we're seeing right here. (Holding up shell) This shell has a little piece of the stuff on the outside called a scute. Now turn and look on the inside of your shell and what do you see on the top, inside? (9:30)

Alex: A backbone.

Teacher: A backbone. So the backbone of the turtle is part of the turtle's shell. So can a turtle crawl out of his shell and find a new shell?

Tim: This one you can't see inside of.

Teacher: That's right. That one's hard to see inside of. A turtle doesn't crawl out of its shell and find a new shell because the shell is part of his skeleton. What animal crawls out of its shell and finds a new shell?

Tim: (raising hand) A hermit crab (Group A Aquatic Turtles Video 1, 6/13/11, 09:31).

Tim has some background experience in science; he attended a public magnet school focusing on science and technology and again had been a part of the pilot study group. However, he also takes topics learned elsewhere and incorrectly applies them to herpetology, such as calling the turtle's shell an exoskeleton and thinking that the shell of the turtle holds air. Like Salamander, he does not use evidence or tools such as field guides and dichotomous keys to support his findings.

On Day 3, the third day in the field, Tim is able to identify species and explain how to handle animals caught under coverboards. After catching two worm snakes, Tim instructs his peers on proper handling techniques and shares a story about his principal, who handled a snake incorrectly and was bitten as a result:

> (Tim picks up snake)
>
> Instructor: I know you held this one (motioning to snake in bag). So would you like to see if someone else would like to take a turn holding? (motioning to new snake) I think that would be nice.
>
> (Tim turns to Collin, hands him the new snake)
>
> Alex: Can I hold? Can I see him? (walks up and takes a picture with camera)
>
> Instructor 1: (handing Tim the bagged snake) And here's your worm snake.
>
> Tim: Don't hold him too hard because you'll crush his ribs. His ribs are like all over the body.
>
> Salamander (off camera): I've seen a ring necked worm snake. They're really cool.
>
> Tim: It's not a ring necked snake.
>
> Salamander: It's not a rat snake. It was a ring necked worm snake.
>
> (Tim hands new worm snake to Alex)

> Adult female voice (off camera): Alex, put your bag down . . . you need two hands to handle snakes.
>
> (Alex uses two hands)
>
> Tim: So you don’t end up like Mr. B.
>
> Instructor 1: Yep! So you don’t end up like Mr. B. Cause what happened to Mr. B?
>
> Tim (taking hold of snake again): He was holding it the wrong way and he got bitten by a snake.
>
> Salamander: Mr. Bill?
>
> Instructor 1: No, the principal at Tim’s school.
>
> Instructor 2: (stepping into frame) Do you see it vibrate its tail? If you watch it for a minute . . . see it vibrate its tail? That’s common in snakes, not just rattle snakes.
>
> Voice behind camera: Tim, why do you think it’s doing that?
>
> Tim: To . . . um . . . to warn you. (Coverboards Video 1, 6/15/11, 06:35)

Tim not only correctly identifies the snake species, but he also explains the need to protect the snake because of its large number of ribs, demonstrating an understanding of the snake’s anatomy. He recognizes the warning signs given by the snake, and can explain the consequences of handling the animal incorrectly.

On Day 5, Tim continues to be a regular contributor to group discussions and an active participant in program activities. He helps his group present their findings from the coverboard research group, and takes the role of a leader as the participants help an undergraduate research assistant track a box turtle using radio telemetry:

> Research Assistant: Did you hear it?
>
> Kids: Yeah!
>
> Tim: It’s coming from that direction (pointing).
>
> Research Assistant: Do you remember what I told you about getting closer to the ground?
>
> Tim: We’ll hear it better because it’s closer to the animal. I heard it!
>
> Kids: Tim, how loud was it? Where was it coming from?
>
> Tim: That way (points and walks; kids follow). (Group Presentations Video, 6/24/2011, 23:01)

Tim entered the program with basic background knowledge of herpetology, but like Salamander was able to further develop his knowledge, skills, and dispositions as they related to herpetological studies. Tim received 18 out of 18 possible points on his post-tools assessment, and 16 out of 20 points on his post-content assessment. Initially, Tim had difficulty explaining content about the physiology of reptiles and amphibians and was unsure about how to handle specimens. However, his competence in these areas increased throughout the week as a result of participation in the *Herpetology* program.

The following section describes the knowledge gained by participants in the *Reptiles* program. The group is analyzed as a whole; then two nested case studies are presented to provide examples of participant gains in scientific content knowledge.

Reptiles. Twelve of the 15 participants with IRB consent in the *Reptiles* program completed both the pre- and post-assessments. Because the *Reptiles* program was established before the research study surfaced, I had to rely on volunteers who could pick their children up later so that they could complete these surveys outside the normal camp program times. These participants also displayed significant growth in content knowledge as measured by the pre- and post-assessment. Participants in this program did not complete the tools assessment before or after the program as requested by the program instructor because tool use was not a focus of this program. Table 5 displays participants' scores on pre- and post-assessments.

Table 5

Participant Assessment Scores, Reptiles

Assessment	***M***	***N***	***SD***	**Significance Level**
Pre-Knowledge Assessment	7.46	12	4.47	
Post-Knowledge Assessment	11.00	12	3.93	
Pre-Post Knowledge		12		.003 (t = 3.75)

Although participants in both programs showed an increase in content knowledge, patterns emerged when comparing participant scores between camps. Participants in the *Herpetology* program entered the program with more content knowledge than participants in *Reptiles* as indicated by pre-assessment scores (t = 1.56, sig. at 0.147). Participants in the *Herpetology* program also showed a greater growth in scores (5.46 points; 56% growth) than participants in *Reptiles* (3.54 points; 47% growth).

Participants came in with significantly different prior experiences. Eleven of the twelve *Herpetology* participants lived in rural areas and spent extensive time outdoors; five had attended summer outdoor programs in the past and one had established coverboards in his yard to look for reptiles and amphibians. Participants in the *Reptiles* program lived within major city limits, and spent limited time outside, according to participant registration forms and conversations with the instructor, children, and their parents. However, eleven of the participants had participated in previous programs offered by Mr. Holliday through the Nature Preserve, including four participants who had previously attended the *Reptiles* program.

Like participants in the *Herpetology* program, participants in the *Reptiles* program came with a variety of previous experiences. The following two nested case studies also demonstrate the growth of content knowledge in selected participants in the *Reptiles* program to provide a more robust example of participant growth.

"Nico." Nico's family immigrated to the United States from Brazil. His parents speak Portuguese as a first language; he is fluent in both Portuguese and English. Like Salamander, he recently completed the fourth grade in a local public school. Nico has an estimated IQ of over 140. He earned 15 out of 20 points on his pre-assessment. This is Nico's second time in the *Reptiles* program, and his third program overall with Mr. Holliday.

Nico is a walking textbook. He answers every question posed by Mr. Holliday to the group correctly and has more or less memorized the presentations the instructor gives each day. Nico, at times, dominates the conversations by answering all questions and not providing others the opportunity to speak. He shows a reinforcement of the content knowledge he already has, but no opportunities for growth of his scientific knowledge, skills, or dispositions on Day 1:

(Instructor is holding a captive pine snake)

Instructor: No, not because he likes it. Remember, I just told you he sees lots of kids. This way I can keep him used to being handled and touched because that's what kids do (Nico has his hand up). Nico?

Nico: I know you're going to tell us this, I think you're going to take out the fossorial one next, which means he lives underground.

Instructor: Yes, we'll get one of those out in a bit.

Trevor: Look at the orange one!

Nico: He's not orange, he's an Eastern rat snake. (Day 1 PM Video 1, 6/20/11, 00:45)

Like Salamander, Nico already comes with a great deal of content knowledge and understanding of science. He has funds of cultural knowledge that prove useful in opportunities to practice scientific skills, such as measuring the length and width of a turtle shell. His family's regular use of the metric system aids in collecting data. However, Nico is presented with few opportunities for growth. The program structure uses the same question and answer format through the week, reiterates that participants look, but do not touch organisms, and limits the scientific terminology and practices in which participants engage:

Cathy: Do you guys remember what that tool is called?

Nico: A thingy.

Cathy: A thingy.

Alexander: A measuring thingy.

Cathy: A measuring thingy. (To another participant) Do you remember what that tool is called? What is that tool called she is using?

Alexander: A ruler.

Cathy: A ruler? What is it called? What do you think?

Nico: A ruler.

Instructor: You can still work with it. You want to measure the plastron, the longest part. Length means long. You have to be able to get it here. Raise it up a little. Raise it up. Read the number.

Nico: 15.4. 154.

Cathy: How did you know that?

Instructor: Very good! Your family is from where?

Nico: Brazil.

Instructor: Do you use metric in Brazil?

Nico: Yeah. (Day 2 PM Video 13, 6/21/11, 02:29)

Nico's performance is consistent through Day 5 of the *Reptiles* program. He continues to correctly answer every question presented to the group and is an eager participant in all activities. Throughout the week, he can be seen at the side of the instructor in all outdoor activities, and seated at the front of the room for each classroom activity. However, Nico does not have any opportunities to expand on his preexisting knowledge of herpetology, given the question and answer format of the program:

Instructor: This is a female. What kind of turtle is it?

Nico: Red eared slider.

Instructor: Very good. This is a serrated posterior. What does posterior mean?

Kid: Butt.

> Instructor: Butt end. This is the anterior. This is the posterior. So this is a red eared slider female. How do I know it is not a male?
>
> Nico: Males are smaller. (Day 5 Video 5, 6/24/11, 01:21)

Nico entered the *Reptiles* program with extensive factual knowledge of reptiles and amphibians; however, his knowledge remains static, throughout the duration of the program. On his final assessment, Nico earns 16 out of 20 points, one point more than he had at the onset of the program. However, when compared to Salamander, who displayed significant growth in her understanding of herpetology and herpetological practices despite having no growth on the assessment, Nico does not have opportunities to expand his understanding of herpetology.

"Connor." Connor entered the *Reptiles* program with some herpetological content knowledge, earning 11 out of 20 points on his pre-assessment. Connor's mother enrolled him the program because he "loved snakes," even bringing in a collection of dead snakes to share that he kept in his kitchen freezer to save for the program. When asked how he acquired the snakes, Connor explained that his neighbor killed some of them with a weed whacker, but let Connor have them rather than throw the snakes away. Connor had been in one of Mr. Holliday's summer programs once before, becoming interested after his older brother participated in the program several years prior to Connor's enrollment.

On Day 1, Connor establishes himself as a rule follower; he does not call out, he raises his hand, and only shares answers three times throughout the entire day. Like Nico, the questions asked enabled Connor opportunities to provide limited answers:

> Instructor: Everything dies, sooner or later. I'm only going to be able to take out certain ones today because some are getting ready to shed. This one just shed. You won't hold him today—everyone will hold him tomorrow. Tomorrow everyone will hold him because a lot of people came in today wearing bug spray and sunscreen. Don't wear those things if you want to hold him. We'll take pictures of you holding the snakes and send them to you. So, what kind of snake is this? (Points at Connor) Thank you for raising your hand.
>
> Connor: Red rat snake.
>
> Instructor: They might call it a red rat snake. (Day 1 PM Video 1, 6/20/11, 01:03)

Although Connor is not a vocal participant in the program (not sharing any answers aloud on Day 2, and two answers on Day 3), he is regularly involved in the program activities, hiking near the front of the line all five days, helping his peers to assemble a turtle skeleton in the classroom, and watching the videos shared during lunch each day. Connor uses the camera from the photo elicitation interviews to take 235 photographs on Day 5 (compared to an average of 33 photos for other *Reptiles* participants in one day). He is also willing to share what he knows about reptiles and amphibians when engaged in one-on-one conversation, such as the example below from Day 5:

> Connor: 250 something pictures I took.
>
> Cathy: What?
>
> Connor: You told me to remind you.
>
> Cathy: We'll have to stop and look at them when we get to the site, because my computer is there.
>
> Connor: Do you know the most popular snake, you can find (them) all at my grandmothers, you can find it all over Florida?

Cathy: What snake is that?

Kid 2: Black Racer.

Connor: They are always there. Whenever I see a snake it is mostly black racers. (Day 5 Video 1, 00:25)

Like Nico, the opportunities presented to Connor to expand his content knowledge, skills, and dispositions are limited. Despite being a quiet participant, Connor does acquire some new factual information about reptiles and amphibians by listening carefully and participating in the program activities. At the end of the program, Connor earns 14 out of 20 points on his post-assessment, showing a three-point growth in his score from the beginning to the end of the camp.

Comparisons across programs. Both the *Herpetology* program and the *Reptiles* program provided participants with opportunities to gain scientific content knowledge related to the field of herpetology. Participants in both programs showed significant increases in content knowledge as measured by pre- and post-assessments. Participants were also eager to share their content knowledge, contribute to discussions and answer questions asked of them in each program. These findings were consistent with the findings of Hsu and Roth's (2010) study of high school participants in a biology internship, who when working alongside local experts demonstrated growth in their scientific knowledge.

When examining content knowledge beyond written pre- and post-assessments, some differences are revealed in the types of opportunities to show content knowledge that are offered in each program. In the *Herpetology* program, participants of all academic levels are provided opportunities to show growth in their knowledge of both scientific content and the skills needed to participate in herpetology. In the *Reptiles* program, however, participants who come in with less background knowledge about reptiles and amphibians, such as Connor, are provided more opportunities to learn scientific content than high achieving participants such as Nico, whose understanding of herpetology is merely reinforced by the activities in which he participates. The knowledge that is learned by participants in the *Reptiles* program is based largely on scientific content, with little to no focus on the skills needed to participate in science. The *Herpetology* program was able to focus on development of both domains of scientific knowledge, both knowledge of science and knowledge about science (Bybee et al., 2009), whereas the *Reptiles* program emphasized primarily just knowledge of science.

The following section of results examines the process skills enabled for participants in both programs over the course of each week. The types of process skills enabled are identified and explained, citing examples from the two different herpetology programs.

Process Skills

Process skills are strategies necessary to engage in scientific practices; they are actions used to gather and share scientific information. Process skills in both the *Herpetology* and *Reptiles* programs were identified and coded using Trowbridge et al.'s (2000) five categories of process skills. Data were analyzed for frequency of each type of skill and changes over the five-day period of each of the programs.

Herpetology. Table 6 displays the process skills witnessed in field notes and video analysis from the *Herpetology* program. On Day 1, participants engaged in a variety of process skills, with 32 instances recorded on videotape and triangulated through field notes. Fourteen of these 32 instances (44%) were classified as acquisitive process skills, which included listening, making observations, and asking questions. Participants made several observations on the first day, such as noting that amphibians have smooth, wet skin. Participants were also full of questions about the organisms caught, such as when one child asked if the dots on the gouler plates of the Yellow-Bellied Slider protect it "so if a predator sees it, it might think those were eyes and attack the shell instead, right?" (Aquatic Turtles Video 5, 6/13/11, 02:02). Participants collected some, but minimal, data on the first day in the program.

Table 6

Frequency Count of Process Skills Used in Herpetology Fieldwork

Process Skills	Day 1	Day 2	Day 3	Day 4	Day 5
Acquisitive					
Listening	1	1			2
Observing	5	4	11	5	3
Searching			2		2
Inquiring	5	3	8		
Investigating	2	5	2	1	
Gathering Data	1	13	12	6	
Researching		2			
Total:	**14**	**28**	**35**	**12**	**7**
Organizational					
Recording	2	16	8	4	
Contrasting		5	1		
Classifying	1	10	7		
Organizing/Reviewing/Evaluating/ Analyzing/Comparing					

Table 6 (cont.)

Process Skills	Day 1	Day 2	Day 3	Day 4	Day 5
Total:	**3**	**31**	**16**	**4**	**0**
Creating					
Planning Ahead				3	
Designing				6	
Inventing/Synthesizing					
Total:	**0**	**0**	**0**	**9**	**0**
Manipulative					
Using Instruments	7	14	15	5	2
Demonstrating		1			
Experimenting/Constructing/ Calibrating					
Total:	**7**	**15**	**15**	**5**	**2**
Communicative					
Questioning	2		1		
Discussing		2	4	4	2
Explaining	6	9	5		5
Reporting					11
Criticizing				1	
Graphing/Writing/Teaching					
Total:	**8**	**11**	**10**	**5**	**18**
Day Totals:	**32**	**85**	**76**	**35**	**27**

In addition to using acquisitive process skills, use of instruments (manipulative skills) and explaining (communicative process skills) were most prevalent, with seven and six instances respectively. Participants had multiple opportunities to engage in instrument use, including using a squeeze box to measure a snake, using dip nets and minnow traps to collect vernal pool specimens, and collecting animals from drift fences and PVC pipe transects. In addition to 14 instances where children had opportunities to use scientific instruments, one child also demonstrated to his peers how to use calipers to measure carapace length and width on a turtle.

Each time participants were asked a question they were required to explain their ideas, such as when Kaitlyn, a ten-year-old participant, is asked to explain what it means to be an amphibian:

> Instructor: What do we know about toads?
>
> Kaitlyn: They're amphibians.
>
> Instructor: What does it mean that they are amphibians?
>
> Kaitlyn: They can be on water or on land. (Coverboard Video 8, 6/13/11, 04:33)

Participants displayed a significant increase in the use of scientific process skills on Day 2, with 85 events noted in video and field note footage. One third of the process skills witnessed were acquisitive (28/85), with a noticeable increase in the number of times data were collected (13 instances). Data that participants collected during Day 2 activities included turtle lengths, widths, and masses in the Aquatic Turtles Group, and newt length and mass in the Vernal Pool Group. Every child was witnessed collecting data using scientific instruments, as well as recording data in their scientific journals.

As participants interacted more with organisms on Day 2 there were also more opportunities to classify animals, an activity witnessed 10 different times by observers. Participants in the Vernal Pools Group classified newts and frogs by species and gender, and participants in the Aquatic Turtles Group classified captured turtles by species and gender:

> Instructor: Now, this guy's different. What is this turtle?
>
> Child 1: Yellow belly.

> Instructor: I need three.
>
> Child 1: Well, he's yellow . . .
>
> Child 2: He has eyes on the bottom . . .
>
> Instructor: What's the bottom called?
>
> Child 1: Plastron.
>
> Child 2: He has two dots on his plastron.
>
> Child 1: He has a yellow bar behind his eye. (Aquatic Turtles Video 4, 6/15/11, 05:38)

As with Days 1 and 2, Acquisitive process skills were the most frequently observed process skills on Day 3, constituting 35 of the 76 process skills observed (46%). Participants were observed collecting data twelve different times, making observations about organisms and tool use eleven times, and asking questions about what they were learning eight times:

> Instructor: We've got PVC pipe over there. Did no one check that one yet?
>
> Child: How do frogs get in it?
>
> Child 2: Is there anything in there? (Coverboards Video 1, 6/15/11, 06:35)

Participants in the Coverboards group were also witnessed searching through leaf litter twice looking for organisms, a process skill not observed prior to Day 3. The Coverboards Group, however, was not witnessed recording or collecting any data on Day 3; instead, the Aquatic Turtles Group gathered and recorded all data as they collected specimens from the lake. Both groups spent nearly equal amounts of time classifying organisms caught (seven instances), and participants in both groups were witnessed explaining their ideas to one another. Participants on Day 3 engaged in more discussion than on Days 1 and 2, working together to collect organisms and determine species:

> Andrew: Can I see? (Looks in pipe)
>
> Tim: I think he's a spring peeper.
>
> Salamander: We found a frog.
>
> Instructor: What kind?
>
> Salamander: We're not sure yet. I don't know why, but he looks kind of like a Puerto Rican frog.
>
> Tanner: He looks like a spring peeper.
>
> (Salamander starts looking through field guide). (Coverboards Video 2, 6/15/11, 15:07)

Participants were witnessed using scientific process skills 35 times on Day 4. Twelve of these instances involved Acquisitive process skills as participants made observations five times, investigated once, and gathered data six times. Participants also were observed recording data four times in their own science journals. Although participants only recorded data four times in their science journals, they assisted their instructors in writing out the entire research process that they used on poster board to share in the Day 5 research conference.

Because the focus of *Herpetology's* fourth day was to develop a research question, participants were observed planning their investigations three times and designing experiments six times, both of which fit into the Creating process skills category.

Participants were able to develop their own research questions, but needed scaffolded assistance to make sure that they addressed their hypotheses, research methodologies, and data collection correctly:

> Girl: Oh, because I was gonna say, another, another question we could ask is how much of the bait would the turtles eat?
> Instructor: Ok, so should we put about the same amount of hot dogs as we have chicken?
>
> Girl: Yeah.
>
> Instructor: How should I tell the amount? What should I do to tell the amount?
>
> Girl: Of how much is eaten? If there’s this much eaten, then we know.
>
> Instructor: How would we tell that though?
>
> Girl: Because we should see a bite mark. (Day 4 Aquatic Turtles Video 4, 6/16/2011, 00:58)

As participants collected data they were observed using instruments four times, including aquatic turtle traps, minnow traps, coverboards, and spring scales. Participants engaged in discussions four times as they determined what types of data they wanted to collect and how to best address their research interests. In one instance, a participant criticized the methodology suggested by a peer because she felt other variables might impact the data collected:

> (Participants are determining whether wood or metal coverboards will attract more snakes).
>
> Cathy: So what might your hypothesis be?
>
> Tim: more in the wood.

> Cathy: Because?
>
> Tim: Because the metal is wavy, so maybe bigger animals might not like to go under there because of the waves.
>
> Salamander: I don't know, I have one concern. Don't you think it would be wood because metal might heat up under the sun, might get too hot? We need to bring a thermometer to see. (Day 4 Coverboards Video 6, 03:01)

On the final day of the *Herpetology* program participants shared their research projects and findings in a mini-research conference with their peers. Communicative process skills were most often used on Day 5 as 11 of the 12 participants reported their findings to their peers (the one participant who did not present had an instructor present his findings for him). Participants had five different opportunities to explain their research and findings when asked about their projects by the instructors and their peers.

Participants also learned how to track box turtles on the final day of the program using radio telemetry. During this activity, participants were asked twice to listen for the radio (transmitter) signals through the telemetry receiver unit, searched in two different locations for the hidden box turtle, and made observations three different times of the signal strength displayed on the telemetry receiver unit. These seven instances accounted for the seven instances in which participants could use their Acquisitive process skills. In addition, participants were able to handle and use the telemetry unit twice, enabling use of Manipulative process skills.

Overall, the *Herpetology* program provided multiple opportunities for participants to engage in all five categories of scientific process skills. The majority of process skills observed were Acquisitive; this is in part due to the introductory nature of the program and participants' basic understandings of herpetology. Use of Acquisitive skills, such as observation and inquiring, provided opportunities for participants to learn more about the reptiles and amphibians they found. The program's focus on tool use enabled Manipulative process skills to be used, particularly as participants collected data for four days in the field. Finally, a research conference enabled participants to use their Communicative process skills to share their findings with others.

Like the *Herpetology* program, the *Reptiles* program provided participants opportunities to use scientific process skills. The following section of this chapter examines the types of process skills enabled by the *Reptiles* program.

Reptiles. Like participants in the *Herpetology* program, participants in the *Reptiles* program also had opportunities to use scientific process skills. Table 7 displays the number of times that participants demonstrated specific process skills during the *Reptiles* program.

Table 7

Frequency Count of Process Skills Used in Reptiles

Process Skills	Day 1	Day 2	Day 3	Day 4	Day 5
Acquisitive					
Listening/Researching					
Observing	12	8	4	5	4
Searching		1		1	
Inquiring	10	8	3		2
Investigating				1	2
Gathering Data		7	2		
Total	**22**	**24**	**9**	**7**	**8**
Organizational					
Recording/Comparing/Contrasting					
Classifying	2		1		0

Table 7 (cont.)

Process Skills	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Organizing/Reviewing/Evaluating/ Analyzing					
Total:	**2**	**0**	**1**	**0**	**0**
Creating					
Planning Ahead/Designing/ Inventing/Synthesizing	**0**	**0**	**0**	**0**	**0**
Manipulative					
Using Instruments		7			
Constructing		5			
Calibrating/Demonstrating/ Experimenting					
Total:	**0**	**12**	**0**	**0**	**0**
Communicative					
Discussing		4		1	
Explaining	1				
Reporting/Writing/Criticizing/ Graphing/Teaching/Questioning					
Total:	**1**	**4**	**0**	**1**	**0**
Day Totals:	**25**	**40**	**10**	**8**	**8**

Acquisitive process skills were the dominant category of process skills seen during both the *Herpetology* program and the *Reptiles* program. On Day 1, Acquisitive process skills accounted for 22 of the 25 process skills observed (88%). In particular, making observations and inquiring comprised the entire acquisitive process skills category, with 12 and 10 instances, respectively. Participants asked questions several times throughout Day 1, related primarily to animal behavior and anatomy. These questions often followed their observations of animals and the environment:

Child 1: Look at the lizard with the blue tail. I’ve seen those! They are cute!

Child 2: Why is he moving?

Instructor: There he is. They’re not good to eat.

Child 1: How do you know? (Day 1 AM Video 6, 6/20/11, 03:20)

Participants also classified organisms twice, once identifying poison ivy by leaf number and color and once identifying a Florida soft-shelled turtle by head shape and location. One participant had the opportunity to explain the life cycle of a reptile during the morning lecture, providing one opportunity for Communicative process skills.

On Day 2 participants had many more opportunities to use scientific process skills. Because Day 2 focused on turtles as the topic of study, participants were able to work in groups to measure the carapace of a turtle shell and report the measurement, providing seven opportunities to use instruments and gather data. Participants also worked in small groups to reconstruct turtle shells, providing five more opportunities to use Manipulative skills. The reconstruction of the turtle shells engaged four small groups in discussion over how the shell pieces should be assembled:

Nico: Oh, Here is a leg.

Cathy: How are you guys doing this? Do you have a system?

Isla: This is hard. Is this a leg?

Nico: Not for me.

Cathy: What do you think Nico, is there a better way to go about doing it?

Nico: Put them in the middle.

Isla: I think these two go together.

Helen: Is this paper towels? It looks like paper towels.

Nico: It’s bones. Everything here is bones.

> Cathy: Okay, so is that the plastron or the carapace?
>
> Nico: Plastron.
>
> Cathy: How do you know?
>
> Isla: Carapace.
>
> Cathy: Is this the top or the bottom?
>
> Nico: Bottom. It's the plastron. Wait a minute these are different sizes. They are different sizes. You have to turn them this way. (Day 2 PM Video 6, 6/21/11, 02:27)

Like Day 1, Acquisitive process skills were again dominant on Day 2, making up 24 of the 40 process skills observed (60%). Observation and Inquiring again comprised the majority of Acquisitive process skills, with eight instances each. This pattern was consistent on Day 3, where Acquisitive skills accounted for nine of the 10 opportunities participants had to engage in scientific process skills. Participants again observed and asked questions about what was taught in the program, but had significantly fewer opportunities to use any other science process skills. Participants gathered data using a pre-made worksheet to find the mean and range of a set of carapace measurements taken over several years from a turtle that was on the park grounds. One child was also able to identify a snakeskin on the morning nature hike by identifying scale characteristics of the snake species.

Day 4, as with the previous three days, predominantly provided participants opportunities to engage in Acquisitive process skills (88% of process skills witnessed). Again, Observation was the main process skill used (five times) as participants looked for organisms on their hike and learned about nonnative species. Participants also had one opportunity to search as they looked for brown anoles outdoors and one opportunity to investigate as they tried different strategies for catching the anoles. Participants also engaged in one discussion over how to determine the sex of a brown anole.

On the final day of the program, opportunities to engage in scientific process skills occurred eight times. All eight instances involved Acquisitive process used on the hike across the nature preserve, where participants observed organisms in their natural habitats twice, asked questions about the behavior of gopher tortoises, and searched for wildlife at two different stops on the hike.

Comparison between programs. The process skills enabled for participants in both programs were somewhat similar. Overall, the use of Acquisitive process skills was common in both programs as participants observed reptiles and amphibians and asked questions about the animals. Organizational, Manipulative, and Communicative process skills were observed in both programs, but more frequently in the *Herpetology* program due to the nature of program activities.

However, when Manipulative process skills were observed they took on very different roles in each program. For participants in the *Herpetology* program, “using instruments” was a central part of the program. For the *Reptiles* program, participants used “constructing” skills as they rebuilt turtle skeletons. Both activities provided valuable opportunities to engage in different sets of Manipulative process skills.

Because participants in the *Herpetology* program were involved in research they had more opportunities to use Organizational and Communicative process skills than the participants in the *Reptiles* program. Participants in the *Herpetology* program were able to use tools and collect data on organisms, whereas participants in the *Reptiles* program were not. Collecting data and presenting in a mini-research conference provided opportunities for participants to record, investigate, communicate, and discuss ideas. Creating process skills were the least common type of process skills observed in both programs; these were evident in *Herpetology* only when participants designed their research projects and were not witnessed at all in the *Reptiles* program. Overall, participants in the *Herpetology* program had a substantially greater number of opportunities to engage in the different types of science process skills than participants in the *Reptiles* program. The skills used in the *Herpetology* program included both basic and integrated process skills (Padilla, 1990; Beaumont-Walters & Soyibo, 2001; Goldston, 2004; DeFina, 2006), whereas the *Reptiles* program focused primarily on basic process skills (Padilla, 1990). These experiences greatly impacted participant perceptions of authentic herpetology and how participants felt their programs aligned with what a herpetologist does, both of which are explored in greater detail later in this chapter.

The following section examines the opportunities for participants to develop scientific dispositions in each program. Programs will be examined individually, then compared.

Dispositions

Herpetology.

Curiosity. Curiosity was a disposition clearly reinforced by instructors in the *Herpetology* program, who encouraged participants to "ask any questions they want" (Vernal Pool Video 1, 6/13/2011, 02:11). Curiosity was observed in several forms as participants asked questions, handled organisms, and interacted with the environment around them. Participants were witnessed inquiring at least 60 times during the week as they participated in activities; this equates to an average of at least one question asked per ten minutes of the program. When asked what they thought it took to be a good herpetologist, several participants mentioned the value of asking questions. One participant noted that scientists ask a lot of questions about animal behavior, and another noted the reason that he thought asking questions was important in herpetology:

> Instructor: Okay, I want to know what does it mean, or what does it take, to be a good herpetologist?
>
> Ethan: Asking lots of questions.
>
> Instructor: And why is it important to ask a lot of questions?
>
> Ethan: So you can learn new things! (Focus Group 1, 6/17/2011, 02:03)

In addition to asking questions, participants noted that being curious also meant wanting to know more about animals. The majority of questions asked by participants related to animals and their behavior; for example, one participant, when asked if there was anything he hoped to learn during the week, stated that he would like to learn how far reptiles could travel in one day. The four characteristics in Table 8 were determined by examining all questions repeatedly for patterns.

Sensory and affective questions occurred most often during the *Herpetology* program, with participants asking an observed 22 times to handle, touch, and interact with organisms. Most often, participants asked to hold the different animals found, which accounted for 10 of the 22 questions in the Sensory/Affective category (45%).

Participants also wanted to touch, see, and take photographs of the organisms found. Not surprisingly, participants asked three times to keep the animals found, and twice asked to name a worm snake and a toad found during coverboard studies.

Table 8

Types/Characteristics of Questions Asked by Participants—Herpetology

Types/Characteristics	Question
Sensory/Affective: *n* = 22	• Can I hold it? x12 • Can I see it? x2 • Can I take a picture of it? x2 • Can we keep it? x2 • Can we name it? x2 • Do we have to put it back? • Can I touch it?
Organism Specific: *n* = 18	• Is that a XXXX turtle? x3 • If mud is on a turtle's back and you scrape off the mud, will it do any kind of damage or do they have protection?" • Snapping turtle! "Will it bite us?" • The males have an indented shell, right? • What happened to the shells of the turtles? • How do turtles hold their breath for so long? • How big can turtles get? • How do they (turtles) grow their shell? How do they get their shell? • What are those (barbels on turtle)? • Why did she mess with the eggs? • Will we find all 6 box turtles? • Can peepers be different colors? • What kind of frog was it? • How do frogs get in the pipes? • Are there beavers here? • Does that thing (Eastern Rat Snake) bite?
Tool Use: *n* = 14	• Can I do it? (lift coverboard, retrieve trap) x8 • Can I put some boots on? • Can I have a container? • Do we have a bag or something? A squeeze box? • If there's a snake, do I just give it like this? (Waving snake stick) • Are there any more traps to get? • Does it work like a metal detector (radio transmitter)?
General Information: *n* = 6	• Is anything in there? x2 • How far do reptiles travel in one day? • When are we going to find the snakes? • Where's the poison ivy? • Whoaaa! What are those?

Eighteen questions asked were organism specific, with participants wanting to identify species, learn about physical characteristics of different species, and better understand the behaviors of different reptiles and amphibians. These questions were basic in nature, such as wanting to know about color variation of a species or simply the name of an organism found. Tool use questions were the third most frequent category of questions asked, with participants requesting opportunities to use tools, offering assistance in tool use, and asking how different types of tools were used. Finally, general questions occurred least often when participants had questions about habitat (such as encountering poison ivy), terrain, and finding animals in general.

In addition to asking many questions, participants also displayed curiosity when provided opportunities to explore in the environment. In multiple instances, participants were very curious about what would be found under coverboards and in traps. In Group A, for example, participants lifted 11 of the 13 coverboards on the first day and took pictures of everything found underneath. This interest in lifting coverboards remained consistent for all of the groups throughout the week. Often, participants would race to be the first to lift the coverboard:

Ethan: What are we looking for exactly?

Instructor 1: That’s a good question, Ethan. Snakes and salamanders.

Mark: Look! There’s one over there!

Instructor 2: Do you want to lift it?

Kaitlyn: Can I do that one?

Ethan: Watch out for prickers!

(Participants begin running to coverboard)

Collin (lifting coverboard): Nothing. Are there any more?

Instructor 2: Does anyone want to get this one?

James: I will! (Lifts coverboard)

Kaitlyn (at coverboard next to James'): Holly, will you help me?

(Girls lift coverboard towards themselves)

Holly: What what what what is that!!!

Collin: A toad! (Coverboards Video 1, 6/13/2011, 03:16)

The interest in finding organisms was not limited to coverboards; participants were also interested in retrieving turtle traps to see what they could catch in the lake and in using minnow traps and dip nets to catch organisms in the vernal pool.

Participants were asked to explain their interests in particular animals, such as the snakes or turtles. Salamander, for example, was asked why she really wanted to find a red eared turtle, a species she marked in her field guide:

> Salamander: Because I think they are really pretty and I saw one in my pond one day. One time it ate out of my hand. I haven't seen him since. I really wanted to find him. I also wanted to find a yellow-bellied slider because I wanted to know more about him. (Salamander PEI Interview, 6/15/2011, 06:46)

In addition to wanting to know more about specific animals, the majority of participants (nine out of 12) indicated in focus group interviews at the beginning of the program that they came to learn more about reptiles and amphibians and that that they were really interested in the animals, indicating a natural curiosity about herpetology.

Two of the participants did indicate that although they came to the program because their father made them attend, rather than due to their own curiosities, they were interested in learning more about snakes in particular. On the pre-assessment question “I think it is important for scientists to be curious,” participants rated their response at an average of four out of five points (5 = “Very strongly agree”). On the post-assessment, participants rated this question at an average of 4.58 points.

Collaboration. The *Herpetology* program explicitly addressed the notion of scientists collaborating to learn more about reptiles and amphibians because an interest of the program coordinators was to combat the common misconception that scientists worked in solitary situations and did not share information with one another. To emphasize collaboration, participants were assigned to small groups (one group of six participants and one group of seven participants) with whom they would work and interact for the first three days of the program. With their groups, participants worked together to collect data and learn about coverboards, vernal pools, and aquatic turtle studies:

> Collin: We found a frog!
>
> Mark: Let’s put him in a bag.
>
> (The frog jumps out of Collin’s hands. He and Mark squat down to catch it).
>
> Mark: Now we need to put some water in it.
>
> Instructor: You can’t keep it.
>
> Holly: We’re going to hold him now and let him go later.
>
> Mark: Can I have a turn holding him?

> (Children pass bag to one another for observation.) (Coverboards Video 13, 6/13/2011, 02:13)

Participants were frequently assigned partner work as they collected traps and recorded data, and were required to check their work with a partner to ensure accuracy.

At the end of the week, participants worked on research questions of their choice to present in a mini-research conference. Participants were allowed to work independently; however, 10 of the 12 participants elected to work in small groups, showing a preference for collaboration.

Collaboration was also noted in how participants interacted with one another and responded to questions when interviewed. Conversations took on a “we,” rather than “I,” format, as participants discussed their experiences during the week during the program:

> Mark: **We** were studying the vernal pool and **our** question was, can **we** catch more animals in the middle or on the outside of the vernal pool?
>
> Partner 1: There were about 18 traps and six of them were in the middle, so the other 12 were on the outside, and the ones **we** caught were in the middle.
>
> Partner 2: In the middle **we** caught 12 newts, four salamanders, six tadpoles, and two frogs. All together in the middle there were 24 animals.
>
> Mark: **Our** conclusion was that **we** found more animals in the middle traps than on the outside. (Group Presentations, 6/17/2011, 09:08)

During whole group discussion, the use of “we” conversations when sharing with others occurred more frequently than “I” conversations, as noted in Table 9.

Table 9

Frequency Count of "We" versus "I" Conversations during Program Activities—Herpetology

Day	1	2	3	4	5	Total
"We" conversations	6	6	8	5	4	29
"I" conversations	4	3	3	1	2	13

Of the 42 total conversations where participants were engaged in discussion regarding the activities, 29 of the discussions (69%) focused on the group as a whole, using "we" rather than "I." The instructors reinforced these conversations, also referring to the group as a whole and often discussing their own work using "we" to denote collaboration between instructors:

> Instructor: Okay, okay. Right. So but **we** can think that, but **we** can't say that **we** are sure because **we** don't know, **we** have to see lots of turtles before **we** can say something. Ok, so **we're** going to use **our** evidence later, which is why it's important for **us** to write it down.
>
> Aaron: I put a question mark.
>
> Instructor: You put a question mark, that's right. So **we** still have lots of questions. Just one trap doesn't answer **our** question, does it? Alright—so let's—**we're** going to take these traps in. So **our** other research question had to do with weighing **our** bait. So I think **we** should weigh **our** hot dogs, even though **we** didn't catch anything. Does **our** hot dog look chewed on? (Day 4 Aquatic Turtles Video 1, 6/16/2011, 04:15)

Overall, participants also noted the value of collaborating with colleagues in the field. One participant stated during an interview that he felt like a scientist because "we (he and his partner) worked together like a team." Two post-program focus groups also noted that working together was something they thought herpetologists did to be successful. Participants entered with strong feelings regarding collaboration, with an average of 4.62 out of five points (5 = "Very strongly agree") on the pre-assessment question "Sometimes scientists work together" and an average of 4.66 out of five points on the same question in the final assessment. Participants ranked this question highly from the beginning; the change in scores was not statistically significant.

Ethics. Ethical behavior was another disposition reinforced in the *Herpetology* program. Participants were taught how to care for animals, including proper handling techniques and rationales for releasing animals after investigations. They were also instructed on managing equipment, reporting accurate scientific information, and looking at their research from a variety of perspectives to make sure they addressed areas of concern.

As part of their pre- and post-assessments, participants answered three Likert-scaled survey questions related to ethics. Table 10 shows the questions as well as participant responses at the onset and culmination of the program.

At both the onset and culmination of the program participants strongly disagreed with the idea that scientists hid their work from others, averaging 1.77 out of five points on the pre-assessment survey (1 = "Very strongly disagree"). There was no statistically significant difference in participant scores at the end of the program. Participants also felt that scientists were honest when they worked, with scores averaging 4.69 out of five points at the beginning of the program and 4.75 out of five points at the end of the program (5 = "Very strongly agree").

Table 10

Participant Rankings on Ethics Questions—Herpetology

Question	Pre-Score *M* (*N* = 12)	*SD*	Post-Score *M* (*N* = 12)	*SD*	Significance Level
1. Sometimes scientists hide their work from others.	1.77	0.73	1.75	0.85	0.67
2. Scientists have to be honest when they work.	4.69	0.63	4.75	0.60	0.67
3. Sometimes scientists are careless (sloppy) when they work.	1.54	0.88	1.92	1.46	0.39

Participants were frequently reminded that they needed to share their work with peers. In addition, participants were instructed to write down all data, including if no observations were made in order to provide a complete picture of the research that took place:

> Instructor: Well look. Tim, show everybody this. Whenever this string is not tied to this, what happens down there? Right, right, so it's not open. When the string is tied tight, what happens down there? So what might have been the problem? Aaron?
>
> Aaron: Maybe a snapping turtle snapped it off.
>
> Instructor: Well. Or. So the trap wasn't open. Maybe the turtles didn't get in because the trap wasn't open. Or maybe the turtles didn't go in because they didn't like hot dogs. So we're not real sure why there are no turtles in here.
>
> Aaron: Let's try trap number 2.
>
> Instructor: That's a good idea. But I think it's important that we write down what was happening. So you want to write a sentence that says something about the trap not being open because the string was missing. You decide what that sentence will look like. Alright, so did you get your sentence about the string?

Aaron: I did.

Instructor: So, so in science we call this stuff that we're writing down data- that's right, data- and later we are going to use our data or data (pronounces word two different ways) to come up with an explanation, using our evidence to support our explanation. And we don't have an explanation if we don't have evidence. Tim, that's the difference between science and a lot of other things. In science, we need to explain what we have evidence for. So, can you say from pulling this one trap that turtles don't like hot dogs? We're gathering data.

Child: No . . .

Instructor: Okay, okay. Right. So but we can think that, but we can't say that we are sure because we don't know, we have to see lots of turtles before we can say something. Ok, so we're going to use our evidence later, which is why it's important for us to write it down. (Aquatic Turtles Video 1, 6/16/2011, 06:30)

Participants also felt that scientists were not careless or sloppy with their work, with responses averaging 1.54 out of five points (1 = "Very strongly disagree") at the beginning of the program and 1.92 out of five points at the end of the program. Throughout the week, participants were encouraged to keep track of their data, to maintain equipment, and to make sure that what they shared with their peers was accurate:

Cathy: Do you guys remember how many traps we checked?

Salamander: I think we had 29. Not 28 because one we hadn't checked.

Cathy: We checked 29, not counting the one we already checked, and do you remember how many were metal?

Salamander: Two.

Tim: Three.

Cathy: Two. Or was it three? Let's check your numbers. You guys had really good data. I was impressed at how well you kept—

Salamander: I think it was three. (Coverboards Video 2, 6/17/2011, 02:14)

Participants developed a sense of ethics when working with the animals as well. They were particularly interested in taking care of the animals and making sure each organism's needs were met, providing one another with instructions about how to handle, care for, and house organisms. Table 11 provides examples of conversations between participants regarding handling of organisms, caring for organisms, and housing of organisms.

Table 11

Participant Conversations Audiorecorded during Fieldwork Regarding Animal Well-being—Herpetology

Handling animals	Caring for animals	Housing animals
Child 1: Can I hold him? Cathy: Are your hands wet? Another good tip is that amphibians like to keep their skin moist. So if you want to hold it, you should have wet hands too. Child 1 (to peer): Can you get my hands wet? Child 1 (to Cathy): Can you wet my hands to hold him? (Ethan Recorder, 6/13/2011, 02:00)	Kaitlyn: I want to take care of the tiny turtle. Instructor: Okay. Before I hand you this, a turtle has a mouth. What was the very first thing I told you? Kaitlyn: Anything that has a mouth can bite. Can I hold him? Can I take care of him? (Aquatic Turtles Video 2, 6/15/2011, 07:05) (Participants catch a sun fish in the aquatic turtle trap)	Instructor: When you release an animal under a coverboard, what do you do? Tim: You let the board down first and then you let it crawl in. Instructor: Completely down, then you let it crawl in. Good job. (Coverboards Video 1, 6/15/2011, 19:05) (Participants find a worm snake) Ethan: Can I keep it?

Table 11 (cont.)

Handling animals	Caring for animals	Housing animals
(Participants have found a worm snake). Alex: Can I hold? Can I see him? (walks up and takes a picture with camera) Instructor 1: (handing Tim the bagged snake) And here's your worm snake. Tim: Don't hold him too hard because you'll crush his ribs. His ribs are like all over the body. (Coverboards Video 1, 6/15/11, 05:00)	Tim: It's okay little fish. Child (off camera): Set him free! Set him free! Set him free! Instructor: How do turtles breathe? Rob: Through the nose and mouth. Tim (kneeling on ground): It's okay, little poor fishy. (Aquatic Turtles Video 2, 6/14/2011, 07:44)	Cathy: So that's a really good question. Should we keep it? Hayley: No. Cathy: Right, Hayley says no. Here's what we'll do. We'll keep it to share with the other group, but when we're all done we'll put it back. Dr. A: So we're not going to keep the snake but what are we going to keep? Kaitlyn: The data. (Coverboards Video 12, 6/13/2011, 01:36)

In multiple instances, participants showed their concern for proper treatment of the animals encountered in the field. They were able to instruct one another on how to handle animals and were able to ask for help to be properly prepared for handling animals. Participants in both Groups A and B showed obvious concern for animals caught in the traps, particularly the sun fish caught in aquatic turtle traps, and voiced their concerns over the fish being out of water for too long. Participants also came to understand the need to return animals to their natural habitats rather than keep them as pets, something many of the participants wanted to do at the onset of the program.

Bravery. A disposition identified by participants, but not initially by the researcher based on the literature review, was bravery. When asked what it took to be a good herpetologist, two of the three focus groups cited "bravery" as something necessary for success. When asked why they needed to be brave, participants said that bravery was needed for lifting coverboards because snakes might be underneath. Participants also noted that bravery was needed to go in the water and when pulling turtle traps, as biting turtles such as snapping turtles might be in the traps.

In the final focus group interview, one participant also mentioned bravery when explaining that he did not think he was brave enough to hold snakes, something a herpetologist needs to do. This fear was something that the participant was unable to overcome:

> Instructor: Mark, what would you change about this week?
>
> Mark: That we can't hold snakes.
>
> Instructor: That you can't hold snakes? Why do you think that you shouldn't be allowed to hold big snakes?
>
> Mark: Because they could bite you. (Focus Interview 1, 6/24/2011, 08:11)

Mark's discomfort with snakes was noticeable throughout the program; for example, when his group discussed coverboards and strategies for lifting coverboards safely, he suggested running away in case something "scary" was underneath. What is interesting, however, is that Mark was one of the two participants who were enrolled in the program because their father made them, but they also wanted to learn more about snakes.

Mark was not the only participant who expressed some discomfort with handling animals. Another participant, John, was also afraid to hold or touch animals for the first three days of the program:

> (Cathy is holding worm snake)
>
> Cathy (to John): Do you want to hold him?
>
> John: Ummmm (shakes his head no).
>
> Cathy: It's okay, You can just touch him if you want. Would you like to see what he feels like? (Coverboards Video 12, 6/13/2011, 6:06)

Although these two participants were hesitant to hold animals, by the end of the week they felt comfortable enough to assist in holding and collecting data on some animals. Mark voluntarily assisted in measuring a snake with a squeeze box, while John had no hesitation reaching into drift fence buckets to collect frogs. However, Mark would not touch a captured Black Rat snake because of its size, and John did not enjoy holding some of the turtles because the claws scratched him.

One recurring discomfort for all participants was not with reptiles and amphibians, but instead with ticks. Participants were particularly concerned about the ticks, constantly checking their bodies to make sure ticks were not on them. If ticks were found, they would ask for help from instructors in removing the ticks. Despite this concern, participants did not express any reservations about going into the woods:

> Ethan: The bad thing is the ticks.
>
> Instructor: The ticks? (laughs) I agree. But they're not too scary. They won't hurt you too much.

> Ethan: Well, I had one on my shoulder yesterday and it didn't hurt 'cause it wasn't set all the way on.
>
> Instructor: So now that you've had one if you get another one it won't be so bad. It didn't hurt you too much (Ethan Photo Elicitation Interview, 6/14/2011, 06:11)

Participants mentioned ticks in three of the 11 photo elicitation interviews as a concern. In addition, ticks were mentioned in every group at least once each day, for a minimum of nine tick references during the week. Not all participants' concern regarding ticks was negative; however, one participant explained during his photo elicitation interview that when he found ticks on him the day before, he removed them and looked at them under a microscope with the help of his father.

Overall, the dispositions encouraged in the *Herpetology* program (curiosity, collaboration, and ethics) were dispositions regularly recognized as valuable in science education literature. In addition, participants felt that bravery was also an essential disposition for herpetologists to possess. The following section reviews the scientific dispositions enabled for participants in the *Reptiles* program.

Reptiles.

Curiosity. Participants in the *Reptiles* program also expressed curiosity when learning about reptiles and amphibians. As with the *Herpetology* program, curiosity was observed in several forms as participants asked questions, handled organisms, and interacted with the environment around them. Participants in this program were witnessed inquiring at least 33 times during the week as they participated in activities; this equates to an average of at least one question asked per 20 minutes of the program.

Like the *Herpetology* program, *Reptiles* participants noted that good herpetologists knew a lot about animals and the environment. However, they did not directly reference asking questions or being curious as part of being a successful herpetologist. Although participants did not recognize curiosity as a skill needed to be a successful herpetologist, the nature of their questions and the number of questions they asked indicated a desire to learn more about the animals discussed during the week. Table 12 categorizes participant questions by their characteristics.

Table 12

Types/Characteristics of Questions Asked by Participants during Program Activities—Reptiles

Type/Characteristics	Question
Organism Specific: *n* = 23	• How do you know they're not good to eat? (racerunner lizard) • How do you know (the turtle shell came from a female)? • Don't they (Eastern Rat Snake) also eat insects though? • Do you think the snake could take on a skunk? • Is that a male or female (rosy boa)? • Why is he crumbled up (Florida King Snake)? • What is musking? • Has that snake (Southern Hognose) ever flipped over? • What are those things? (maggots) • How did the bones get here? • Are those smooth scales or keeled scales? • Do chicken turtles have hard eggs? • Why are they called chicken turtles? • How will it (alligator snapping turtle) bite you? • Is that a girl or a boy? (alligator snapping turtle) x2 • What is that pink thing? (snapping turtle's vermiform – a worm-shaped appendage used to attract prey- on tongue) • These are different sizes (bone pieces). How are they supposed to fit together? • Why would they do that (cut knees on cypress trees)? • How do they (cicadas) make that noise? • What is it (cicada) doing? • What is that? x2

Table 12 (cont.)

Type/Characteristics	Question
Sensory/Affective: *n* = 5	• Can we eat some (Spanish moss)? • Is this the right part (to eat)? • Can you help me? • Why didn't they want him (alligator snapping turtle) any more? • Why did you do that? (throw live anole in chicken coop)
General Information: *n* = 2	• What is a botanist? • Is there anything in there?
Other: *n* = 2	• Where are your pink shoes? • Can that snake hide in your beard?
Tool Use: *n* = 1	• Do I do it like that (use calipers)?

For participants in the *Reptiles* program, organism-specific questions were most popular, comprising 23 of the 33 questions (70%) recorded. Participants wanted to know factual information about animals, such as how to determine sex, details about animal behavior, and learning species identification. Participants were also interested in having the instructor prove the facts that he shared with the group, asking him several times "How do you know?"

Participants were also interested in sensory/affective experiences in the program. In one instance, a participant identified Spanish moss (*Tillandsia usneoides*) for her peers and taught them how to identify edible parts for consumption. As a result, several participants asked questions to make sure they were eating the correct pieces. Two events also impacted emotions; in the first, the instructor introduced participants to an alligator snapping turtle he had acquired from an aquarium that did not want to keep it on display. Participants wanted to know why an aquarium had needed to give away the alligator snapping turtle, viewing it as the aquarium's pet. The second question came when the instructor fed a live brown anole to the chickens on the nature preserve and a participant asked him how he could do that. Participants never asked to hold or pet the organisms, largely due to the fact that the instructor continually reiterated to participants that they would not hold animals, except under special conditions that the instructor specified.

Only one participant asked about tool use, wanting to make sure that he was using the calipers correctly to measure a turtle carapace. Given that tool use was not a focus in this program, it was not expected that participants would ask many questions about tools. Participants asked a few general questions; one student wanted to know what a botanist was and another asked if there were any alligators hiding in an overgrown area. Finally, one participant asked two different questions regarding the instructor's appearance, one question about the instructor's pink shoes and another question asking if a snake could hide in his beard after watching the snake curl around the instructor's face.

Participants in the *Reptiles* program also responded to the statement, "I think it's important for scientists to be curious" on their pre- and post-assessments. Initially, participant responses averaged 4.42 points out of five (5 = "Very strongly agree"). At the end of the program, participant responses averaged at four out of five points, showing a decrease in rankings of 0.42 points. However, the decrease was not statistically significant.

Overall, participants in the *Reptiles* program were eager to ask questions and felt curiosity was a valuable disposition for herpetologists to possess. The following section describes the reinforcement of independence during the *Reptiles* program, the second disposition witnessed in all activities during the week.

Independence. Unlike the *Herpetology* program, the *Reptiles* program infrequently encouraged collaboration among participants. Participants worked together in two different activities, first assembling turtle skeletons in small groups and then playing a terrapin board game in small groups. However, both of these group activities were designed as competitions, with the instructor challenging participants to see which group could assemble their skeleton the fastest and to see which group could beat other players in the terrapin board game.

Due to the nature of the program, which was structured around lecture and minimal group discussion, participants seldom had time to work together and collaborate with their peers. Table 13 displays the number of "we" and "I" conversations held by participants each day during all phases of the program.

Table 13

Frequency Count of "We" versus "I" Conversations—Reptiles

Day	1	2	3	4	5	Total
"We" conversations	0	2	1	1	1	5
"I" conversations	3	4	4	2	1	14

Participants in the *Reptiles* program had far fewer opportunities to engage in academic conversations with one another regarding herpetology. Only 19 total conversations occurring that focused on program activities and that did not use a basic question and answer format. Of these 19 conversations, only five (26%) used "we," such as when participants found organisms together or shared ideas. Instead, the majority of conversations, 74%, focused on individual accomplishments and findings, such as when one participant finds a piece of turtle shell on a hike:

> Child 1: Mr. George, **I** found a huge piece of a turtle shell.
>
> Child 2: **Don't** let anybody else touch it.
>
> Instructor: Whoa!
>
> Child 1: **I** found it!!
>
> Instructor: Ahhh . . . red eared slider. Guess who ate this? An alligator. Ahhh . . . that is beautiful. Look at the spine. Who found this?
>
> Child 1: **Me**! (Day 5 Video 4, 6/24/2011, 01:59)

The proportion of "we" to "I" conversations on each day was fairly consistent, with most days having one to two "we" conversations and two to four "I" conversations. On Day 2, when participants worked together to assemble their turtle skeletons, these proportions did not change, despite opportunities for group work. Instead, participants took on a divide and conquer attitude towards skeleton assembly, working independently at their tables rather than as a group:

> Cathy: How is it going?
>
> (Kids do not answer)
>
> Cathy: Wilmer, what part are you putting together?
>
> Wilmer: The plastron.
>
> Cathy: What about you two?
>
> Kevin: The carapace.

Ben: The head.

Cathy: So, you are doing the head and you are doing the carapace? What pieces are you looking for?

Kevin: This is hard. (Day 2 PM Video 7, 6/21/2011, 01:48)

The instructor of the *Reptiles* program regularly talked about his accomplishments as a herpetologist, using "I" conversations to share personal achievements. However, it is important to note that while the *Herpetology* program involved multiple instructors, whom participants saw working together, the *Reptiles* program instructor was largely on his own, with some assistance from his daughter and two younger former students. This limited opportunities for participants to hear about collaboration between the instructor and his colleagues.

Despite the fact that participants worked on academic tasks independently, they made use of all available free times (during hikes, independent work time when they were to read, color, and do puzzles, and during transition times) to converse with peers about nonacademic topics. Participants talked during snacks, lunch, and arts and crafts time, but again, these conversations were nonacademic in nature. While participants did not indicate that collaboration was a skill necessary to be a successful herpetologist, they did note that it was important to have fun as a herpetologist and that they had fun talking with friends during the week. Participants' initial responses to the statement "Sometimes scientists work together" averaged 4.5 out of five points (5 = "Very strongly agree"). At the end of the program participant responses averaged at four points, showing a decrease of 0.5 points.

The *Reptiles* program, overall, encouraged participants to be independent, rather than collaborate with their peers. The following section addresses ethics and their importance to participants in the *Reptiles* program.

Ethics. As part of their pre- and post-assessment, participants answered three Likert-scaled survey questions related to ethics. Table 14 shows the questions as well as participant responses at the onset and culmination of the program.

Table 14

Participant Rankings on Ethics Questions—Reptiles

Question	Pre-Score *M* (*N* = 12)	*SD*	Post-Score *M* (*N* = 12)	*SD*	Significance Level
1. Sometimes scientists hide their work from others.	2.58	1.44	2.58	1.08	1.00
2. Scientists have to be honest when they work.	4.08	1.16	4.12	1.03	0.34
3. Sometimes scientists are careless (sloppy) when they work.	2.5	1.09	2.75	1.14	0.61

In the *Reptiles* program participant perceptions of scientists hiding their work from others were unchanged from the beginning to end of the program, with participant responses averaging 2.58 out of five points both times (5 = “Very strongly agree”). Participant ratings showed no significant changes for the question “Scientists have to be honest when they work,” where initial ratings averaged 4.08 out of five points and final ratings averaged 4.12 (5 = “Very strongly agree”). Participants also showed no significant differences in their ratings for the question “Sometimes scientists are careless (sloppy) when the work,” with ratings averaging 2.5 out of five points at the beginning of the program and 2.75 out of five points at the end of the program (5 = “Very strongly agree”).

Because participants did not have opportunities to collect data, to do fieldwork, or to collaborate with one another in collecting data, ethical considerations were not of concern regarding these topics. One would not expect significant changes in their ratings on these questions, as the participants had no experiences during the program upon which to judge their answers. However, like the participants in the *Herpetology* program, participants had very strong ethical feelings when it came to caring for organisms in the classroom and out on the hikes. Table 15 provides examples of participant conversations regarding handling animals and caring for animals. Participants did not regularly capture organisms during the program; therefore, ethical concerns regarding housing animals were not a topic of discussion during the week.

Table 15

Participant Conversations Audiorecorded during Program Activities Regarding Animal Well-being—Reptiles

Handling animals	Caring for animals
(Isla throws a live anole into the shrubs) Helen: Don’t step on it! Back away! Assistant: Nope. Nope. Don’t follow her. We don’t want anyone to step on him. Helen: You dropped it.	(Instructor feeds live anole to chickens) Kid: Whoa! That’s chicken tenders for the chicken. (Helen is crying) Instructor: Get used to it. It’s life. Did they eat it? Kid: Not yet.

Table 15 (cont.)

Handling animals	Caring for animals
Cathy: It's going to be alright. Helen. She threw him! Isla: I am sorry. Helen (glaring): You threw him. (Day 3 AM Video 10, 6/22/2011, 01:00)	Instructor: We are getting rid of them. Kid: He took off its tail. Instructor: It will entertain them all day long. Helen: Why did you do that? Instructor: Chickens catch them all the time when they go in there. Helen: You are cruel! (Day 4 AM Video 4, 6/23/2011, 00:41)
Instructor: When you hold a snake you make a bookshelf. Hold your arms like this (models for kids). Give the animal a lot of support for his body. Use your fingers like tree limbs. Lots of support. You don't hold him hanging. If the snake bites you do not drop it. Take the bite. (Sarah holds snake easily, with arms exactly as directed) Cathy: You look like a pro! Have you ever held a snake before, Sarah? Sarah: Yeah (nodding her head). (Day 2 AM Video 1, 6/21/2011, 01:43)	(Instructor sharing about non-native species) Instructor: Now, some people say kill it and go through and kill every brown anole. It doesn't matter. If I kill one it is not going to kill the other 10 million. You know trying to get rid of the brown anoles, killing one is not going to do anything. So I just let them go. It is like going down to the ocean and pouring a cup of water in to see if it will raise the water level. It is not going to do anything. So I don't get any joy out of killing anything. So I just leave them alone. They are here to stay. (Day 4 AM Video 14, 6/23/2011, 03:51)

Although participants had fewer opportunities to handle animals during this program, several participants had clear expectations for the ethical treatment of animals, and felt dissonance when their peers or instructor did not reinforce their beliefs. One participant in particular, Helen, was outspoken throughout the week when it came to handling animals. After helping a peer catch an anole while the group was hiking, she was extremely upset to see the anole tossed aside by the girl and voiced her anger at Sarah for throwing the anole. Two days later, as the group was walking the trails, she voiced her anger when the instructor threw a live anole into the chicken coop without forewarning the children. She called him “cruel,” cried, and asked why he would do such a thing.

Although Helen was the only participant to vocalize her beliefs on handling animals, her actions did not go unnoticed by other participants. Seeing Helen’s concern for the anole thrown by her friend, Sarah, two other participants went to check on the anole and make sure it was okay. Three girls in the camp also comforted her when she cried about the anole thrown in the chicken coop and made sure that the instructor knew Helen was upset.

The instructor also recognized that his actions upset the participants, later sharing that he did not enjoy killing animals and that he would prefer to leave them alone. He was also an advocate for not handling the animals outdoors at all, encouraging participants to watch them and not harass the reptiles that they found on their walks. He also repeatedly reminded participants not to wear scented lotions, perfumes, or bug sprays that might cause distress to the reptiles and amphibians, and encouraged students to use proper handling procedures to ensure the safety of the organisms and the participants.

Overall, advocacy for ethical animal treatment during the *Reptiles* program was supported and recognized by some participants, but not mentioned by others. In particular, the female participants, especially the friends of Helen, the most outspoken participant, expected animals to be treated fairly and with care. Although the male participants did not voice their concerns regarding animal care, they also did not encourage inappropriate care of the animals and they followed all animal-handling procedures properly. It may be that because the program placed minimal emphasis on handling of live organisms it was not a topic regularly discussed among participants.

In addition to curiosity, independence, and ethics, the fourth disposition recognized in the *Reptiles* program was bravery. The following section addresses the disposition of bravery and its importance to participants in the *Reptiles* program.

Bravery

Like the participants in *Herpetology*, the participants in *Reptiles* also felt that bravery was an important disposition for herpetologists to possess. Two of the three focus groups noted that bravery was essential, because herpetologists may encounter alligators, snapping turtles, and venomous snakes. These perceptions of danger in dealing with reptiles might have stemmed largely from lectures during the week, where the instructor regularly warned participants of the inherent danger in looking for reptiles and amphibians:

> Instructor: Whoever finds it first . . . Do NOT go in these bushes, there are six-foot rattlesnakes! I know I keep harping but I do not want to deal with someone being hurt! It’s not that I don’t want to deal with it, I just don’t want anyone to get hurt. (Day 2 AM Video 3, 6/21/2011, 04:40)

Table 16 below notes the number of references to danger used by the instructor each day while outdoors, where participants may have encountered animals. The dangers included venomous species, disease, bites, poisonous and thorned plants, and alligators.

Table 16

Frequency Count of References to Danger Used Outdoors—Reptiles

Day:	**1**	**2**	**3**	**4**	**5**
References	8	4	4	3	8

The instructor made the most references to danger on the first and last days of the program, which was expected, given the nature of the activities on both days. On the first day of the program the instructor set up his expectations for the week, sharing his rules and rationale for the rules, which included keeping everyone safe. In addition, because it was the first day that participants would hike in the program, the instructor reiterated several times that participants must remain on the path due to danger lurking off the path.

On Days 2 through 4, the instructor was consistent in the number of warnings he gave on each 1.5 hour hike, reminding participants to watch their footing and to be careful of what they picked up. On the final day the instructor warned participants eight times of danger while on the hike. Although this was double the number of warnings in previous days it was proportionally consistent, as participants spent three hours outdoors on Day 5 instead of 1.5 hours. Overall, participants were warned, on average, every twenty minutes to be cautious while outdoors.

Constant reminders to be careful did not go unnoticed by participants; in particular, many of the female participants in the *Reptiles* program showed clear anxiety when hiking with the group. In one instance, for example, the group had to walk through an area with high grasses and thorns. When two girls were asked if they were okay (both were crying), one noted that she was scared of being “eaten by snakes.” As the group hiked, participants regularly kept watch for snakes, alligators, and poison ivy along the trails.

Overall, bravery was an important aspect of herpetology to the participants in the program. Participants felt bravery was important for success as a herpetologist, perhaps due to the stories they heard from the instructor about dangerous reptiles on the premises.

Comparisons between programs. Participants in both the *Herpetology* and *Reptiles* programs exhibited curiosity. Participants in both groups were eager to ask questions, particularly to learn to identify organisms and recognize specific physical characteristics of animals. Participants were interested in exploring outdoors in both programs and learning more about wildlife found in their geographic locations.

However, there were also some differences in markers for curiosity between the *Herpetology* and *Reptiles* programs. Because participants in the *Herpetology* program could handle animals, they asked far more often to hold, handle, and care for animals than did participants in the *Reptiles* program. Participants in the *Reptiles* program asked many more “How do you know” questions of the instructor, as if to test his knowledge. Participants in the *Herpetology* program identified curiosity as important for success as a herpetologist, while participants in the *Reptiles* program did not.

The *Herpetology* and *Reptiles* programs promoted different values for collaboration among scientists. Participants in the *Herpetology* program identified collaboration as another important disposition for herpetologists to possess, a disposition that along with curiosity is recognized in the literature as valuable for learning (Carr, 1999; Carr & Claxton, 2002). Participants in this program used “we” language, discussing themselves as a group and sharing their findings as a group, rather than one individual repeatedly boasting of his or her own accomplishments. The instructors in the *Herpetology* program were able to work together and encouraged participants to do the same. In the *Reptiles* program participants worked as individuals, even in small group settings. Although “we” language was used occasionally, the use of “I” language occurred much more frequently. These differences in language use were reinforced by the expectations of the instructor, which aligned with Carlone et al.’s (2011) findings in their study of two fourth-grade classrooms. However, there was only one instructor in this program who shared his work with participants, limiting their exposure to collaboration between herpetologists. Participants also did not have opportunities to collect data in the field, limiting their opportunities to collaborate.

Ethical behavior was another important disposition in both the *Herpetology* and *Reptiles* programs. Participants in both programs felt that scientists did not hide data from one another, that they were honest in their work, and that they were careful when working. In the *Herpetology* program, participants exhibited ethical behavior when collecting data, sharing their ideas and making sure to view data from multiple perspectives to give an accurate report. Participants were also ethical in how they handled, cared for, and housed animals, making sure to use proper handling procedures and to release animals at the end of each session. Similarly, participants in the *Reptiles* program also showed ethical behavior when working with animals with one participant leading the others in ensuring that all of the reptiles were handled with care and treated humanely. In both programs, instructors were sure to teach participants how to handle animals properly and how to tell when an animal was agitated or stressed from being handled too much.

The fourth disposition, and one that emerged from this setting, was bravery. Participants in both programs articulated the need to be brave, particularly when handling reptiles and amphibians and working in new and unfamiliar environments. Snakes were a species of special interest in both groups; participants thought herpetologists had to be brave in case they found a snake. These findings were consistent with previous research that suggests that children have misinformed anxiety regarding these reptiles (Cardak, 2009, LoBue & DeLoache, 2011). In addition, participants in the *Herpetology* program were concerned about ticks, while participants in the *Reptiles* program worried about alligators and thorns.

The following section reviews normative scientific practices identified as valuable in the *Herpetology* and *Reptiles* programs. The scientific practices are identified and described, and relevant supporting examples are provided. This section is then followed by a description of how program structure impacted participants' experiences and their perceptions of herpetology.

Research Question 2

What were the ways in which elementary students engaged in scientific practices, in two different one-week long herpetology programs?

Normative Scientific Practices

Participants were able to experience a variety of scientific practices while enrolled in the *Herpetology* and *Reptiles* programs. The instructors in both programs reinforced these scientific practices, providing both explicit instructions on and modeling scientific practices for participants. The reinforcement of specific practices within each herpetology program was consistent with Cobb et al.'s (2001) assertion that practices within a community are impacted by both the expectations of the individuals themselves and the group as a whole. The scientific practices that are recognized in the following section were noted because of their repeated reinforcement in the programs, because they were key goals of each program as determined by instructors, and because participants identified them as important indicators for being a successful herpetologist.

Herpetology.

Data collection (scientific practice #1). Throughout the *Herpetology* program participants enacted a variety of scientific practices, many of which were reinforced by the instructors running the different program activities. The practices in which participants engaged included data collection, use of scientific language, use of tools, and use of evidence to support their findings. As participants engaged in these activities, reinforced by instructors, they began to use scientific practices without reminders from program staff.

Scientific data collection was an expected practice for participants in the *Herpetology* program. Participants received a science journal on the first day of their program that was used for the week. The science journal included data sheets for each of the field activities, as well as extra lined paper and graphing paper for data collection. Participants were encouraged to use their science journals regularly by program instructors. For example, on the first day of the summer program, participants were reminded twice in the coverboards group and once in the vernal pool group to record data in their science journals. Instructors provided clear directions and rationales for participants to collect and record their data in science journals:

> Instructor 1: So we're not going to keep the animal but we are going to keep the data.
>
> Instructor 2: I'm going to give each of you a journal with your name on it, and there's a pocket and there's some plain white paper. You're going to write down the length when you get it, and draw a picture of him. I've got crayons. (6/13/11, Coverboards Video, 4:08)

In examining scientific journals from Day 1, participants demonstrated a wide variety of abilities in recording scientific data. The seven participants in the coverboard group (Group A) were asked to record the length of a worm snake found and to draw a simple picture of their worm snake. Every participant recorded the length accurately and labeled the name of the snake species correctly, however only one child drew a detailed, colored picture of the worm snake. One participant drew a line to represent the snake. One participant, although she did not draw a picture of the snake, wrote a description of what the snake looked like and how to use the squeeze box:

> To measure with the squeeze box, press between glass and pad and trace the snake with marker on glass than (sic) put string on marker than mesure (sic) string. Snake measures 6½ in. long. Underneath is tanish (sic) pink, top light grayish. (Student journal, page 1, 6/13/11)

The vernal pool group from Day 1 (Group B) was to record specific characteristics for the specimens that they caught in their minnow trap, including air temperature, water temperature, time, trap number, water depth, and names of species caught. Of the six participants, all recorded the air temperature, water temperature, time, and date correctly. Four participants (66%) correctly identified their trap number, three (43%) correctly recorded the water depth, and all seven correctly identified the organisms caught in their minnow traps.

In examining participant science journal entries from day one, participants had noticeable difficulty with recording more than two to three key data points required. While all of the participants (*N* = 12) were able to identify their species, many of the participants (54%) left out at least one data point that they were asked to collect on Day 1. Table 17 shows accuracy percentages for student data collection for Days 1-4, as well as percentages for the amount of qualitative and quantitative data collected. In addition, percentages for the number of participants who correctly recorded all qualitative data and all quantitative data are provided. Data were not collected on Day 5 because participants were presenting their findings in a mini-research conference.

On Day 2, participants in the vernal pool study (Group A) were asked to draw a map of the vernal pool and identify where their traps were and the species found in the traps. All six participants were able to draw the picture of the vernal pool and identify the location of their traps; one participant did not record the species found in his minnow trap. In addition, three of the six participants were able to collect data on their specimens, including measurement of length and width.

Table 17

Participant Data Collection—Herpetology

	Day 1 (N = 12)	**Day 2 (N = 12)**	**Day 3 (N = 7)**	**Day 4 (N = 11)**
% Qualitative Data	30%	31%	18%	56%
% Quantitative Data	70%	69%	82%	44%
Participants who collected all qualitative data points	23%	92%	67%	100%
Participants who collected all quantitative data points	31%	58%	100%	100%
% of participants who collected all required data points	46%	92%	67%	100%

Group B worked with aquatic turtles on Day 2, recording air and water temperature, time, water depth, turtle weight, turtle carapace length and width, and turtle plastron length and width. In addition, participants recorded species name and trap location in the lake. All six participants of Group B were able to correctly collect all quantitative data points, including turtle weight, plastron and carapace length and width, water depth, and temperatures. All six participants were able to identify the turtle species as well as the trap location for data collected.

On Day 3 only Group A collected data during their aquatic turtle study. Participants had eleven data points to collect, two of which were qualitative and nine that were quantitative. All of the participants collected the nine quantitative data points, including water and air temperature, water depth, and turtle measurements. All six participants recorded the name of the turtle specimens that they measured, and four of the six (67%) were able to record where the trap was located in the lake. Therefore, 67% of the participants collected all eleven data points for Day 3.

On the final day of journaling, Day 4, participants divided into research interest groups to complete vernal pool, aquatic turtle, and coverboard studies. Four participants elected to complete a vernal pool study. All four participants collected qualitative and quantitative data in their studies. Qualitative data included drawings of the vernal pool and species identification lists. Quantitative data included frequency counts for specimens found. All four participants recorded 100% of the data points for their study. Four participants elected to complete an aquatic turtle study. Qualitative data for their study included descriptions of trap locations and evidence of aquatic turtle feeding preferences. Quantitative data included mass of bait before and after the investigation. All four participants recorded 100% of the data points for their study. The final group of four participants collected data in a coverboards study. The data collected was entirely qualitative; participants kept an inventory of specimens found under wood and metal coverboards. All participants in this group collected data for the coverboards.

Overall, qualitative and quantitative data points remained proportionally consistent until the final day of data collection, when participants collected more qualitative data than on previous days. Participants' collection of qualitative and quantitative data points improved over the week, with 100% of participants collecting all qualitative and quantitative data points on Day 5, compared with only 46% of participants collecting all data points on Day 1. While some of this may be attributed to the fact that participants were in smaller groups, which allowed for more one-on-one interaction with instructors and program leaders, an increase in participant data collection is an important marker for the value of collecting data as a scientific practice within the *Herpetology* program. These findings aligned with those of Roth and Roychoudhury (1993), who found that when participants engaged in authentic inquiry, their abilities to develop questions, refine data collection techniques, and analyze their findings improved over time.

As participants collected data and learned about reptiles and amphibians, scientific vocabulary became a reinforced normative scientific practice in the *Herpetology* program. The following section describes the normative scientific practice of using scientific vocabulary and provides examples from the *Herpetology* program.

Scientific vocabulary (scientific practice #2). The use of scientific vocabulary was another important component of the *Herpetology* program. Participants were taught the correct terminology for organism anatomy, tools, and inquiry (devising a research question, collecting data, creating a hypothesis, and considering alternative explanations for participant findings). One instructor, the leader of the aquatic turtle studies, used the "rule of three," where participants had to use scientific vocabulary and provide three facts to back up their identification of specific turtle species caught in the aquatic turtle traps.

Instruction on terminology for organism anatomy was explicit in the aquatic turtles group; participants learned terms before interacting with organisms through drill and practice. In the vernal pool and coverboards groups, participants were introduced to vocabulary as they interacted with the species. Table 18 provides sample conversations from fieldwork regarding the introduction of scientific terminology.

Table 18

Comparison of Conversations during Fieldwork Regarding Scientific Terminology—Herpetology

Vernal Pool	Aquatic Turtles	Coverboards
(Participants are learning to use dichotomous key) Instructor: Number eight. All righty. Tim, can you take it at number eight? Tim: Dry, watery skin. Instructor: **Warty**. Tim: Warty. Instructor: **That means all those little bumps.** Tim: Or **moist** skin... Instructor: Dry warty, or moist? Dry, warty. He's a toad. Go to nine. Okay. Back to Salamander. You've got to be the defining person.	(Participants are studying turtle shells) Teacher: That's okay. Your other hand on the top of it like this. **Now the part of the shell that you're touching is the carapace. Say it**. Child: Carapace. Teacher: Carapace. Now if you lift your hand up and look, what letter does it look like? Child: C. Teacher: C. That's right. So that's how you remember the carapace, because it's on the top shell like that. **What is the name of that top shell?** Child: Carapace.	(Participants caught a toad) Instructor: So what do we know about toads? Erin: They're amphibians. (The toad pees on Alex, who hands it back to Jeff). Instructor: **What does it mean that they are amphibians**? Erin: They can be on water or on land. Jeff: Hey look! It's 10 times bigger than that one! (6/13/11, Coverboards Video, 4:35) --- (Participants find a Spring Peeper)

Table 18 (cont.)

Vernal Pool	Aquatic Turtles	Coverboards
Salamander: ‘Black spots’ . . . wait . . .’Black spots on the back contain only one or two warts . . . he’s an **American Toad**. Several, he’s a **Fowler’s Toad**.’ He’s a Fowler’s Toad. He’s got . . . most of the black dots have four or five. Instructor: Good! Very good! Salamander: I knew it was a Fowler’s Toad! Instructor: So, you used a **dichotomous key** to identify a Fowler’s Toad! (6/15/11, Coverboards Video, 22:40)	Teacher: Carapace. All right. Turn it over and look at the bottom. Some of you have a bottom and some of you don’t have a bottom. It’s flat, isn’t it? **It’s called the plastron. Say it**. Children: Plastron. Teacher: **Plastron. Okay, what’s the bottom, flat shell called?** Children: Plastron. (6/15/11, Aquatic Turtles Video, 12:00)	Instructor: So the other cool thing about him—look at his back, what shape does he have on his back? (Jeff and Collin get close to the baggie to look). Collin: An x? Instructor: He has an x on his back, so **that’s how you can identify that he’s a peeper**. (6/13/11, Coverboards 14 Video, 2:28)

Initial conversations that focused on the introduction of scientific vocabulary focused predominantly on learning about the anatomy and physical characteristics of organisms caught; on Day 1, for example, 52% of the total conversations (N = 21) about scientific vocabulary focused on these characteristics, while 38% focused on tools and tool use, and 10% focused on scientific inquiry.

At the midweek (Day 3), conversations about vocabulary (N = 19) were proportionally similar to Day 1, with 53% of vocabulary discussion focused on anatomy and physiology, 37% focused on tool use, and 10% focused on scientific inquiry. As the week progressed, however, the conversation shifted from learning the characteristics of the animals to learning the names of the tools and how to use them, as well as learning the characteristics of scientific inquiry: devising a research question, collecting data, creating a hypothesis, and considering alternative explanations for participant findings. On Day 5, none of the vocabulary conversations focused on anatomy or focused on tool use; 100% focused on inquiry strategies. This is largely due to the fact that Day 5 entailed research presentations by participants, where they had to explain their research questions, hypotheses, methodologies, and conclusions. Table 19 depicts the frequency of these conversations across Days 1, 3, and 5 to demonstrate this change.

Table 19

Frequency Count of Conversations during Fieldwork Regarding Scientific Vocabulary—Herpetology

Vocabulary Focus	Day 1	Day 3	Day 5
Anatomy	11	10	0
Tool Use	8	7	0
Inquiry	2	2	12
Total	**21**	**19**	**12**

When asked in post-program focus group interviews, participants also noted the value of understanding scientific language. In one instance, for example a participant stated, "to be a good herpetologist you have to know what '**width**' means. You have to know your animals and how to use a **field guide**." (Focus Group 1, 6/16/11). An understanding of scientific language, including terminology, knowing the names of tools, and being able to identify parts of an animal were named by participants in all three focus groups as markers of what it takes to be a good herpetologist.

Participants continued to develop their use of scientific vocabulary through the use of tools, a common activity during the *Herpetology* program. The following section describes tool use as a normative scientific practice during the *Herpetology* program.

Use of tools (scientific practice #3). For the herpetological educators running the *Herpetology* program, the use of tools for data collection was an important scientific practice. Participants were engaged in tool use throughout the program; Table 20 provides a list of tools used by participants in each field of study.

Table 20

Tools Used in Herpetology Fieldwork

Vernal Pool Study	Aquatic Turtles Study	Coverboards Study
• Journals	• Journals	• Snake hooks
• Minnow Traps	• Aquatic turtle traps	• Baggies
• Waders	• Bait	• Collection containers
• Boots	• Calipers	• Coverboards
• Dip nets	• Spring scales	• Drift fences
• Baggies	• Thermometer	• Rulers
• Collection containers	• Dichotomous Keys	• Squeeze Boxes
• Calipers	• Field Guides	• Dichotomous Keys
• Spring Scales		• Field Guides
• Thermometer		
• Dichotomous Keys		
• Field Guides		

Participants began the *Herpetology* program with little background knowledge of tool use; on a pretest where participants had to identify the names of tools and their purposes, the average score was 10.83 out of 18 points. By the end of the week, the average score was 15.83 out of 18 points on the tools assessment. Participants demonstrated an ability to identify each tool by name, as well as select the correct purpose for each tool's use.

Tool use was explicitly taught to participants; instructors walked participants through the steps to using each tool before allowing participants to try tools on their own:

> Instructor: We're going to use this. It's called a squeeze box. What do you think you do with it?
>
> Collin: You squeeze it?
>
> Instructor: How'd you get that idea Collin?! So we're going to stick the snake inside the squeeze box and press down . . .
>
> Ethan: That would hurt!
>
> Instructor: It won't hurt them. Feel it; it's nice and soft (Ethan feels the box).
>
> Ethan: But that plastic . . .
>
> Instructor: It's uncomfortable, but it doesn't hurt them. So we're going to stick the snake under here and one of you is going to hold the plastic down. Then one of you will trace the snake with the marker. You'll trace right down his back. (6/13/11, Coverboards Video 12, 03:45)

As described in Table 19, discussion about tools and tool use accounted for 38% of the conversations regarding scientific terminology on Day 1, 37% of the conversations on Day 3, and none of the conversations regarding scientific terminology on Day 5. Discussions on tool terminology greatly decreased through the week as a result of program structure; initially, the first three days of the summer program were spent teaching participants how to use tools and learn about animals in the field, while the remaining two days allowed participants to take what they had learned and apply it to a research area of their choice.

In the program, participants learned about more than simple terminology regarding tool use, they also learned about the purposes behind tools, the reason tools were used in data collection, and how to decide what tools to use and when. Conversations about tool use also changed as the week progressed. Initially, conversations focused primarily on what tools to use and how to use them. For example, on Day 2, the instructor of the aquatic turtles group was specific in explaining how to use calipers to participants:

> Instructor: This tool is called a caliper. Right. And the way you use a caliper is you put the tip on one end and then the other tip at the other end. And you read the measurement. Now, we don't need this big of a caliper so we do have a smaller set of calipers. This is a tool. (Aquatic Turtles Video 2, 6/14/11, 30:10)

As the week progressed, conversations shifted to suggestions for tools to use (for example, "Why don't you see if you can measure it with the calipers," and participant requests for particular tools. For example, on Day 3 a participant finds a worm snake and wants to measure the organism:

> Child: Did you just catch it with your hand?
>
> Seth: Yes.
>
> Instructor: Why do you think it's looping itself around your fingers like that?
>
> Seth: So I can't try to grab him and stuff. So I can't try and harm him. Do we have a bag or something? A squeeze box? (Coverboards 2 Video, 6/15/11, (03:10).

Table 21 demonstrates the nature of tool use conversations for instructors and participants during the five-day program. Conversations are examined by percent initiated by instructors versus participants. They are further divided into conversations focusing directly on how to use tools, conversations where participants explicitly ask for tools to use, and conversations about the purpose and the rationale for tool use.

Table 21

Nature of Tool Use Conversations (Frequency, Percentages) during Fieldwork—Herpetology

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Instructor-led conversation	12 (80%)	8 (73%)	8 (73%)	7 (64%)	4 (80%)
Participant-led conversation	3 (20%)	3 (27%)	3 (27%)	4 (36%)	1 (20%)
Reason for Conversations on Tool Use:					
Instruction on tool use	7 (47%)	7 (64%)	7 (64%)	3 (27%)	2 (40%)
Participant requests for tools to use	4 (26.5%)	0 (0%)	3 (27%)	5 (46%)	2 (40%)
Discussion on tool purposes	4 (26.5%)	4 (26%)	1 (9%)	3 (27%)	1 (20%)

On Day 1, 80% of conversations about tool use were instructor-initiated, with the remaining 20% of tool conversations being student-led. Forty-seven percent of the conversations on tool use were related to direct instruction on how to use the tools, with the remaining 53% of tool conversations divided evenly between conversations on the purposes behind tool use and participants’ requests to use tools. These statistics remained fairly constant through Days 2 and 3, with 73% of tool conversations led by instructors and 27% led by participants on both days. Day 2 and Day 3 also showed an increase in direct instruction on how to use tools, with 64% of conversations focusing on instructional techniques on both days.

Instructor-led conversations regarding tool use were again dominant on Day 4, as instructors helped participants develop their research questions and determine how they would collect data. However, participants had an increased role in leading tool use conversations, initiating 36% of the tool use conversations observed and recorded on Day 4, compared with only 27% on Day 3. Participants also made more frequent requests to use tools, with 46% of the conversations regarding tools focusing on participant requests to use equipment:

> Instructor: Do you want one (camera) that takes pictures or videos?
>
> Kaitlyn: Pictures.
>
> Mark: And video.
>
> Instructor: Okay Kaitlyn?
>
> Kaitlyn: What kind of problem did we find? Yeah, like, are there more kinds of frogs in this trap?
>
> Instructor: Okay, so you think you have a special place you want to put the traps when you do the science experiment?
>
> Mark: We want to make the traps in the middle of the pool, because more animals could be in the middle of the pool than on the sides.
>
> Instructor: Okay, so someone is going to have to set the traps. Maybe this question would work. What if I set both traps, and I set six in a big cluster right in the middle of the pool and I set six on the outside and we could say do you catch more animals with minnow traps in the middle or around the outside of the pool?
>
> Kaitlyn: We could put like three on each side.

> Mark: Or two on each side. Can we do it? (Vernal Pool Video 3, 6/16/2011, 02:30)

On the final day of the program there were a reduced number of both instructor-led conversations on tools (four out of 5; 80%) and participant-led conversations on tools (20%). Half of the program session was spent on research presentations, so participants did not engage in tool-use conversations during this time other than to briefly mention what type of traps were used to collect data. However, participants spent the second half of the session learning to use a radio telemetry unit to track box turtles. During this time the instructors led several conversations on how to use the unit (three of the instructor-led conversations), and participants led a conversation on using the unit to locate the box turtles. One conversation focused on the purpose behind the unit, two focused on how to read the screens on the unit and use the antennae, and the fourth conversation focused on a participant offering to read the screen and listen for the frequencies. The final participant-led conversation occurred when a camp counselor shared captive animals with the participants and Salamander offered to look up the animal and identify it in her field guide.

Overall, instructors led most conversations on tool use, which is not unexpected given the introductory nature of the program to learn about tool use. Instances of participants volunteering to use tools or requesting to use tools were sporadic; however, participants asked to use tools almost every day of the program. The majority of tool-use conversations focused on instructions for using the tools, which again fits with the intent of the *Herpetology* program to introduce novices to fieldwork and tool use techniques.

Interestingly, there was no difference between males' and female participants' requests for tools. Both males and females shared tools fairly well, used "we" language, and were not aggressive when it came to sharing tools with peers. These results were unlike those found by Jones et al. (2000) when studying elementary participants' use of tools in a classroom-based setting.

Data collection, scientific vocabulary, and tool use were essential practices in the *Herpetology* program for helping participants with the fourth normative scientific practice, using evidence to support ideas. The following section on normative scientific practices focuses on the need to use evidence to support ideas.

Use of evidence to support ideas (scientific practice #4). The fourth practice in which participants of the *Herpetology* program engaged was to use evidence to support their ideas. One of the instructor stated to a child, "You feel it in your heart, right? Scientists can feel things in their hearts, but they can only report what they see" (Aquatic Turtles Video 3, 6/15/11, 01:03). Participants were required to provide evidence to support their identifications of reptile and amphibian species, to demonstrate their content knowledge, and to support their findings in their research projects. Table 22 provides examples from the three different activities that demonstrate the need to use evidence to support one's findings.

Table 22

Participant Use of Evidence during Fieldwork—Herpetology

Vernal Pool Study	Aquatic Turtles Study	Coverboards Study
Instructor: And **what other clues did you have**, Alex, that you were telling me? Alex: If the eye is red that means it's a boy, if it's a girl it's either orange or brown. Salamander: I'm pretty sure it's opposite. I'm pretty sure if it's red it's a girl. Instructor: **So we have some debate**. Does anyone in the vernal pool group remember what you heard about the eyes? Instructor 2: **Why don't you check your field guide**? (Group Share Video, 6/13/11, 04:26)	Instructor: All the turtles we're going to find live in water today. Why is a fish not a reptile? Child: Because . . . most . . . reptiles are . . . um . . . omnivores? Instructor: I don't know, so far I'm pretty convinced a fish is a reptile. **I have no evidence, from what you've told me, to prove otherwise.** (Aquatic Turtles Video 1, 6/14/11, 06:27) Instructor: Okay, there's one thing. So whenever we identify something, we have to say something about it that helps us identify it. And I have a three rule. So everybody put up three fingers. My rule is you can't tell me that something is anything **unless you can tell me three things about it that proves it's that thing** (Aquatic Turtles Video 1, 6/15/11, 00:07)	Child: We found a huge toad! Huge! Look at it! Look how big! Instructor: Good eyes, there. Okay, so what do we have out here? We've got two kinds of toads. What kinds of toads do we have? Child: Fowlers and Americans. Instructor: Okay. What do we have to do to figure out what one it is? **Use your key. Count your number** of . . . Child: He looks like an American. Instructor: You both agree? **How do you know?** (Coverboards Video 2, 6/15/11, 17:45)

Participants were expected to provide evidence to support their ideas every time that they identified an organism in the field, for the duration of the program. Often, they were encouraged to use the tools that they had to find supporting evidence, such as using a field guide or dichotomous key to help with species identification, using calipers, rulers, and spring scales to calculate measurements on the organisms, and they were also encouraged to use evidence to check their work and that of their colleagues:

> Instructor: Have you checked one another's work? Okay, that's good.
>
> Ethan: (Reading off paper) For the plastron length, I got 4.320.
>
> Alex: For the plastron length? Okay.
>
> Instructor: Is that what you got?
>
> Alex: (Checking paper) Yep.
>
> Ethan: (Reading off paper) For the plastron width, I got, 2.087.
>
> Alex: (Checking paper) Me too! (Scientific Language Video, 6/14/11, 00:24)

The normative scientific practices noted in the *Herpetology* program immersed participants in activities directly linked with the real-world application of herpetology; in the field, herpetologists must (a) collect data, (b) use tools, (c) use proper terminology, and (d) use evidence to support their ideas. These skills were repeatedly reinforced in participants throughout the week; enough so that participants themselves made reference to these four practices when describing what a herpetologist does and what it takes to be a successful herpetologist.

In the following section, the practices reinforced in the *Reptiles* program are identified and described. This is followed by a comparison of the different practices used in both programs.

Reptiles. Like the *Herpetology* program, *Reptiles* enabled opportunities for participants to engage in different scientific practices. The scientific practices for the *Reptiles* program were also identified based on their repeated use by the instructor and the instructor's repeated reinforcement of participant use, as well as participants' identification of these practices as important markers for being a successful herpetologist.

Show what you know (scientific practice #1). The main practice consistently reinforced by the instructor of the *Reptiles* program was for participants to "show what they know," or prove their competency by sharing scientific facts. The fixed curriculum program structure followed a consistent format each day, where the instructor would ask participants a question and participants would reply with a one or two word answer. The following is an example of the format followed throughout this summer program:

> Instructor: They are cold-blooded and because they have . . .
>
> Kid: Scales.
>
> Instructor: Scales. That's right. They are one of the groups of animals or reptiles that are very, very threatened. About 300 species in the world. Do you know how many species there are here?
>
> Multiple Kids: No.
>
> Instructor: You know there are over 2,500 different kinds of snakes. But turtles are a very small group of animals. They have been around for over 200 million

> years and they walked the Earth with dinosaurs. And in the world there are somewhere over 300 species. What does SP mean?
>
> Kids: Species.
>
> Instructor: What does species mean?
>
> Kids: Different kinds.
>
> Instructor: Different kinds. Very good. And in the United States there are 50 . . . wait let's see they just discovered this. 55 species and here . . . Do you know how many? (Reptiles Video 2, 6/21/11, 00:59)

When asked in focus groups what it meant to be a good herpetologist, each of the three focus groups indicated that knowing facts about reptiles was an important part of being a good herpetologist. Participants who had been through the program before knew the answers to the questions and would consistently raise their hands to respond; as one boy said, "This is my fourth time here. I just know it" (Day 2 Video 3, 6/21/11, 03:22). Table 23 displays the percentages of daily discussions in the program that followed the "show what you know" format.

Table 23

Percentage of "Show What You Know" Conversations during Program Activities—Reptiles

Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**
86% 12/14	83% 15/18	71% 5/7	79% 11/14	90% 9/10

Overall, conversations recorded between the instructor and participants followed the question and answer format, on average, 82% of the time. These conversations occurred both in the classroom, during whole group discussion, and outside during the nature hikes. Participants were not asked to share any information about amphibians; the geographic location of the program was too hot and dry for any amphibians to be seen at this time of year.

Observation (scientific practice #2). *Reptiles* also promoted the practice of observation, encouraging participants to watch and use aural observation for animals in the environment rather than handle or touch organisms. Each day, before participants left for a hike on the nature preserve grounds, the instructor would emphasize the need to watch and listen for animals rather than touch:

> If you guys want to see gopher tortoises you're going to have to be quieter than you were back there. Otherwise we're just taking a walk in the sun. If we're quieter we can see more. We need to be able to listen for the animals. They're walking around back in the brush. They can hear a lot better than we can and can hear all of us. Let's see what we can find. I'm sure we'll see one this week if we don't today. This is not like the zoo, where you're guaranteed to see animals. (Day 1 AM Video 6, 6/20/11, 13:55)

The instructor of the *Reptiles* program discouraged participants from handling reptiles for several reasons. In five instances, participants were told that they could not handle organisms because of all of the "poisons" and "potions" that they were wearing, such as bug spray and sunscreen. In another four instances, the instructor informs participants that they should try not to handle organisms outside because of concern of picking up and handling dangerous or venomous species.

Following procedures (scientific practice #3). Another common practice in the *Reptiles* program was following procedures. Following procedures was a crucial step to participation in the activities implemented throughout the week in the *Reptiles* program, which was situated in a classroom context. Participants were reminded frequently to follow procedures. Following procedures served as an important strategy for providing participants with scientific and factual information; when participants were told to follow procedures, they were provided scientific explanations for why they should do so. In the example below, scientific information is highlighted in bold in the directions given to participants by the instructor:

> Zeke: Don't step right there!
>
> Instructor: Right where I said not to step is where you are standing. (Child 1 moves). Thank you. Please don't stand on the back of the burrow. Don't step on **the apron**. The mom might have **laid her nest** right there and you're standing on the eggs. The sand all of you are standing on is right where we never stand! You need to move (Child 2, Child 1, and others move) Thank you. **This is real thin right** here—I could stand here and crush it. The tortoises are most likely in their burrows right now because it's too what? (Kids: Hot). Right, hot. We need to come out when it's cooler. I would sit in my burrow and watch—**they sit right on the edge and we can see their head and shell**, but you have to pay attention. Let's go look.
>
> (Group begins walking again).
>
> Instructor: Watch where you put your legs. I've caught lots of rattlesnakes around here. Some of them were 6'3" and I'm only 6'1", so that gives you an idea of how big they are.
>
> (Group walks)
>
> Instructor: We'll go check that one down on the right and see if anything's in there. Don't run up to it too fast, but go look. (3 children, followed by others, go look) (Day 1 AM Video 7, 02:06).

Following procedures in the *Reptiles* program fell into three different purposes: protection of the animals, protection of the children, and participation in classroom-based activities. The instructor repeatedly would tell participants what to do and explain to them why he wanted them to do it. Table 24 shows the number of conversations focused on following procedures, as well as the purpose behind following the expected procedures:

Table 24

Frequency Count of Conversations on Following Procedures during Program Activities—Reptiles

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**
# focusing on classroom activities	3	7	7	5	1
# focusing on animal safety	2	1	1	3	1
# focusing on child safety	2	2	1	1	5
Total # of conversations	**7**	**10**	**9**	**9**	**7**

On the first day of the *Reptiles* program seven conversations between the instructor and children revolved around following procedures. Of these seven conversations, three focused on following procedures to complete group activities. Given that this was the first day of the program, an emphasis on classroom management and expectations was to be expected:

> Instructor: I’ve never lost anybody out there. I’ve had a few that I would like to have lost, but I’ve never lost anyone. But poison ivy, stinging nettles, cottonmouths, alligators, rattlesnakes, are out there and other things that are dangerous, or hazardous. So we have to stay on the trail and when I say single file we walk one, one, one, one, one. When I say single file that doesn’t mean why, that means Mr. G sees poison ivy or something I don’t want you to get into.

> Single file, one one one one. That doesn’t mean one one one wandering back and forth between the plants, that means single file down the middle of the trail. (Day 1 AM Video 1, 6/20/11, 03:33)

Two conversations focused on the safety of the participants; one of these conversations involved instructing children to stay on the path to avoid poison ivy, and the second focused on watching their footing to avoid rattlesnakes. Two conversations on following procedures focused on the need to protect animals in the park. One of these conversations instructed participants to get off the apron of the gopher tortoise burrow, or the thin shallow covering, to prevent the burrow from collapsing on the tortoise. The second conversation focused on the need for participants to refrain from wearing any topical sprays, perfumes, or lotions if they wanted to hold the snakes in order to protect the animals. Although most of these conversations were brief in nature, the first conversation with participants on expectations for the week took over forty minutes to complete.

On the second day of the *Reptiles* program, 10 of the conversations that took place between the instructor and the children focused on following procedures or directions. One conversation emphasized the need to follow procedures to protect the animals (in this instance, a Chuck-will’s-widow, a ground nesting bird), 20% (two out of 10) emphasized safety when working with animals (preventing a bite and washing hands), and 70% focused on following steps to complete classroom activities, which included learning to average a set of numbers and assembling a turtle shell.

Nine conversations witnessed on Day 3 of the *Reptiles* program emphasized following directions. One conversation emphasized procedures to maintain animal safety and one conversation emphasized procedures to maintain participant safety. As with the previous two days, the majority of these conversations (seven) focused on completion of classroom activities. Participants were frequently given explicit instructions on what to do and how to do it, such as when they found the mean of a data set:

> Instructor: Somebody tell me the mean. What do we have to do? We have to take this number here and do what? Nico.
>
> Nico: You got to take the whole number and divide it by how many samples there are.
>
> Instructor: How many samples? Very good! What was our sample size Ronald? Take a look at it. How many turtles did we measure Ronald?
>
> Ronald: (mumbles, cannot be heard).
>
> Instructor: No. Leah, how many turtles did we measure? Carrie?
>
> Carrie: Seven.
>
> Instructor. Seven. Seven turtles. Why did we divide by seven?
>
> Carrie: Because there are seven turtles that we measured.
>
> Instructor: Seven turtles to measure then we add them all up. So. Seven goes into 9. Shhhh…two times right? How many times does seven go into nine?
>
> Kid: One.
>
> Instructor: One. Bring down the seven and that is two. So I bring down the nine. Seven goes into nine how many times? (Day 3 AM Video 2, 6/22/11, 02:22)

Day 4 maintained the general pattern for conversations focusing on following procedures at the *Reptiles* program; nine total conversations focused on following procedures, with five of the nine conversations (56%) focusing on procedures to complete program activities. Conversations focusing on procedures for animal safety became more prevalent on Day 4, particularly after the instructor of the program dropped a Cuban tree frog on the floor where the participants were sitting:

> Cathy: Shhhh. Everybody. You have to think about it. If you move and that frog is on the ground . . . Isla. That is a lot of people walking around that could step on the frog. Let's all stay still. If he gets out Mr. George will catch him, okay. You don't want to step on him. Then we'll have a bigger mess than if he just peed on you. Then we would have to clean up frog guts. (Day 4 AM Video 9, 6/23/2011, 02:19)

On Day 5, the final day of the *Reptiles* program, child safety took precedence in conversations regarding following procedures, accounting for five of the seven (71%) total conversations. Only one conversation focused on classroom procedures, and only one focused on safety of animals. The conversations regarding participant safety took place on the three-hour, three-mile hike from one end of the nature preserve to the other, where participants were able to go off trail and hike with the instructor along the edge of the lake. The instructor repeatedly emphasized the need for caution, citing rattlesnakes, green briar, fire ants, and alligators as causes for concern:

> Instructor: When you cross trees that have fallen over in the woods, you need to be alert stepping over them. Who do you think loves to lay up against trees? Snakes. Every once in a while I see rattlesnakes right up against a log. They feel that security so they get against it and you step over it and it grabs you on the back of your legs. I can have an ambulance here in two or three minutes but you will be in the hospital for several days screaming in pain. You do not want to be bitten by a venomous snake. You don't have to be if you pay attention. I have got lots of friends missing fingertips and gnarled up hands, all that. Do I have any fingers messed up? I have handled hundreds and hundreds of rattlesnakes, cobras, and cottonmouths. I use a snake hook, I use tubes. Only fools do it the way crocodile hunter Steve Irwin did, grabbing things with their hands. You do not have to be bitten if you pay attention. So look where you are walking when you step over the log and when you approach the log. Step aside and watch where I step over the log. You are going to come through with me two at a time. Nothing

> is going to get you if you pay attention. So I am walking up to the log, this is the kind of place snakes like to lay. I am looking; I am listening for rattles and movement. I look over the log before I step over it. I hope you are listening. When you walk up to a log, look over the log before you step over it and then it is okay. Go slow, the little vines in here will grab you. Come on, go real slow watching the vines, the vines are green briars. They have got thorns on them. Hope y'all are listening. They will grab your legs and cut you. Pay attention and you will see them. Right here are some. These are green briars. See the weird shape. Cat's claw. Why do you think it is called cat's claw? They have sharp vines that will grab your legs and cut you. If you don't believe it you will be hurt. Pay attention, you should step on them not over them. Step on them. I am already bleeding. See my knee, I am pretty cut. I did that on purpose, I wanted to see what it would do. That's what it will do to you. (Day 5 Video 2, 6/24/2011, 03:10)

The sense of concern emphasized in the instructor's talks on the final day permeated the participants' time outdoors; participants were constantly reminded to stay with the group, to stay alert, and not to touch anything on the trails or near the trails. For some participants, the feeling of a sense of danger in walking on the trail was noticeable; two female participants cried when they had to go off the trail and step over a log and voiced their fears to the adults in the program:

> Cathy: How do you feel about going through here, Liza?
>
> Liza: Scared.
>
> Cathy: You're scared. Can you tell me what you're worried about?
>
> Liza: Being scratched by cat's claw and eaten by snakes.
>
> Cathy: I think it will be cool, though, if we make it through. Something to feel good about. What do you think, Hayley?
>
> Hayley: Scared.
>
> Cathy: You are scared too? Well, Ms. E is right in front of you and I am right behind you. We'll help you. Mr. G wouldn't take us anywhere he didn't think was safe.

> Instructor: Come on, if you want to be a herpetologist, keep moving. (Day 5 AM Video 3, 6/24/2011, 01:03)

The participants in the *Reptiles* program noted the need to be brave and identify animals as herpetologists; these perceptions were reiterated in end of program focus group interviews when participants were asked what it took to be a good herpetologist. Participants also noted that herpetologists needed to go on long hikes and watch for animals, both ideas that developed after the final hike during Day 5 activities.

The normative scientific practices promoted by the *Reptiles* program were (a) “show what you know,” (b) observation, and (c) following procedures. These normative practices were quite different from the normative scientific practices promoted in the *Herpetology* program as described above. The following section provides a comparison of the normative scientific practices enabled in each of the herpetology programs.

Comparisons between programs. Normative scientific practices in the *Herpetology* program included data collection, use of scientific language, tool use, and providing evidence to support one’s findings. Each of these practices aligns with historical normative scientific practices (Carlone et al., 2011; Chinn & Malhotra, 2002; Hsu & Roth, 2010; van Eijck & Roth, 2009). At the *Reptiles* program, participants engaged in practices including “show what you know,” observation, and following procedures. While observation is a valuable scientific practice (NRC, 2011), both following procedures and “showing what you know” are practices associated with narrow definitions of what it means to be scientific (Carlone et al., 2011). However, these practices were reinforced by the instructor and recognized by the members of the program, characteristics of normative practices (Carlone et al., 2011; Cobb et al., 2001).

The opportunities provided through each program gave participants very different perspectives on the field of herpetology and on the activities in which participants engage. Those involved in the *Herpetology* program took a more involved role in data collection, including opportunities to handle organisms and test their own research questions of interest. The need to collect data, use scientific vocabulary, and provide evidence to support their findings aligned with traditional views of authentic scientific practices. These participants had broader perceptions of what it meant to be a herpetologist than did participants in the *Reptiles* program, which allowed fewer opportunities to engage in scientific discussion and to collect data, and far fewer natural experiences holding captured animals. The program structures and their impact on participants' perceptions of herpetology will be explored in further detail in the findings for research question three.

Research Question 3

What was the relationship between the students' engagement in practices and the camp structures of each herpetology program and the knowledge, skills, and dispositions enabled in each program?

The final research question addressed how program structure affected the knowledge, skills, dispositions, and practices enabled for participants in each program. Participants were interviewed in focus groups at the beginning and end of each program to determine what they thought were the knowledge, skills, and dispositions necessary to work in herpetology and what were the practices of a herpetologist. Another purpose of the pre- and post-focus group interview was to assess how well participants felt their experiences aligned with their views of herpetology. Photo elicitation interviews also allowed an opportunity to examine what meanings participants made of their experiences, what made them feel like scientists, and to what extent participants felt their experiences were authentic science experiences.

Herpetology

Participants were asked in their initial focus group sessions, prior to the program, to describe what a herpetologist does. Although 10 of the 12 participants in the two focus groups noted that herpetologists studied reptiles and amphibians, only one participant was able to provide an example of what a herpetologist might study, sharing that herpetologists might track animals to see where they went.

In the three focus group interviews at the end of the *Herpetology* program, participants were asked again to "describe what a herpetologist does." Participants identified several factors that described the role of a herpetologist. All three groups described herpetologists as people who collect animals, specifically reptiles and amphibians, and collect data on animals, including measurements of size and weight. Two of the focus groups mentioned additional tool use practices of herpetologists, including setting traps, tracking and tagging species, and using tools such as dip nets. Participants also noted that herpetologists get dirty and wade in the water, that they do not always catch organisms, they make lists, charts, and take notes, and that herpetologists work together. Table 25 categorizes participant responses as they relate to scientific knowledge, skills, and dispositions.

Table 25

Characteristics of Herpetologists and Their Work from Post-Focus Group Interviews—Herpetology

Knowledge	Skills	Dispositions
• Smart (x2) • Know how to use tools (x2) • Can identify animals (x2) • Know terminology • Use knowledge from school	• Collect animals (x3) • See what they can find • Collect data on animals (x3) including size • Set traps (x2) • Tag/Track animals (x2) • Use tools (x2) including dip nets • Take notes • Make lists and charts	• Don't always catch "stuff" • Work together (x2) • Patience (Wait for animals to get in traps) • Focused • Curiosity (x2) (Ask questions, Want to know more about animals) • Bravery (Lift coverboards) • Adventurous (Wade in the water, Get dirty)

Participants were also asked, "What do you think it takes to be a good herpetologist?" Participants in two focus groups noted that herpetologists are smart and that herpetologists can use tools and identify animals. In addition, participants noted that herpetologists use knowledge from school and that they understand scientific terminology. The dispositions that participants identified included curiosity, which they described as asking questions and wanting to learn more about wildlife, as well as being collaborative. In two groups, participants shared that herpetologists must work together. Participants also identified characteristics including keeping focused, recognizing that one might not catch animals every time, and being patient while waiting for animals to enter traps. In addition, participants noted that herpetologists must be brave to lift coverboards (because they might find a snake) and adventurous to get into the water or get dirty.

Participants' descriptions of herpetologists and their work broadened greatly from the beginning of the program to the final focus group interview. In addition to recognizing that herpetologists did, in fact, track animals, participants were able to come up with seven additional skills that herpetologists use, described the knowledge needed to be a herpetologist, and identified their own list of dispositions necessary for work in herpetology. Characteristics that participants identified aligned with the practices promoted in the *Herpetology* program, including use of tools, data collection, and use of scientific vocabulary. The dispositions identified by participants included two anticipated before the program began (collaboration and curiosity), but multiple participants shared an additional disposition (bravery) not anticipated by the researcher before the program started. These findings are similar to those of Charney et al. (2007), who found that engagement in a summer science program that involved active participation in scientific activities enabled participants to broaden their own perceptions of what science is and what scientists do.

In order to determine to what extent participants defined their experience as authentic, they were asked in the final focus group interview whether the activities in which they participated reflected what they thought a herpetologist did and whether the activities involved what they thought it took to be a good herpetologist. Participants indicated several overlaps in their descriptions of herpetology and herpetologists and the activities completed in the *Herpetology* program. Participants in all three focus groups noted that they studied animals and used tools to collect data on the animals, something they thought real herpetologists also do. The participants were able to provide descriptions of when these events occurred, such as catching ABI, a yellow-bellied slider, in the lake and listing tools used throughout the week to collect data, including scales, rulers, calipers, thermometers, hand lenses, turtle and minnow traps, and hand lenses. Table 26 identifies areas where participants felt their program aligned with their perceptions of the field of herpetology.

Table 26

How Herpetology Participants Felt the Program Aligned with Their Perceptions of Herpetology—Post-Focus Group Interview

Knowledge	Skills	Dispositions
• Know how to use tools (x2) • Can identify animals (x2) • Made species lists	• Collect and study animals (x3) • Take notes • Use tools to understand animals (scales, rulers, calipers, spring scales, plastic bags, hand lenses, traps, coverboards, drift fences) • Collect data (x3) (measurements, identification lists) • Check and set traps	• Work together (x2) • Patience (Wait for animals to get in traps) • Curiosity (x2) (Ask questions, Want to know more about animals) • Bravery (Hold a snake) • Adventurous (Wade in the water, get dirty)

In determining how participants defined “being a scientist,” each was asked to participate in photograph elicitation interviews. Participants were provided cameras and instructed to take photos of things that made them feel like a scientist. Nineteen photographs were described and selected by the eleven participants who opted to complete photograph elicitation interviews. Participant responses from the interviews were categorized and coded for common themes across responses, which are displayed in Table 27.

Table 27

Photo Elicitation Interview Responses—Herpetology

Category	Frequency	Rationale
Organism: • Snake • Turtle • Frog • Salamander • Turtle eggs	9 • 2 • 3 • 1 • 2 • 1	• "We got to see the underside of the animal close up." • "It's exciting to find stuff. And a scientist finds stuff a lot." • "Because it shows how to identify the turtle." • "Because I knew stuff. The eye color. If you see the brown it's a girl; if it's red it's a boy." • "Because they're kinds of animals you don't see everyday." • "We sort of like looked at it and asked questions like why it did such and such."
Tool: • Camera • Turtle Trap/Nets • Spring Scale • Calipers	7 • 2 • 3 • 1 • 1	• "It shows me weighing the turtle in the bag with the Pesola scale." • "Because the camera helps you study or identify animals." • "Because to be a scientist sometimes you have to break down stuff about animals."
Environment	2	• "Because we were in the woods" • "There are a lot of things in the woods and that's where scientists find things."
Colleagues	1	• "Because we worked together like a team"

Working with animals emerged as a dominant theme in making participants feel like scientists, with nine of the nineteen photographs selected showing animals and participants handling animals. Tool use was also a dominant category, with seven photographs depicting participant use of tools and how tool use aided them in their investigations. Two participants also noted that being in the woods was an important part of making them feel like a scientist, and one identified working with a friend because they felt like part of a team. In addition to the nineteen photographs selected, two of the participants exclaimed that “everything” made them feel like a scientist during the week.

When comparing focus group data and photo elicitation interview data, participants demonstrated several common themes in describing the general field of herpetology and their own practices during the week. Participants explained in individual interviews that working with animals made them feel like scientists; this theme was reiterated in all three focus groups at the end of the program:

> Participant: I like the newts. Because when we went to the vernal pool I liked the newts.
>
> Instructor: I really liked the newts too! Of all the things you did yesterday, we caught turtles and fish, which one or anything really, what things yesterday made you feel most like the scientist?
>
> Participant: Snapping turtle!
>
> Instructor: Snapping turtle. I thought that was awesome. That was really cool.
>
> Participant: I had never seen one before. I thought that was really cool.
>
> Instructor: I had never seen one before especially one that big. Why did it make you feel like a scientist?
>
> Participant: Because it was big and we sort of like looked at it and asked questions why it did such and such . . .
>
> Instructor: And scientists ask lots of questions, don’t they? Okay, was there anything else you did yesterday that made you feel like a scientist?
>
> Participant: Ummm . . . recording the painted turtles.
>
> Instructor: When we did the data?
>
> Participant: Mmm huh.

> Instructor: Why did that make you feel like a scientist?
>
> Participant: Because to be a scientist sometimes you have to break down stuff about animals. (PEI Interview 1, 6/16/11, 13:48)

Tool use was the second theme in photo elicitation interviews and was also a recurring theme in focus group discussions. Participant rationales for why they selected certain photographs also reflected the knowledge, skills, and dispositions that participants felt were necessary to be a good herpetologist.

In examining the knowledge that participants felt was necessary to be a successful herpetologist, many used the expertise they developed during the program to describe the photographs selected. Four of the six participants who selected animal photographs used the expertise they gained through the program to explain how to identify animal species, pointing out descriptive evidence such as spots on the gouler plates and eye color to identify the turtles in the photographs as yellow-bellied sliders or box turtles. Participants used the terminology of herpetologists to identify and describe the tools used to collect data on specimens; for example, one participant explained, when sharing his picture of weighing a turtle, how a Pesola scale was used to calculate the mass of a turtle. He shared how the weight of the baggie was subtracted from the total weight, and pointed out that he also used calipers to collect measurements on the turtle's carapace.

In describing their photographs, participants also highlighted some of the key dispositions they identified in their focus group interviews, including being adventurous and curious. When asked about curiosity, participants explained that they learned a lot about the animals by observing them and asking questions, sharing that the species observed were “kinds of animals you don’t see everyday.” Two of the participants affiliated well with being adventurous, sharing that they enjoyed wading into the vernal pool and finding things in the woods. Finally, one of the participants emphasized the need for scientists to be collaborative, sharing that working with a friend made him feel the most like a scientist.

Reptiles

Participants were also asked in initial focus group sessions in the *Reptiles* program to describe what a herpetologist does. Similar to participants in the *Herpetology* program, participants knew that herpetologists studied reptiles and amphibians, but most could not provide an example of what a herpetologist might study using the organisms. Two male participants suggested that herpetologists would study venomous species to learn how to make anti-venom.

Participants were asked again to “describe what a herpetologist does” during end of program interviews. Participants identified several factors that described the role of a herpetologist. Two groups indicated that herpetologists know about snakes. Factual information was important in several groups; participants suggested that in addition to knowing about snakes, herpetologists could identify species, know about reptiles, and know about the environment. Participants also thought that herpetologists went on long hikes, looking for animals. Table 28 categorizes participant responses as they relate to scientific knowledge, skills, and dispositions.

Table 28

Characteristics of Herpetologists and Their Work from Post-Focus Group Interviews—Reptiles

Knowledge	Skills	Dispositions
• Know about snakes (x2) • Know about reptiles • Can identify species • Know about the environment	• Go on long hikes • Find uncommon species • Look at snakes • Look for wild animals	• Have fun • Brave (x2) • Can be out in the heat

Participant views of herpetologists and their work broadened slightly from the beginning to the end of the program. Initially, participants indicated that herpetologists knew about reptiles and amphibians; knowledge of reptiles was reiterated in the responses participants gave that related to scientific knowledge. Participants identified skills that they felt a successful herpetologist needed, including looking for animals and hiking. Dispositional characteristics that participants felt were necessary were having fun, being brave, and being able to withstand the heat.

Participant responses regarding the work of a herpetologist are directly related to the experiences they had during the week-long program. Participants learned solely about reptiles and the environment during the week; amphibians were discussed only incidentally, as specific invasive species, and therefore were not mentioned in end-of week interviews. Participants hiked every day looking for organisms, and the practice of observation was reiterated throughout the week as they were instructed to look for organisms on their hikes. These hikes occurred in very hot (95º F+), dry, summer conditions, which is a likely reason that one focus group brought up the need to withstand the heat. Given the nature of the program, where participants were repeatedly told to follow directions because of the threat of alligators and venomous snakes, bravery was mentioned by two of the three focus groups as a disposition necessary to be a herpetologist.

As with the *Herpetology* program, participants in the *Reptiles* program were asked in the final focus group interview whether the activities in which they participated reflected what they thought a herpetologist did and whether the activities involved what they thought it took to be a good herpetologist. Participants indicated some overlaps in their descriptions of herpetology and herpetologists and the activities completed in the *Reptiles* program. Participants felt that at the end of their program they knew about snakes, other reptiles, and the environment. Participants agreed that they went on long hikes, looked at snakes (participants specified that these snakes were captive), and that they looked for wild animals. The participants felt that they had fun. In addition, participants brought up events that would characterize herpetologists as resilient people; in one instance, a participant was upset at witnessing the instructor feed a live brown anole to chickens in a chicken coop, while laughing. Another participant did not enjoy examining an alligator's decomposing carcass on one of the nature walks, stating "I thought we were just going to look at snakes this week." Table 29 identifies areas where participants felt their program aligned with their perceptions of the field of herpetology.

Table 29

How Reptiles Participants Felt the Program Aligned With Their Perceptions of Herpetology—Post-Focus Group Interview

Knowledge	Skills	Dispositions
• Know about snakes (x2) • Know facts about reptiles • Know about the environment	• Go on long hikes • Look at snakes • Look for wild animals	• Have fun • Be resilient (Can be out in the heat) • Look at "gross" things

To determine how participants defined "being a scientist," each was also asked to participate in photo elicitation interviews. Participants in the *Reptiles* program were provided with cameras and instructed to take photos of things that made them feel like a scientist. Eleven photo elicitation interviews were conducted. In this program, the environment was the prominent theme, with seven photographs selected that showed the environment. Animals came in second, followed by "nothing" that made participants feel like scientists. Finally, tool use, scat, and nonrelated items each had one photograph. Participant responses from the interviews were categorized and coded for common themes across responses. The themes are displayed in Table 30.

When one examines the structure of the camp, the fact that environment was a dominant role is not surprising—participants spent the most time outdoors, rather than working with animals. Because the instructor was also an ecologist, much of his focus was spent on environmental factors that impacted herpetological health. Participants learned about habitat change, forest succession, using scat to study animal health, and the use of controlled burning to encourage forest growth.

Table 30

Photo Elicitation Interview Responses—Reptiles

Category	Frequency	Rationale
Environment: • Box turtle pen • Lake • Trees • Flowers	7 • 1 • 2 • 2 • 2	• "I felt like a scientist cleaning the box turtle pen because we had to hunt for turtles like a scientist would." • "I was able to correctly identify a soft shell turtle there (the lake)." • "I was correctly able to identify the roots of the tree."
Organism: • Gopher tortoise shell • Captive snake • Dead mole	4 • 2 • 1 • 1	• "I didn't know you could study it (gopher tortoise shell) like this." • "I like this one (gopher tortoise shell) because it's cool and I never saw a turtle that came out of its shell and looked like this or that was white." • "I liked looking at the snake." • "I like studying dead things."
Other: • Nothing • Scat • Feather	4 • 2 • 1 • 1	• "Nothing made me feel like a scientist." • "I didn't know you could study gopher tortoise scat like this." • "It's pretty because of all the fluffy parts,"
Tool: • Camera	1	• "Using the camera to take pictures of things to study made me feel like a scientist."

Comparison between Programs

Participants' perceptions of authentic science and scientific practices were directly linked to the activities in each of the programs. While participants in both programs thought that their experiences were contextually authentic, each group had different indicators for what made the experience authentic. Participants in the

Herpetology program specifically examined reptiles and amphibians and their role in local ecosystems, while participants in the *Reptiles* program learned about herpetology in a broader form, as a type of ecology. In the *Herpetology* program, the focus on three different habitats (woods, vernal pools, and lakes) and the organisms in each of those environments afforded participants opportunities to learn in-depth information about each habitat and to interact with the animals in each habitat. Participants in the *Reptiles* program, through themed days, learned a great deal of general information about reptiles, amphibians, and the overall Florida hammocks ecosystem, but did not have opportunities for in-depth, extended investigation and exploration.

For the *Herpetology* program, authentic science involved fieldwork, collecting data, using tools, and working with others. For those in the *Reptiles* program, authentic experiences included seeing animals, learning about animals, knowing facts, and working independently. Both programs provided participants opportunities to explore the outdoors using trail-based experiences. Participants in the *Herpetology* program used trails to explore coverboards and drift fence transects, while participants in the *Reptiles* program used trails for their daily nature hikes. A comparison of these two experiences is provided in Figure 12.

Both programs enabled participants to spend time doing semi-structured activities as they walked along trails. Participants were able to interact with experts in the field and learn more about animals and the local environment through both programs. Participants were also able to witness animals in their natural habitats, as opposed to solely working with animals in artificial settings.

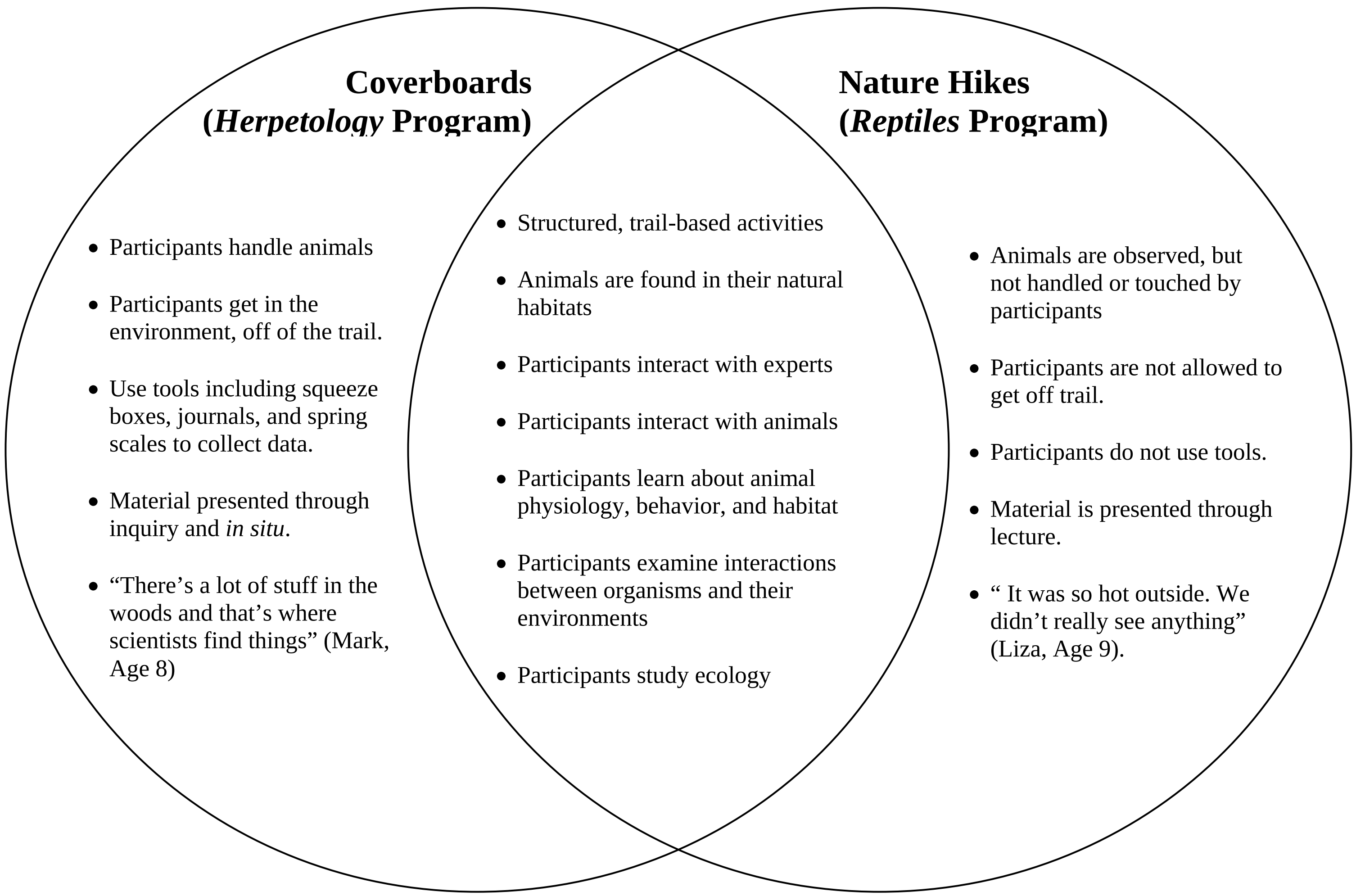


Figure 12. ***Venn Diagram Comparing Trail-based Activities in Each Program***

The differences in these activities impacted the meanings made by participants of their experiences in the outdoors. Participants in the *Herpetology* program were able to leave the trail and handle animals, while participants in the *Reptiles* program were expected to stay on the trail and solely observe, rather than touch. This difference was accounted for in the practices witnessed in each program, as participants in the *Herpetology* were encouraged to collect data and use their scientific process skills, while participants in *Reptiles* were expected to observe, follow procedures, and learn through watching. The fact that participants in the *Herpetology* program were expected to use tools and provide evidence to support their findings, while participants in the other group were not, also accounts for participant perceptions of what herpetology is (specifically, including the use of tools), for practices encouraged in each program (data collection and tool use in *Herpetology* and observation in *Reptiles*) and the practices in which participants were able to engage.

Participants in both programs were able to complete herpetological studies of wetlands. The *Herpetology* program included a focus on vernal pool studies that allowed participants to collect organisms in the vernal pool. Participants in the *Reptiles* program were able to observe alligators in their natural habitats from observation decks along the nature preserve. A comparison of wetlands activities for each program is provided in Figure 13.

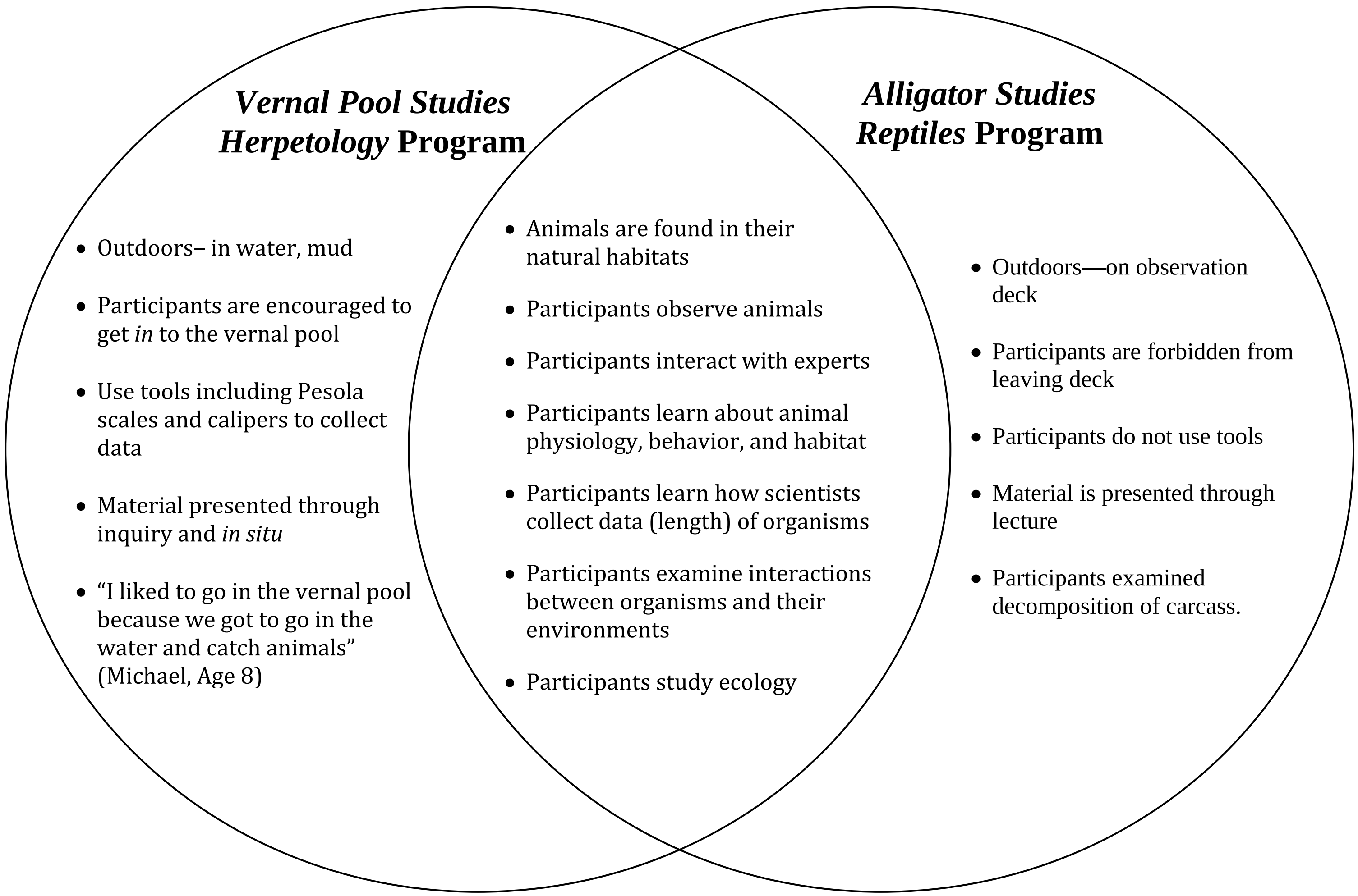


Figure 13. ***Venn Diagram Comparing Wetlands Activities in Each Program***

In both programs, wetlands-based activities allowed participants opportunities to observe organisms in their natural habitats. Similar to the trail-based activities, participants learned about animal physiology and behavior from local herpetological experts. Participants in the *Herpetology* program learned how scientists collect data on salamanders and newts using Pesola scales for mass and calipers for length, while participants in the *Reptiles* program learned how scientists estimated the length of an alligator by measuring the distance between the eyes (for example, an alligator with seven inches between the eyes is approximately seven feet long). Participants were able to learn about common reptiles and amphibians in their geographical area, rather than learn about animals they would be unlikely to encounter locally.

As with the trail-based activities, the differences between the wetlands-based activities in each camp helped shape participant perceptions of herpetology, defined the practices in which participants engaged, and impacted the knowledge, skills, and dispositions learned by participants. In the *Herpetology* program participants were encouraged to get into the vernal pool to collect organisms; in contrast, participants could not get into the water to observe alligators during *Reptiles* for obvious safety reasons. The *Herpetology* program enabled opportunities for tool use in the wetlands study as participants used Pesola scales and calipers to collect data on animals; both data collection and tool use were important practices by participants and experts in this program. For many participants, the ability to get into the vernal pool and explore impacted their scientific dispositions, encouraging their curiosity about the natural world.

As stated by Mark, one of the participants, “I liked to go in the vernal pool because we got to go in the water and catch animals” (Focus Group Interview 1, 6/17/11, 00:21).

The *Reptiles* program provided experiences focused on wetlands animals that were not seen in the *Herpetology* program. Participants were able to examine, in depth, the decomposing carcass of an alligator, allowing them to study interactions between organisms in the environment. Participants learned how scientists could estimate the length of an alligator without the use of tools, while remaining at a safe distance from the creature. These experiences engaged participants in observation, a dominant practice for the *Reptiles* program. Given the implicit danger in working with reptiles such as alligators, following procedures was another essential scientific practice in which participants needed to engage during the program.

Both summer programs also enabled opportunities for participants to engage in independent work. Participants in the *Herpetology* program had to devise their own research questions for the final two days of the program, collect data, and present their findings to their peers in a mini-research conference. Participants in the *Reptiles* program also had time to work independently as they flattened snake sheds, colored reptile and amphibian pictures or drawings, and read from herpetology field guides. Figure 14 provides a comparison of independent activities for participants in both the *Herpetology* and *Reptiles* programs.

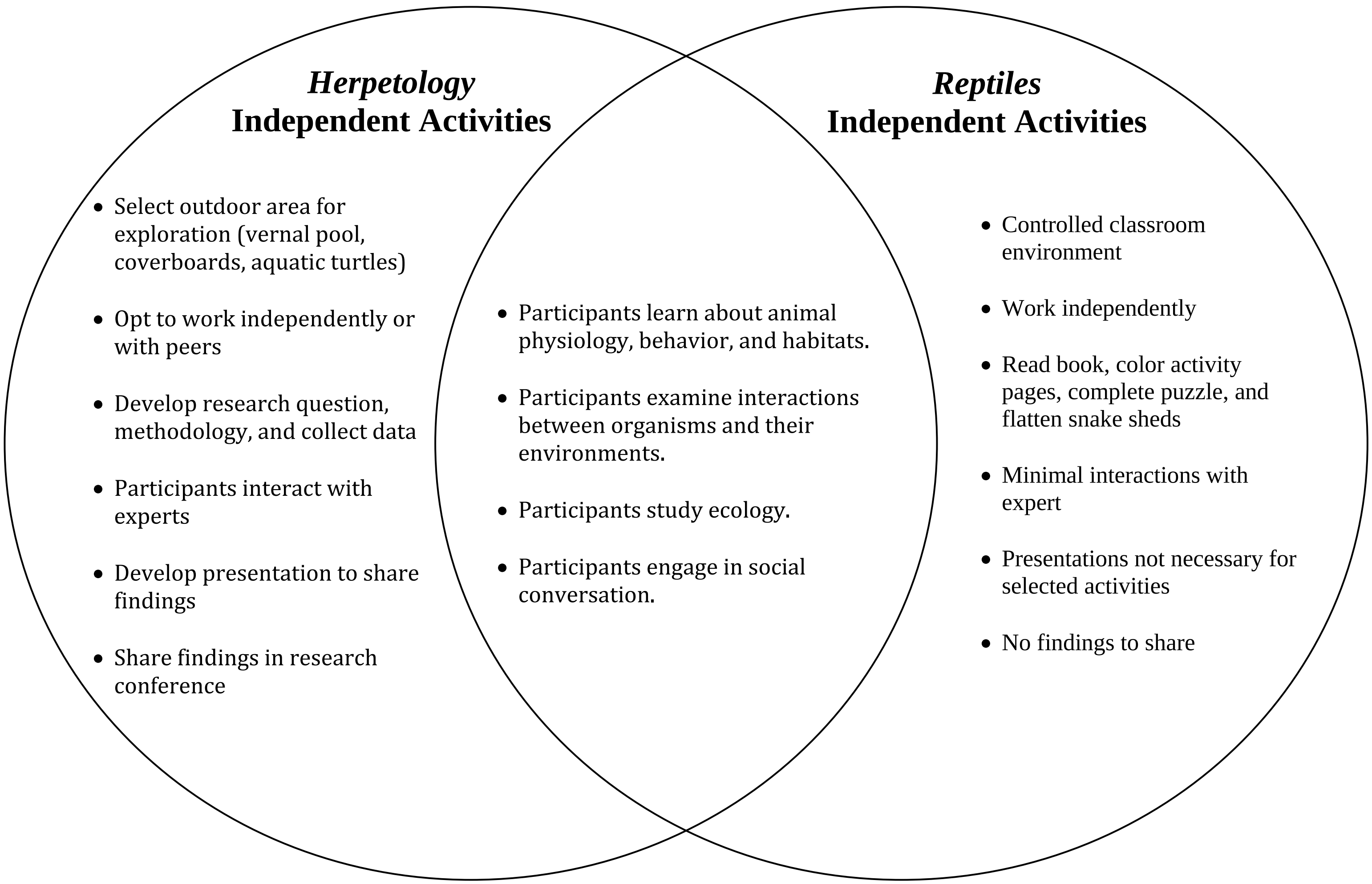


Figure 14. ***Venn Diagram Comparing Independent Activities in Each Program***

The independent activities in both programs provided opportunities for participants to learn about reptiles and amphibians through research. They also enabled participants to engage socially with their peers, something participants in both programs enjoyed. However, there were significant differences in what independent activities in both programs enabled for development of scientific knowledge, process skills, and scientific practices. Independent activities in the *Herpetology* program encouraged participants to use their scientific process skills as they developed research questions and collected data. They also had opportunities to collaborate in these activities if they preferred to do so. Participants were held accountable to their peers as they presented at a research conference. The *Herpetology* activities also encouraged participants to collect data, support their ideas with evidence, and work alongside experts as they completed their research.

In contrast, the independent activities in the *Reptiles* program were not designed so that participants were held accountable; instead, they were used as transitions as the instructor prepared the next activity for whole group instruction. Participants could engage in meaningful research using supporting texts provided by the instructor, but could instead also choose to color a picture or complete a puzzle. The instructor did not assist participants in these activities, limiting opportunities to interact with an expert.

In examining the practices of both programs, it is easy to link participant definitions directly to what they witnessed and enacted in each program. *Herpetology* participants used tools, collaboration, and handled animals all while in the field. The *Reptiles* program used classroom settings and structured hikes, and participants were allowed to hold only captive animals. Participants in the *Reptiles* program saw a limited variety of organisms outdoors—enough so that participants never reference any amphibians in describing the work of herpetologists. Tool use was viewed as a scientific practice in the *Herpetology* program, but as a scientific process skill in the *Reptiles* program due to the nature of the programs and the ways in which participants engaged with tools throughout each of the herpetology programs. In the *Herpetology* program, for example, participants were expected to know the names of the tools, their purpose, and how to use the tools. In contrast, the use of tools was not emphasized in the *Reptiles* program; instead, tools were merely a means to collect data. Children were not expected to know the name of the tools and were provided minimal opportunities to use them.

The skills and knowledge recognized as important by participants in the *Herpetology* program resulted from learning ***to be*** herpetologists. These participants learned about and participated in the types of activities that herpetologists do, such as collecting data and handling organisms in the wild. In contrast, the participants in the *Reptiles* program learned ***about*** herpetology, but never had the opportunity to experience some of the standard scientific practices of herpetologists. Due to these differences, the perceptions of herpetology that participants had in each program were quite different, which aligned with Carlone et al.'s (2011) findings in two elementary school classrooms. The normative scientific practices in which participants engaged impacted what they considered to be science, what they thought it took to be a good herpetologist, and what they considered as important when describing authentic herpetology.

Although participants in both programs felt that their experiences were authentic, those in the *Herpetology* program had a better opportunity to learn at the “elbows of experts” in an authentic setting about topics of their own interest, two key components of what makes science “contextually authentic.” In contrast, participants in the *Reptiles* program learned about fixed curriculum topics through listening and observing, rather than enacting. In examining the continuum of authentic science, the *Herpetology* program more closely aligned with the principles of contextually authentic science, whereas the *Reptiles* program more closely aligned with the principles of canonical science. Figure 15 depicts my perception of each program’s position along the continuum of science based on my analysis of the data from this study.

Figure 15. ***Program Placement on Continuum of Science***

The *Herpetology* program is positioned between canonical and contextually authentic science, but closer to contextually authentic science, for several reasons. First, the *Herpetology* program reinforced some of the key ideas found in canonical science, including the use of specialized knowledge to carry out scientific procedures (Chinn & Malhotra, 2002; Lee & Songer, 2003). Participants asked questions, planned investigations, and communicated their results. They shared data and critiqued their own research and that of their peers (Lee & Songer, 2003). Normative scientific practices including language use and use of equipment contributed to participants' feelings of authenticity, two important markers of canonical science noted by Hsu and Roth (2010).

However, the *Herpetology* program did not rely on canonical science principles alone. For two days, participants had opportunities to incorporate their own interests and perspectives into their research, an important component of youth-based science (Barton, 1998; Brickhouse, 2001). The informal setting of the *Herpetology* program enabled participants to engage in youth-focused science. Researchers encountered barriers when trying to implement youth-focused science in a more formal school-based setting (Braund & Reiss, 2006; Buxton, 2006). The program itself began with youths' interests in reptiles and amphibians, but was also sure to include normative scientific practices that were important in the herpetological world, including data collection, supporting findings with evidence, and collaborating. The scientific knowledge, skills, and dispositions shared also aligned with traditional perspectives on what participants need to succeed in herpetology, but also enabled participants to gain knowledge and skills through research on topics of their choice. This negotiation between traditional, canonical perspectives of science and youth-focused science aligns well with the principles of contextually authentic science (Buxton, 2006).

The *Reptiles* program more closely aligned with the principles of canonical science than contextually authentic or youth-based science. Throughout the program, participants were limited in their opportunities to engage in authentic herpetological practices such as tool use or data collection, because the instructor felt that these procedures were too complicated and advanced for young children, a canonical view of science (Chinn & Malhotra, 2002). As suggested by Lee and Songer (2003), the instructor of the program created simple activities to introduce participants to herpetology, largely because he felt that real-world herpetology required advanced content knowledge that was too difficult for young, inexperienced participants. These limited opportunities to actually engage in authentic practices impacted participants' perceptions of what herpetology was and limited their views of themselves as herpetologists, which aligns with van Eijck and Roth's (2009) findings regarding participation in a scientific community.

One aspect of the *Reptiles* program that aligned with contextually authentic science was the use of children's interests to allow them to gain scientific knowledge and expertise. All of the participants were highly interested in herpetology and the instructor attempted to draw on these interests to engage participants. Despite having limited opportunities to engage in scientific practices such as data collection and animal handling, participants were motivated to come to the program. Several participants were there for not their first time, but their second, third, and in one instance, fourth year in the program. These participants also felt that they were worthwhile members of the herpetological community in which they were involved, much like participants studied by Barab and Hay (2001) in a structurally similar program. However, participants were limited in their abilities to negotiate meanings within the program due to the format of activities (classroom based activities which included coloring, watching movies, and listening to lectures), which prevented this program from aligning more closely with contextually authentic science.

Summary of Findings

The *Herpetology* program and the *Reptiles* program engaged participants in a variety of activities related to herpetology. Participants in the *Herpetology* program worked in the field with herpetologists and herpetological educators to collect data on local reptiles and amphibian species, learning how to use scientific tools and conduct research. Participants in the *Reptiles* program learned about general characteristics of reptiles and the general ecology of the Florida hammocks ecosystem through nature walks and classroom-based activities. Participants in both programs greatly enjoyed their experiences and learned about reptiles and amphibians, but their learning was based largely on the structure of each program and the skills, dispositions, and normative scientific practices reinforced by the instructors and their peers.

Participants in both programs gained significant content knowledge regarding herpetology in their week-long programs. However, the *Herpetology* program provided more opportunities for participants at all academic levels to gain content knowledge that focused on an in-depth understanding of local reptiles and amphibians and their environment. The *Reptiles* program enabled some participants to gain significant content knowledge, but only reinforced what high-performing participants already knew.
The content knowledge gained in the program provided participants with a broad picture of herpetology as a form of ecology, rather than examining particular reptiles and amphibians in depth for extended periods of time.

Both the *Herpetology* and *Reptiles* programs enabled participants to develop their scientific process skills, skills necessary to engage in scientific practices. Acquisitive process skills were dominant in both programs as participants made observations and asked questions about reptiles and amphibians. Participants in the *Herpetology* program were witnessed using scientific process skills 255 times during the five-day period, while participants in the *Reptiles* program were witnessed using scientific process skills 91 times during the program. Participants in both programs had opportunities to use Manipulative process skills, but with different purposes. For the *Herpetology* program, participants were able to use tools for data collection and recording. For the *Reptiles* program, participants reconstructed turtle skeletons with their peers. Overall, the *Herpetology* program provided participants opportunities to use a broader range of process skills than the *Reptiles* program.

Curiosity, ethics, and bravery were all scientific dispositions reinforced by both programs. Participants in both groups were curious, asking many questions about the reptiles and amphibians found and discussed in the programs. Participants were eager in both programs to find animals in the environment. In addition to asking questions to learn about the organisms, participants in the *Herpetology* program were also interested in learning to handle and care for organisms, something not allowed in the other program.

Participants in both programs showed a sense of ethics when handling animals. Instructors taught proper handling procedures and exhibited concern for both animal and participant safety. Participants in both groups had clear beliefs on how animals should be handled and cared for. In addition, participants in the *Herpetology* program expressed concern over how to house the animals collected. In the *Reptiles* program, one participant was able to lead her peers in ensuring that animals were cared for, vocalizing her concerns about what she saw as the mistreatment of some of the reptiles caught during the week.

Participants in both programs felt the need to be brave, citing concerns about snakes and other organisms encountered in the field. The researcher did not consider this disposition as essential for herpetologists until participants in both programs mentioned bravery as necessary for success. The organisms that concerned participants varied based on geographic location; in North Carolina, participants were concerned about ticks and snakes, while participants in Florida were worried about briars, rattlesnakes, and alligators.

Both programs gave participants different opportunities to engage with one another in investigation. The *Herpetology* program encouraged collaboration among participants, who worked together to complete investigations, discussed and checked their findings with their peers, and used “we” language instead of focusing on individual accomplishments. In contrast, the *Reptiles* program encouraged independent work, did not provide opportunities for participants to collaborate with one another, and focused on individual accomplishments rather than examining whole group contributions.

The scientific practices enabled in both programs also differed. In the *Herpetology* program, scientific practices witnessed and reinforced included data collection, tool use, use of scientific terminology, and use of evidence to support ideas. At the *Reptiles* program, participants engaged in practices including “show what you know,” observation, and following procedures. Participants in both programs recognized the importance of these practices to each of their programs, identifying them as important practices for successful herpetologists.

The structure of each program impacted the knowledge, skills, dispositions, and practices enabled for participants. The *Herpetology* program took participants into the local environment and encouraged the handling of animals. Participants were expected to use tools and were held accountable for their work. In reflecting on their experiences, participants used these activities as markers for what a successful scientist does, sharing that handling animals, using tools, and being in the woods made them feel like a scientist. Participants also felt that their engagement in these activities aligned with what they expected herpetologists to do.

In the *Reptiles* program, participants were encouraged to observe, rather than touch. There were limited opportunities to engage in data collection and handle animals, and participants were not allowed off the trail and into the environment for exploration. However, the instructor shared a robust amount of scientific information regarding reptiles with the participants, something that participants felt was a marker of a successful herpetologist. Participants noted that successful herpetologists also look for animals and observe them in the environment, and felt that their experiences aligned with what they thought were the practices of a herpetologist.

The findings of this study have clear implications for researchers and educators alike. Chapter V discusses the limitations and implications of this study. Suggestions for how this research applies to teacher practices are also addressed.

CHAPTER V

IMPLICATIONS

In this chapter I first provide a summary of the findings and then discuss the implications of these findings for researchers and educators who are interested in providing authentic science learning opportunities for students. Then, the limitations of this study are acknowledged.

Summary of the Findings

This study examined the knowledge, skills, and dispositions enabled for elementary-aged participants in two summer herpetology programs. An additional purpose of this study was to examine the normative scientific practices in which participants engaged and to describe how these experiences differed across each of the herpetology programs. Finally, program structure was examined to determine how program activities impacted participants' perceptions of herpetology and authentic science.

The findings of this study clearly inform our understanding of the types of knowledge, skills, and dispositions gained by participants, as well as the types of normative scientific practices reinforced in two herpetology programs with very different structures. The findings also inform our understanding of how participants' perceptions of herpetology and authentic science are impacted by program structure. For example, this study found that although participants in both programs gained statistically significant increases in content knowledge, participants with more extensive background knowledge had more opportunities to further develop their knowledge in the program that more closely aligned with contextually authentic science.

Additionally, participants in the *Herpetology* program, which more closely aligned with contextually authentic science, were provided more opportunities to engage in scientific process skills than participants in the *Reptiles* program, which more closely resembled canonically-based science. Although process skills were used in both programs, participants in *Herpetology* experienced a greater variety of process skill opportunities, including process skills that emphasized higher order thinking strategies. Participants in both programs experienced growth in scientific dispositions, specifically curiosity, bravery, and ethics. However, the more contextually authentic program clearly reinforced the disposition of collaboration, whereas participants in the more canonical program instead were encouraged to be independent.

The structure of each program impacted the normative scientific practices emphasized in the *Herpetology* and *Reptiles* programs. In the contextually authentic-based program the normative scientific practices of data collection, use of scientific vocabulary, tool use, and using evidence to support ideas were reinforced. In the canonically-based program, “show what you know,” following procedures, and observation were identified as normative scientific practices. These practices, combined with program structure, directly impacted how participants viewed herpetology and how they described each program as authentic.

Participants in the *Herpetology* program used several indicators to describe herpetology and how their program aligned with herpetology. These indicators included understanding more about reptiles and amphibians, using tools, exploring in the woods, working with animals and collaborating with peers. Handling animals and using tools enabled participants to feel like scientists. In contrast, participants in the *Reptiles* program had fewer indicators to describe herpetology and how their programs aligned with herpetology. Participants in this program felt that herpetologists knew facts about snakes, went on long hikes, and were brave. They felt like scientists when they observed animals and explored in the environment.

The *Herpetology* program more closely aligned with contextually authentic science by using participants' interests to teach them about the knowledge, skills and dispositions necessary to complete fieldwork. Participants were able ***to be*** herpetologists, working alongside experts as they collected data and conducted research. The *Reptiles* program enabled participants to ***learn about*** herpetology rather than to be herpetologists, limiting their opportunities for fieldwork, for hands-on work with animals, for tool use, or for data collection. The evidence from this study indicated that the methodologies used and experiences provided in the *Herpetology* program offered participants experiences that not only built on their interests, but also engaged them in the practical and informative work of herpetologists in the field. In contrast, the *Reptiles* program enabled participants to gain scientific knowledge and hone dispositions, as well as develop some scientific process skills, but it also limited opportunities for participants to have a more realistic view of what herpetology is and what a herpetologist does. These findings have clear implications for both researchers and educators. In the following section, these implications are further discussed with recommendations for how both researchers and practitioners can best respond in light of the information gleaned from this study.

Implications for Researchers

The findings from this study suggest future areas of research on contextually authentic science and the scientific knowledge, skills, dispositions, and normative scientific practices enabled for elementary students. Researchers must examine more facets of participants' learning. What do participants know that cannot be measured in a pre- and post-assessment? What background knowledge did participants already have and how was it acquired? What experiences have participants already had using scientific process skills? Conducting individual interviews with participants regarding what they already know and have experienced would assist with a better understanding of all of the knowledge that participants possess. In addition, more research on the knowledge, skills, and dispositions gained by elementary aged participants in authentic science would add to the body of literature heavily populated by studies of high school and university participants.

There have been limited studies on normative scientific practices, particularly with elementary-aged children. Much more research must be done to determine what normative scientific practices are consistently reinforced for elementary-aged participants and in what ways. Future studies on normative scientific practices must also examine why individuals (both instructors and children) reinforce selected normative scientific practices and not others. Examination of both the ways that normative scientific practices are reinforced and reactions to these methods would provide a better understanding of the ways meanings are negotiated in scientific settings. In addition, more studies could be done to examine elementary school students' tool use; participants in the *Herpetology* program were successful with tool use. However, participants in the *Reptiles* program did not have similar opportunities for tool use because of concern that tool use was not an appropriate practice for young children.

Researchers would also benefit from examining the types of authentic science (canonical, youth-centered, and contextually authentic) and the ways that each is enacted in school. Both of these programs occurred in an informal setting; could something similar happen at an elementary school? If so, how do students and teachers negotiate the challenges and hurdles of implementing these kinds of programs in schools?

To summarize, there is still work to be done in understanding the ways that authentic science experiences enable participants' engagement in normative practices and their development of scientific knowledge, skills, and dispositions. This work may be well situated as a collaborative endeavor to be pursued with educators and practitioners who are interested in bringing authentic science experiences to their students. Examining authentic science through studies that enable educators to reflect on their practices and students' meaning-makings of these practices may result in a better understanding of more effective science teaching methods. More effective science teaching methods should result in increased student learning.

Implications for Educators

Undoubtedly, authentic instructional practices are important across all content areas. The findings from this study are of particular importance to both formal and informal science educators. The ways in which students are engaged in science directly impact the scientific knowledge, skills, and dispositions that they gain. In addition, the structure of science activities, and the ways in which scientific practices are reinforced, directly influence how students describe science, scientists, and their own abilities to do science. The findings of this study reveal that although participants may gain scientific knowledge, skills, and dispositions through engagement in authentic science activities, the extent to which each of these things happen and the ways in which students are challenged are directly impacted by what they are able to experience and do. In addition, the ways in which students experience and do science impact the normative scientific practices established within the learning setting and shape the meanings that students make of their experiences. Therefore, while educators continue to promote authentic science experiences for children, they must also take into consideration what meanings they want participants to make of these experiences and what types of knowledge, skills, and dispositions they want students to develop.

Educators may begin by intentionally considering the goals they have for student learning. Do they want students to have experiences that develop basic knowledge and basic process skills, or are they aiming for higher thinking skills and more advanced use of the process skills? What normative scientific practices will be recognized in their classrooms or learning settings? How do they want their students to describe their learning experiences and the fields of science that they are studying?

The findings of this study show that more canonically-based and more contextually authentic science experiences both enable the acquisition of scientific knowledge. In addition, both promote science process skills; however, contextually authentic science promoted more frequent use of science process skills, including advanced skills. While both promoted scientific dispositions, one program promoted working as an individual, while the other favored collaboration. Which of these experiences would teachers prefer? Is it context dependent? Should participants learn about science, or learn to be scientists, or both? One would suggest the use of more contextually authentic practices in elementary learning settings, due to the fact that they enabled more challenging opportunities for participants to learn and grow as student scientists. In addition, if an educational goal is to provide participants opportunities to learn about the nature of science and the processes of science, contextually authentic science may provide more leverage and room to develop these understandings than canonical science.

Tool use is another aspect of normative scientific practices for educators to consider. In one program, participants were provided with limited opportunities to use tools; the instructor stated that seven to eleven-year-old children were too young to use tools. Conversely, participants in the other program, of the same age, were able to use tools successfully to gather data. How often may teachers overlook similar opportunities because of concerns regarding students’ ages and abilities?

If we want our students to engage in meaningful science experiences, we must provide them opportunities to do so. Participants in each of these programs demonstrated their abilities to take on meaningful scientific work, including fieldwork, despite their novice understandings of science and young age. Participants were also able to pinpoint what made them feel like scientists and to identify the normative practices reinforced within each program – something that educators must consider when working with students of their own. Even the youngest participants realize what counts in their classroom and in their science experiences.

Limitations

The limitations of this study (two programs, each one-week in duration, and a small number of participants) reduce the ability to make generalizations. The narrow focus of each program on herpetology may limit the ability to generalize to other science programs. The fact that both programs were held in informal settings, with voluntary participation, impacts the ability to generalize to formal school settings where participation is expected. Finally, a small sample size limits the ability to generalize the findings to other elementary-aged children.

The duration of the program, one-week, limits how much information can be uncovered. Scientific dispositions, for example, are fostered over extended periods of time. Although participation in these programs enabled participants to hone their dispositions, the scientific dispositions witnessed by the researcher were undoubtedly influenced by other factors such as previous schooling and prior experiences. In addition, the use of a pre- and post-assessment limits our knowledge of what participants knew coming into the program and what experiences they already had with science.

The resources provided in each program also limit a comparison between programs. The *Herpetology* program had extensive resources, instructors and volunteers (nearly one adult per child). The instructors' formal training in elementary education impacted how material was presented to children, with a purposeful intent to expose them to scientific knowledge, skills, dispositions, and practices. The close relationship that the researcher had with the instructors and volunteers undoubtedly impacted some of the findings.

Conversely, the *Reptiles* program had only one instructor, three assistants, and thirty children. Funds for resources were very limited, which may have prevented participation in different activities. The instructor was formally trained as a biologist, not an educator, which also impacted how he presented material to the participants. Finally, having me come to visit his program, without knowing me at all, undoubtedly impacted how the Florida program was presented.

Because of these differences, one must be cautious to compare the programs. The instructors in each program worked to the best of their abilities to meet the needs of participants with available resources. The purpose of this study was to examine the experiences offered to participants in each program and to see what meanings participants made of those experiences, knowing that the factors described above would likely lead to quite different outcomes for the children participating in each program.

Conclusion

The structure of informal science programs directly influences participants' opportunities to gain scientific knowledge, skills, and dispositions, as well as their opportunities to participate in normative scientific practices. In addition, program structure directly impacts the meanings that participants make of their experiences and how they describe their work. If science educators are to respond to the needs of students and to challenge their students to engage in authentic science, they must take into consideration how they want their students to define authenticity in science. For example, the participants in the *Herpetology* program had a more encompassing description of what herpetology was and felt that their program aligned with herpetology more so than participants in the *Reptiles* program. Although participants in both programs felt that their experiences were authentic, the descriptions from the *Herpetology* program better aligned with the realities of practicing herpetology from what I know about the field.

For participants, engagement in normative scientific practices that reflect the goals of science is critical. Participants learn by doing, and are capable of scientific practices such as using tools, gathering data, and supporting their ideas with evidence. It is not enough to observe science; one must also be engaged in scientific practices in order to gain experience with advanced scientific process skills and to develop a better understanding of scientific content knowledge.

We now have a better understanding of authentic science and how program structure impacts the scientific knowledge, skills, and dispositions gained by participants, as well as the types of normative scientific practices with which participants identify and engage. We also have a better understanding of how program structure directly influences the meanings that participants make of their experiences and how they describe the authenticity of their experiences. These descriptions can be used as a guide for developing future science programs so that they enable participants to engage in meaningful normative scientific practices and develop the scientific knowledge, skills, and dispositions necessary for success. In addition, these descriptions can be considered when developing scientific programming for children that enables contextually authentic experiences and allows opportunities for participants to make meaning of their experiences.

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APPENDIX A

CONTENT AND SURVEY ASSESSMENT ADMINISTRATION PROTOCOL

a) Instructions to be read aloud to the participants are in **bold**.

b) Instructions for assessment administrator are in regular font.

I am __________ (your name), an instructor working with the Herpetology Program and we are here this week to learn about reptiles and amphibians and to have fun. How does that sound? But first I need your help. Today, I would like you to complete a survey. We will complete the survey together. Do you have any questions before we begin? You should read the assessment and survey pieces aloud to the participant. Feel free to explain the questions and language in as much detail as possible, but DO NOT provide the answers to the participant(s). Ask them to try their best.

You will be asked to answer questions about reptiles, amphibians, and science. No one at camp or at home will see your answers. Your answers will help us learn about campers participating in the Hands-On Herpetology program. Read each question carefully and pick the answer that is true for you or write in the answer that you think is correct. I will also read the questions aloud to you. Mark the answer on your questionnaire. This is not a test, and you will not be rewarded for right answers or punished for wrong answers. No one will know exactly what you said unless you tell them, except me. If you have any questions, please ask me for help, but remember that I will not be able to give you any of the answers. Do you have any questions?

Content Assessment with KEY

1. Circle the most correct answer. Herpetology is the study of:

    a. Amphibians (1)

    b. Reptiles (1)

    c. Amphibians, reptiles, and fish (0)

    d. Amphibians and reptiles (2)

2. Name at least 2 tools or pieces of equipment that herpetologists use to collect information about animals.

    Spring/Pesola scales, calipers, digital scales, snake hooks, squeeze boxes, hand lenses, rulers, nets, minnow traps, turtle traps, coverboards, drift fences, traps, microscopes (other kid terms are fine, 1 point per each correct answer, a total of 2 points maximum)

3. How would you accurately weigh (mass) a salamander or a frog?

    Weigh the animal, in a wet baggie, using a Pesola/spring scale. Then, remove the animal from the baggie and reweigh the baggie. Subtract the weight of the baggie and water from the total weight. (3 pts total – 1 pt if description references scale only, 2 pts for referencing scale and baggie, but not subtraction of weight, or referencing scale and subtraction, but not baggie)

4. What are differences between reptiles and amphibians? Name at least one difference.

Reptiles lay eggs on land, while amphibians do so in the water.

Reptiles have leathery eggs, while amphibians have moist, squishy eggs.

Reptiles always have lungs, while amphibians start with gills and develop lungs.

Amphibians must live near moisture, while reptiles can live in dry places.

Reptiles have dry, scaly skin, while amphibians have moist, sticky skin.

Reptiles look the same as babies and adults. Amphibians go through complete metamorphosis.

(2 pts per correct comparison, 1 pt for correct identification of reptile or amphibian characteristic, but not both)

5. Name 2 reptiles and 2 amphibians that you think you might find at the camp.

   Amphibians:

   a. **Frogs (Spring peeper, Northern Cricket Frog, Green Frog, Bullfrog, Leopard Frog)**

   b. **Toads (American, Fowler's)**

   c. Salamanders (Spotted, Marbled, Red Efts, Newts)

   Reptiles:

   a. **Turtles (Yellow-bellied slider, Red-eared slider**, Eastern Box, Painted, Musk, Mud, Snapping)**

   b. **Snakes (Rat, Black racer, Garden, Garter, Copperhead, Green, Brown, Worm, Rough Earth)**

(1 pt. for correctly identifying animal – i.e., snake, turtle, lizard; 2 pts for identifying species – i.e., Rat snake, yellow-bellied slider, fence lizard – up to 8 points total)

6. If you were a herpetologist what kinds of questions might you want to ask about the animals you would study? Write at least two questions.

   (1 pt for each question actually related to reptiles and amphibians)

7. How long is this salamander (use your ruler)? What type of salamander is it? This salamander is **4"** long **(2 pts)**. It is a **<u>marbled</u>** salamander **(2 pts)**.

Survey

1. When I grow up, I would like to be a scientist.

Strongly Disagree		Agree		Strongly Agree
1	2	3	4	5

2. I think exploring outside is a part of science.

Strongly Disagree		Agree		Strongly Agree
1	2	3	4	5

3. I do NOT like working with different animals.

Strongly Disagree		Agree		Strongly Agree
1	2	3	4	5

4. I think it is important for scientists to be curious.

Strongly Disagree		Agree		Strongly Agree
1	2	3	4	5

5. Sometimes scientists work together.

Strongly Disagree		Agree		Strongly Agree
1	2	3	4	5

6. Sometimes scientists hide their work from others.

Strongly Disagree		Agree		Strongly Agree
1	2	3	4	5

7. Scientists have to be honest when they work.

Strongly Disagree		Agree		Strongly Agree
1	2	3	4	5

8. Sometimes scientists are careless (sloppy) when they work.

Strongly Disagree		Agree		Strongly Agree
1	2	3	4	5

9. I do NOT like school science

Strongly Disagree		Agree		Strongly Agree
1	2	3	4	5

10. How would you describe your current *ability* as a science student?

Not good		Okay		Very Good
1	2	3	4	5

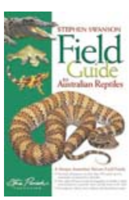
11. How would you describe your current *interest* in science?

Not interested		Sort of interested		Very interested
1	2	3	4	5

1. ______________

2. ______________

3. ______________



4. ______________

5. ______________

6. ______________

7. ______________

8. ______________

9. ______________

MINNOW TRAP

FIELD GUIDE

DRIFT FENCE

DIP NET

COVERBOARD

SPRING SCALE

TURTLE TRAP

CALIPER

THERMOMETER

a. Used to tell the temperature (how hot or cold something is).

b. Used to catch larger animals like turtles in a pond or a lake.

c. Used to measure the length, width, and height of a turtle's shell.

d. Laid in the woods to attract snakes and salamanders so we can find them.

e. Dipped in water to collect creatures.

f. Used to weigh (mass) a frog or a salamander.

g. Used to trap small animals like salamanders that live or spend time in the water.

h. Used to help people identify different animals or plants.

i. Used to make animals walking through the woods and fields go a certain way.

NAME: ________________

APPENDIX B

FOCUS GROUP INTERVIEW PROTOCOL

(To be administered before camp activities begin and after they end)

Focus Group Interview Protocol:

Exact words that focus group moderator will use are in **bold** type. Please record this interview.

Purpose of the Focus Group:

Thank you for agreeing to participate in this focus group discussion today. I'm {person name}. I will be asking you some questions for this session; {person name} will be taking notes.

The purpose of this focus group is to learn more about your interests in and knowledge of herpetology. We'd like to hear about what you think about working with reptiles and amphibians so we can learn more about what makes this camp really good for you. That is what kinds of activities did you like today? Are there specific things that you would like to do tomorrow at camp?

Process:

There are no right or wrong answers to our questions. We want to know what YOU think and are glad that you are willing to help us learn more about your camp experiences! We are tape recording the session in order to ensure that we accurately remember what you tell us. What you share in this group will not be shared outside of the research team unless you choose to share the information, and we won't share

your names. Our group will be identified as the Herpetology Camp group only and each of you will be recorded under a pseudonym, like an alias ("secret name") in a movie or a video game.

Ground Rules:

Because we are taping and taking notes, I may remind you occasionally to speak up and to talk <u>one</u> at a time so that we can hear you clearly.

Each time I ask a question, there is no need for everyone to respond unless you want to. However, it is important that a wide range of ideas is expressed. If you would like to add to an idea we would love to hear what you want to say. You don't have to go in a circle.

Participant introductions:

Let's start by asking each of you to introduce yourselves. You can say your name, your grade level, and tell us if you've been to the program before.

Questions:

PRIOR TO PROGRAM:

Why did you decide to come to herpetology camp?

What is herpetology? (Study of reptiles and amphibians – let me tell you what it is – give them feedback, what are reptiles and amphibians?)

What is your favorite reptile or amphibian? Why is it your favorite?

What types of work do you think scientists do when they are studying snakes, frogs, and other reptiles and amphibians? Why do you think this?

What types of activities do you hope to do this week? Why?

What does it take for someone to be a good scientist or herpetologist?

What kinds of tools or equipment do herpetologists use? Why do you think their use is important to use tools/equipment as a herpetologist?

How would collecting information about these animals be different if herpetologists did not have tools?

Is there anything else you would like to share with us?

AFTER PROGRAM:

What is your favorite herpetology activity you've done so far? Why was it your favorite?

What is the most difficult thing you've done at camp this week with reptiles and amphibians? What made it hard?

What are the most interesting or important things about reptiles and amphibians that you learned?

Were the activities that you completed at camp what you thought you would be doing? Why or why not?

Let's make a list of all the things herpetologists do while in the field. Let's circle the ones you felt like you did this week. (What does that mean? Did you like that or not? Why?)

What does it take to be a good herpetologist? (Ask them why they selected whatever characteristics they chose – for example, "You said a good herpetologist is patient. What does that mean to you?"

You guys said it was important for them to use tools – let's talk about all of the tools used - Why do you think their use is important to herpetologists?

How would collecting information about these animals be different if herpetologists did not have tools?

If you could change one thing about this herp program, what would it be? Why?

Is there anything else you'd like to share with us?

APPENDIX C

PHOTO ELICITATION INTERVIEW PROTOCOL

Photograph Elicitation Interview Protocol

Questions to read to participants are in **bold**. Please use an audio recorder to record this interview. Take notes on participant responses to the questions. Please note what three photos the participant selects as the "**most important**" and put a sticky note on each photo (numbered 1, 2, or 3) these three photos on the top of the stack of photos.

Directions to children:

The children have been directed to take 15 photographs each day of what they think are the most important events and activities. Children have been informed that if more than fifteen photos are taken, only the first fifteen visible (no blurs, photos of shoes, hands, etc) will be printed for them to review.

Interview Questions:

I have copies of the photos that you took during yesterday's activities. Can you tell me what is happening in each of these pictures?

I want you to look through your photographs. Which three do you think show the most important activities from yesterday's session?

Ask for all three photographs:

1. Why did you select this photo?

2. What made this picture (event) important?

3. What did you learn about ________ (e.g. frogs, for example) yesterday that you didn’t know before?

4. What were you able to do that you’ve never done before?

5. Has this changed your mind about these (the same ___ as in question 3) ___ at all?

Are there any events that you thought were important, but didn’t get pictures of?

Why were these events important?

Is there anything else you would like to add?

PEI Interview Information	
Scientific Knowledge in description? _____ Y ______N	Evidence:
Scientific Disposition shared in description? (list)	Evidence:
Scientific Process Skills shared in description? (list)	Evidence:
Other notes:	

APPENDIX D

FIELD NOTES PROTOCOL

This is a study that examines summer program activities and structure and participants' knowledge skills, and dispositions. One method for collecting data on camper knowledge, skills, and dispositions will be observations of their participation in program activities.

You will want to observe participants as they engage in program activities, while looking for examples of the five categories of scientific process skills and the scientific dispositions. The five categories of scientific process skills (DeFina, 2006) are:

1. Acquisitive	2. Organizational	3. Creative	4. Manipulative	5. Communicative
Listening	Recording	Planning ahead	Using instruments	Questioning
Observing	Comparing	Designing	Demonstrating	Discussing
Searching	Contrasting	Inventing	Experimenting	Explaining
Inquiring	Classifying	Synthesizing	Constructing	Reporting
Investigating	Organizing		Calibrating	Writing
Gathering Data	Outlining			Criticizing
Researching	Reviewing			Graphing
	Evaluating			Teaching
	Analyzing			

The scientific dispositions that we are interested in for this study are curiosity, collaboration, and ethics.

Curiosity	**Collaboration**	**Ethics**
Asking questions Investigating (designing studies, planning investigations) Exploring (lifting logs, pulling traps, examining coverboards)	Working with others Asking others for help Helping others	Recording data accurately Keeping track of/carrying equipment Handling animals with care Following directions and procedures Exhibiting safety procedures

Take notes while you observe the program activities. In your notes, describe what happens during the activity. Describe the activity in sufficient detail so that someone reading the notes would have a sense of what the **participants and leader did** during the activity.

Note: I expect the field notes to be “rough”; that is, you do not need to write in complete sentences. You do not have to revise field notes in any way, just turn them in ‘as is’ at the end of each day.

Collect all materials you can from the activity—data collection sheets, leaders’ instructional plans, and any handouts.

Using your field notes, complete the Observation Checklist (see detailed instructions below) as soon as possible after the session is completed.

Observation Checklist

Date of observation: _________________________

Observer: _________________________________

Session Leader: ______________________

Title or brief description of observation:

____

Attached Materials (please check)

Field notes Handouts Instructional Lesson Plans

Time Starting Observation: ____________________

Time Ending Observation: ___________________

Participants:

Location of activity:

Nature of the activity:

Resources used (tools, guides, etc)

Field Note Analysis:							
Science Process Skill Discussed:	Who discussed the process skill?	What did they say?	Who did they say it to?	What was going on around them?	What were other people doing?	What scientific knowledge was used?	How do you know?

Science Disposition Discussed:	Who discussed the disposition?	What did they say?	Who did they say it to?	What was going on around them?	What were other people doing?	What scientific knowledge was used?	How do you know?

Alignment with Contextually Authentic Science:	Who discussed the science?	What did they say?	Who did they say it to?	What was going on around them?	What were other people doing?	What scientific knowledge was used?	How do you know?

APPENDIX E

VIDEO TAPE ANALYSIS PROTOCOL

Video Tape Analysis							
Science Process Skill Discussed: Video start and end time:	Who discussed the process skill?	What did they say?	Who did they say it to?	What was going on around them?	What were other people doing?	What scientific knowledge was used?	How do you know?

Science Disposition Discussed: Video start and end time:	Who discussed the disposition?	What did they say?	Who did they say it to?	What was going on around them?	What were other people doing?	What scientific knowledge was used?	How do you know?

Alignment with Contextually Authentic Science: Video start and end time:	Who discussed the science?	What did they say?	Who did they say it to?	What was going on around them?	What were other people doing?	What scientific knowledge was used?	How do you know?

APPENDIX F

PARTICIPANT JOURNAL DATA SHEETS (*HERPETOLOGY)*

Vernal Pools Study June _____, 2011 Researchers: ___________________

Air Temperature: _____ degrees F

Time: _______________________

Water Temperature: _______ degrees F

Description of trap location (in water, on land, next to branches, etc).

Trap #______ Location (CCR Vernal Pool or Matthews Vernal Pool)

Water Depth:

Trap Contents:

Invertebrates (insect larvae) (identify, count, describe)

1.

2.

Vertebrates:

1.	Length:	Weight:
2.	Length:	Weight:
3.	Length:	Weight:

Sketch of one of the vertebrates:

Aquatic Turtles Study June _____, 2011 Researchers: ___________________

Air Temperature: _____ degrees F

Water Temperature: ________ degrees F

Time: _______________________

Water Temperature: _______ degrees F

Description of trap location (where in the lake?).

Water Depth:

Trap Contents:

Turtles:

1.	Carapace Length:	Carapace Width:
Weight:	Plastron Length:	Plastron Width:
2.	Carapace Length:	Carapace Width:
Weight:	Plastron Length:	Plastron Width
3.	Carapace Length:	Carapace Width:
Weight:	Plastron Length:	Plastron Width

Sketch of one of the turtles:

APPENDIX G

HERPETOLOGY PROGRAM CURRICULUM

Day	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
10 am – 11:40	Field Explorations Rotations: A. Cover boards, drift fences, streams with J B. Vernal Pools with C & A	Field Explorations Rotations: A. Aquatic Turtle Project with T & A B. Vernal Pools project with C	Field Explorations Rotations: A. Cover boards, drift fences, streams with J B. Aquatic Turtle project with T & A	Field Exploration Rotations: Student choice	Field Exploration Rotations: Student choice
11:40 am - 12:00 pm	Group Meeting (what did students find, what tools did they use, anything exciting, etc)	Group Meeting	Group Meeting	Group Meeting	Group Meeting

Dr. M – vernal pools
Dr. A – vernal pools
Ms. A – cover boards
J – cover boards
Dr. T – aquatic turtles
A – aquatic turtles

Ms. B – help whoever needs it

Slip, Slidin' Away: Monitoring Local Reptile and Amphibian Populations
Student Curriculum (Original Curriculum, used as a guide for *Herpetology*)

Overview

Students will inventory and monitor the reptile and amphibian populations on Chestnut Ridge Camp and Retreat property for one week in the summer and six additional days throughout the school year. An outgrowth of participation in this inventory and monitoring project will be student-generated independent inquiry projects. An in-depth study of the following concepts is included: the interdependence of organisms, matter, energy and organization in living systems, and the adaptive responses of organisms. Students will experience and begin to understand the human dimensions of science, the nature of scientific thought, and the role of science in society. Particular relevance will be explored in the areas where humans affect and are affected by other organisms and the non-living environment. This curriculum offers opportunities for students to make decisions based on evidence in the areas of environmental stewardship and economic realities.

Science As Inquiry

The essence of the inquiry process is to ask questions that stimulate students to think critically and creatively to formulate their own questions. Observing, classifying, using numbers, plotting graphs, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing, and experimenting all help students to build knowledge and communicate what they have learned. As SSA students are exposed to the biology and ecology of local amphibian and reptiles species and habitats they will be encouraged to employ creative thinking to consider problems of interest to them and to design methods for determining potential answers to those problems. The long-term value provided by the experience of generating new knowledge through scientific exploration will be the focal point of participation in this project. The process of inquiry, experimental design, investigation, and analysis is as important as finding the correct answer. Students will master much more than facts and manipulative skills; they will learn to be critical thinkers.

Most scientific knowledge and technological advances develop incrementally from the labors of scientists and inventors in response to specific problems or conflicts. Students will gain an appreciation of the scientific thought and effort of individuals by reading two accounts of evolving understanding of the relationship of amphibians and reptiles to environmental issues: *Tracking the Vanishing Frogs* and *Their Blood Runs Cold*. Students will explore original writing by scientists as well as current work of undergraduate biology students.

Background

<u>Content to introduce/use: Amphibians</u>

- Unique characteristics: dual life cycle, most must lay eggs in water. Restricted to moist places, some completely restricted to water.
- Feeding
  - Adult amphibians and larva of salamanders are carnivores eating insects, worms, small crustaceans, other amphibians, small fish and small mollusks.
  - Frogs & toads have long sticky tongues to capture prey.
  - Aquatic larvae of frogs and toads (tadpoles) are filter feeders, straining algae or bits of organic matter from the water.
- Ectothermic: dependent on primarily environmental sources of heat to regulate body temperature.
- More means of respiration than any other animal. Adults: Breath with lungs, mouth cavities and skin. Same salamanders do not have lungs. Larva: Breath with gills, expelling CO_2 through their skin. Mouth breathers because don't have well developed chest muscles.
- Calls used to find a mate, announce a territory, or sound a warning or alert (release calls and distress calls). Males have large expandable vocal sacs that amplify sound. Vocal sacs are inflated as air is pushed into them through slits in the floor of the mouth. Calls are generated by pushing air back and forth over the vocal cords causing them to vibrate and produce sound. Salamanders lack vocal chords but a few make squeaks.
- Body coverings
  - Bodies covered with thin, moist, glandular skin without scales (great for gas exchange but water is constantly lost by evaporation).
  - Color of skin used in camouflage, to attract a mate, or to detract a predator.
    - Toxins in skin are being investigated as possible future use as anesthetics, muscle relaxants, and heart medications. Also being studying because of regenerating of lost limbs (salamanders can but frogs can't).
  - Can change color by concentrating or dispersing pigments in skin cells called chromatophores.

<u>Content to introduce/use: Reptiles</u>

- Class: Reptilia; Orders: Squamata (lizards & snakes), Crocodilia (crocodiles, alligators), Chelonia (turtles & tortoises)
- Body
  - Dry, scaly body sealed to prevent dehydration (many shed skin)
  - Limbs suited for rapid movement, four legs with five clawed toes (except snakes)
  - Advanced heart and lungs
- Ectothermic: dependent on primarily environmental sources of heat to regulate body temperature.
  - Active only when temp. is favorable
  - Bask in sunny areas, or cool in shade

    - Burrow in ground
    - Some can change color to absorb (or not) sun
    - Can raise legs or tail off surface to reduce heat
- Reproduction
    - Internal fertilization
    - Eggs covered and sealed with membranes and shells suited for development on dry land (some give live birth- eggs held inside body until hatch)
- Breathes with lungs only
- Sense of smell poorly developed except lizards and snakes that have Jacobsen's Organ located in roof of mouth. Tongue is flipped out, molecules from the air gather on it. Drawn back into the mouth and onto the Jacobson Organ.
- Order Squamata (lizards & snakes)
    - Lizards
        - Long body, long tail (grasping, balance storage), some tails will regenerate
        - Most have four legs with five claws on each toe
        - Eyelids & eternal ear openings
        - Most carnivorous
        - Many can alter their body colorings
        - Have teeth
    - Snakes
        - No external ear or eardrum
        - No eyelids
        - Carnivorous
        - Flexible & elastic muscles and ligaments around the jaws and throat (can swallow objects bigger than head). Extends tube-like opening of air passage, called the glottis, outward so that it is clear while swallowing prey (like a diver breathing through a snorkel).

APPENDIX H

REPTILES PROGRAM CURRICULUM

BHNP Herpetology Camp (Teaching Plan; 20-24 June 2011)

Monday: Introduction to Herpetology Camp and the World of Amphibians and Reptiles

We will explore the diversity of amphibian and reptile life and examine a number of species up close. An introduction to their ecological importance will set the stage for this week's studies. Our group will search for herps (including their tracks and signs), look for alligators from the boardwalks and watch gopher tortoises along the trails. A hands-on activity will introduce methods for identifying snake sheds found in the woods.

9:00 am: Opening activities

a) sign in

b) locate cubbies and store lunch coolers

c) look at books and explore classroom

d) use restrooms

9:15 am: Welcome and camp rules

a) welcome campers (attended past BHNP nature camps?)

b) introduce ourselves (discuss our backgrounds and interests)

c) discussion of camp goals and experiences (cover camp highlights)

d) review camp rules

wear name badges (leave in cubby at end of each day)

seating (same seat for the day)

parents must sign you in and out

be kind to each other

be polite

raise hands (no talking over each other)

no yelling or loud voices

no horseplay

stay on path during hikes (safety)

no sticks or rocks during hikes

no discouraging words

time out (ranger's office)

care of equipment and supplies

handling snakes (cannot be wearing bug spray, sunscreen or perfume)

use of restrooms (always with a partner)

ask questions and participate in discussions and activities

most important: have fun

9:30 am: Create a badge (distribute art supplies and colored circles)

10:15 am: Break (restrooms and snacks)

Complete assembly of badges

10:30 am: What is a herp and why are they important?

herpetology: study of amphibians and reptiles

characteristics of all amphibians:

1. They are ectothermic (cold-blooded) vertebrates.

2. Their skin is usually smooth and lacks scales, hair, and feathers. They are dependent upon moisture and subject to desiccation; their skin must remain moist to aid in breathing.

3. They lack claws on their toes.

characteristics of all reptiles:

1. They are ectothermic (cold-blooded) vertebrates.

2. Their skin has scales, but no hair or feathers.

3. They have claws on their toes (except those which do not have legs, such as legless lizards).

4. They are the first animals, in evolution, to develop the amniotic egg. This allows reptiles to lay eggs on land.

encourage student participation with the following list

amphibians and reptiles are beautiful, mysterious, fascinating animals

interesting ecological roles
diverse and complex roles as predator and prey

provide homes for other species consequently increasing biodiversity

many species play a role in the cycling of nutrients

seed dispersers (gopher tortoises in uplands)

importance to ecological health and safety as indicators of habitat quality

economic impact: important form of natural insect control

economic impact: important form of rodent control

economic impact: nature-based tourism (example: alligators)

medical value: used to produce antivenin

10:45 am: Hike in preserve (uplands and wetlands; bring cell phone and first-aid hike bag)

a) use restrooms before leaving

b) learn safety in the woods (gators and venomous snakes)

c) practice safe wildlife watching (keeping a distance)

d) explore characteristics of different habitats (upland and wetland)

e) search for wildlife, tracks and signs

12:00 pm: Lunch (watch part of BBC's *Life In Cold Blood: Sophisticated Serpents*)

12:45 pm: Presentation on snakes

a) live animals (emphasize diversity and adaptations; discuss growth and foraging)

red rat snake

yellow rat snake

Florida kingsnake

northern pine snake

western hognose snake

rosy boa

b) venomous snakes (examine preserved specimens outside; use *Florida's Fabulous Reptiles and Amphibians*)
c) venomous snake warnings (demonstrate sound of rattlesnake rattles)

d) show new Florida snake guides (available for sale)

2:15 pm: Break (restrooms and snacks)

2:30 pm: Presentation on snakes (continued)

e) snake skins (boa and rattlesnake)

f) snake sheds (python, rattlesnake and hognose)

g) activity: snake sheds (examine with magnifying glasses, paper project)

h) coloring page of coral snake and mimic

3:45 pm: Closing activities

a) clean up (collect books and pack materials to take home)

b) organize cubbies

c) sign out

d) distribute snake posters (roll in advance)

Equipment/supplies list

class notebook (teaching plan, student roster and registration forms)

sign-in/out sheets

cubbie name labels

badge name labels

clear packing tape

scissors

books: Florida's Fabulous Reptiles and Amphibians (12 copies)

badge making equipment and colored circles

art supply boxes

cell phone

extra t-shirt

first-aid hike bag

camera in yellow box

TV/VCR/DVD

DVD (BBC's *Life In Cold Blood*)

live animals (red rat snake, yellow rat snake, Florida kingsnake, northern pine snake, western hognose snake, rosy boa, and Vietnamese mossy frog)

snake tank labels

spring water

preserved venomous snakes

latex gloves (1 pair XL)

rattle and battery-powered toothbrush

snake shed Rubbermaid

misters

magnifying glasses

herp coloring pages (including coral snake and mimic)

puzzles

herp cards

reptile books

Southeast U.S. venomous snake posters (already rolled)

rubber bands

hat

Tuesday: Florida Turtles - A Conservation Challenge

Today's lesson will introduce Florida's diverse turtles and the broad conservation challenges facing these ecologically significant reptiles. Students will meet several species up close and learn how to sort turtle bones. A visit to the preserve's upland habitats will provide an opportunity to study gopher tortoises and their role as a keystone species.

9:00 am: Opening activities

- a) sign in
- b) look at *Florida's Fabulous…* books
- c) use restrooms

9:15 am: Snake holding session (red rat snake; take photos of campers holding snake)

10:00 am: Break (restrooms and snacks)

10:15 am: GT Hike in park (bring cell phone and first-aid bag)

11:30 am: Presentation on gopher tortoises (Outdoor Classroom)

Video: gopher tortoise burrow camera

12:00 pm: Lunch (watch *Terrapin*)

12:30 pm: Presentation on turtles

- a) live animals and bioartifacts (emphasize diversity and adaptations; introduce reading turtle shells)
  - loggerhead sea turtle (skull; diet)
  - green turtle (shell)
  - common musk turtle (shell; size)
  - Florida softshell (carapace; shells)
  - peninsula cooter (shell; gator scars)
  - alligator snapping turtle (diet and harvest)
  - Barbour's map turtle (shell; sexual dimorphism)
  - diamondback terrapin (crab pot study)

Florida box turtle (at turtle pen: shell adaptations, diet and pet trade)

b) brief presentation on nesting (annual timeline and nesting sites)

c) activity: radiographs of turtles with eggs (learn how to count eggs)

d) activity: terrapin clutch size worksheet

2:00 pm: Break (restrooms and snacks)

2:15 pm: Activity: sort turtle bones/reassemble turtle shells

3:15 pm: Playground?

3:45 pm: Closing activities

a) sign out

Equipment/supplies list

class notebook (teaching plan, student roster and registration forms)

sign-in/out sheets

cell phone

first-aid hike bag

camera in yellow box

TV/VCR/DVD

Video (*Terrapin*)

terrapin coloring pages

turtle bioartifacts (2 Rubbermaids)

live animals (alligator snapping turtle and diamondback terrapin)

Suwannee cooter harvest poster

crab pot

BRD

radiographs of turtles with eggs

terrapin clutch size worksheet

disarticulated turtle shells (1 box)

tape dispensers

Wednesday: Ecology of Amphibians and Reptiles

We will focus on the ecology of amphibians and reptiles and learn how they defend themselves, how they locate food, how they communicate, and how they reproduce and grow. Students will participate in fun-filled environmental activities as we explore these fascinating subjects, including transforming our class into a frog chorus. Continued exploration of the preserve's varied habitats will provide an opportunity to learn about the ecological needs of different species.

9:00 am: Opening activities

a) sign in

b) store lunch coolers in cubbies

c) look at *Florida's Fabulous…* books and explore classroom

d) use restrooms

9:15 am: Snake holding session (yellow rat snake)

10:00 am: Break

10:15 am: Hike in preserve (bring cell phone and first-aid hike bag: bring snacks and fluids)

a) explore characteristics of different habitats (upland and wetland)

b) search for wildlife, tracks and signs

c) snack break during hike (sheltered area)

11:30 am: Presentation on alligators

a) ecology, adaptations (show osteoderm), size (length), conservation

b) activity: gator length (record length: 19' 2")

12:00 pm: Lunch

12:30 pm: Video: *Alligators* (30 minutes)

1:00 pm: Activity: clean box turtle pen, pool and sign

2:00 pm: Break (restrooms and snacks)

2:15 pm: Activity: terrapin board game

3:15 pm: Nature questions game

3:45 pm: Closing activities

a) clean up (collect books and pack materials to take home)
b) discuss Friday's hike

c) sign out

Equipment/supplies list

class notebook (teaching plan, student roster and registration forms)

sign-in/out sheets

cell phone

first-aid hike bag

camera in yellow box

TV/VCR/DVD

alligator skull

alligator osteoderms

alligator rope

video (*Alligators*)

terrapin board game and game pieces (1 game and sheet of game pieces per camper)

cards with nature questions

Thursday: Conservation - Saving Herps and Their Habitats

More fun-filled activities will help us learn about the conservation of amphibians and reptiles. We will discuss habitat conservation and learn how to identify roadkills. We will also take a hike in the preserve where we will explore problems associated with non-native plant and animal species and learn about their impact on native wildlife and natural areas.

9:00 am: Opening activities

a) sign in

b) distribute hike flier to parents

c) store lunch coolers in cubbies

d) look at *Florida's Fabulous…* books and explore classroom

e) use restrooms

9:15 am: Snake holding session (species to be determined; take photos of campers holding snake)

10:00 am: Break (restrooms and snacks)

10:15 am: Presentation on non-native species (animal corner of nature center)

a) red-eared slider, Cuban treefrog and marine toad

10:45 am: Hike to explore non-natives (bring cell phone and first-aid hike bag)

a) search for non-native wildlife and invasive non-native plant species

b) catch anoles on trails

12:00 pm: Lunch

12:30 pm: DVD: Nature's *Frogs: The Thin Green Line* (watch first half)

1:00 pm: Activity: paper bowl turtles

2:00 pm: Break (restrooms and snacks)

2:15 pm: Complete paper bowl turtles

Activity: frog CD (use computer)

Activity: make our own frog chorus

3:30 pm: Closing activities

a) distribute hike flier to parents (talk with each parent)

b) sign out

Equipment/supplies list

class notebook (teaching plan, student roster and registration forms)

sign-in/out sheets

cell phone

first-aid hike bag

camera in yellow box

TV/VCR/DVD

DVD (Nature's *Frogs: The Thin Green Line*)

paper bowl turtles (bowls, head and limbs sheet and popcorn kernels; 35)

stapler and extra staples

frog call DVD and DVD player

frog flash cards

frog band instruments

hike flier (35)

Friday: Camp Hike

A hike from one end of the preserve to the other will provide an opportunity to view native wildlife and explore the diversity of natural communities present. Students will become familiar with the ecological components of these habitats as they trek through the preserve. Identification of scat (animal poop) and what it can reveal will be introduced.

9:00 am: Opening activities (begins at Osprey's Roost)

a) sign in

b) use restrooms (need access to Osprey's Roost)

c) prepare for hike (staff to take lunches to Environmental Education Center)

9:30 am: Hike from ESA to Environmental Education Center (bring first-aid hike bag; 10:30 am: meet ranger at nursery building for drinks and snacks)

a) explore characteristics of different habitats (upland and wetland)

b) search for wildlife, tracks and signs (examine GT scat: bring gloves)

12:00 pm: Restrooms (wash hands)

Lunch (picnic area)

Playground

1:00 pm: DVD: Nature's *Frogs: The Thin Green Line* (watch second half)

1:30 pm: Presentation on scat (wear scat shirt)

a) scat samples

b) terrapin diet study

c) activity: scat identification

2:30 pm: Break (restrooms and snacks)

2:45 pm: Activity: roadkill presentation and ID activity

3:30 pm: Nature questions game

3:45 pm: Closing activities

a) clean up (collect books and pack materials to take home; clean cubbies)

b) sign out

Equipment/supplies list

class notebook (teaching plan, student roster and registration forms)

sign-in/out sheets

cell phone

first-aid hike bag

camera in yellow box

TV/VCR/DVD

scat collection

terrapin fecal samples

roadkill Rubbermaid

dice