Chapter 1

INTRODUCTION

Identifying the problem

There is mounting evidence that one component of the science education reform process must be a sustained effort toward making the study of science accessible to more students (Jones, 1997). For example, it was found that only 7 percent of all positions in science and engineering were held by minorities despite constituting 24 percent of the current United States population (National Science Foundation, 2002). Furthermore, reports have indicated that United States students rank very low in science scores with only 2 of 20 nations behind them in international tests (Glenn Commission, 2000). When race is considered, the difference is even more pronounced: while the scores of white students in the U.S. were exceeded by only three other nations, black children were outscored by every single nation (Berliner, 2001). Despite this disparity, documents clearly put forward the idea that all students, regardless of culture, gender, and/or race, are capable of understanding and doing science (National Research Council, 2002). Because 53 % of African-Americans live inside cities and 88 % reside in metropolitan areas (United States Census Bureau, 2001), it is critical to engage and motivate urban students to learn science in order to achieve many of the goals of the National Science Foundation (2002), such as diversifying the workforce.

It is increasingly recognized that authentic learning opportunities are one way to make science more relevant to all students (Bouillion & Gomez, 2001; Fusco, 2001; Rahm, 2002). Chinn and Hmelo-Silver (2002) described authentic scientific inquiry as designing complex procedures, controlling for non-obvious confounds, planning multiple measures of multiple variables, using techniques to avoid perceptual and other biases, reasoning extensively about possible experimental error, and coordinating results from multiple studies that may be in conflict with each other. That statement could simply be paraphrased as engaging students in scientific activities similar to those engaged by scientists (Barab & Hay, 2001). Authentic means different things to different people (Chinn & Hmelo-Silver, 2002; Hay & Barab, 2001). I view authentic science activities as providing an opportunity for students to learn how scientists conduct their research; this could be by directly participating with scientists or in simulations (see Barab & Hay, 2001) such as videos taken from research activities (indirect participation) that are brought to schools. The simulation perspective of authenticity provides the possibility for students to engage like scientists where it is not feasible to take students into the scientists' domains for monetary and/or logistic reasons

Using the scientific method, authentic inquiry oriented activities encourages students to think critically (Howe & Warren, 1989) and become scientists by inquiring, testing and observing, collecting and analyzing data, recording findings, and presenting findings and conclusions. These beliefs and visions clearly articulate the active learning environment descried by progressive and constructivist theorists (Cuban, 2000; Dewey, 1929; Orion, Hofstein, Tamir, & Giddings, 1997). Place-based curriculum in informal (or nonformal) outdoor settings (Howe & Disinger, 1988) encourages participants (teachers, students, and community members at large) to achieve local ecological and cultural sustainability (Hungerford, Bluhm, Volk, & Ramsey, 1998; Thomson & Diem, 1994; Woodhouse & Knapp, 2000; Yerkes & Haras, 1997). I define sustainability as being within carrying capacity of local resources, both ecologically and culturally (i.e., having an understanding of how one relates to their local environment). Informal, genuine, authentic learning environments provide firsthand experiences for people of all ages (Fusco, 2001; Hudson, 2001).

Many studies have focused on students participating in authentic scientific activities in outdoor experiences (Barnett et al., 2004; Bouillion & Gomez, 2001; Fusco, 2001; Rahm, 2002). Odom (2001) noted that outdoor-based activities are not the exclusive domain of exotic wilderness settings, but worthwhile field projects can be done in any setting, including cities. The important thing is that inquiry-based authentic activities allow one to experience, not just imagine, reality (Thomson & Diem, 1994).

In the article by Bouillion and Gomez (2001), "*Connecting School and Community with Science Learning: Real World Problems and School-Community Partnerships as Contextual Scaffolds*," the researchers described a partnership that bridged the disconnect that existed for students between science (and school) and real world everyday issues. The authors presented a real world problem (river pollution) and showed how fifth grade students and their teachers could create partnerships with the community to fix/solve a problem in a mutually beneficial way to all project participants. This study provided qualitative data to demonstrate that students improved in their ability to access information, form questions, share ideas, and analyze and compare data. Additionally, students talked about an increased sense that they matter, that their voices can be heard, and that they can make a difference in the world – essentially, the students felt empowered because they did something good for their community (Bouillion & Gomez, 2001). The feature that real-world problems have no clear answers afforded a repositioning of authority in the classroom where teachers were able to engage students as co-contributors and co-investigators (Bouillion & Gomez, 2001).

Similar studies (Fusco, 2001; Rahm, 2002) have also noted the importance of local community events to aid in students learning science. For example, in Fusco's community based urban gardening project she found that the practicing culture of science learning was important and relevant because it: was created from participants' concerns, interests, and experiences in and outside science; was an ongoing process of researching and then enacting ideas; and was situated within the broader community. In this study the enactment of science included access to practical science knowledge and the opportunity to engage in science and action research that served a purpose within the community. Importantly, young people (i.e., students) were at the center of this interaction giving their work relevance and meaning to their activities.

Rahm (2002) demonstrated that people learn science in a variety of ways, for a variety of purposes, and from a variety of sources. Using an urban gardening program as her means to involve students in informal science education, Rahm found that the science that got done was authentic in the eyes of the youth and meaningful in the context of their everyday lives. Most important, youth were the creators and not merely the consumers of the science curriculum.

The results from these studies underline how children can become masters of the science embedded in their everyday communities and practices if provided with opportunities to do science that is meaningful and real to them (Rahm, 2002). These reports challenge the formal model of science teaching, in which adults teach and children learn, instead emphasizing community learning, which defines every person as a learner exploring an issue of genuine concern to the community (Rahm, 2002). A conception of children as their own creators of knowledge, and of adults solely as guides in this process, is an important vision to keep in mind when crafting science education reform strategies.

One way to provide students the opportunity to engage in authentic activities is to partner schools with scientists (e.g., Barab & Hay, 2001; Hay & Barab, 2001; Means, 1998). In this collaboration, students can learn the scientific process through their mentors (i.e., scientists) while the scientists can provide important community outreach and at the same time receive assistance in collecting valuable data (Hay & Barab, 2001). Wormstead et al. (2002) described a student-teacher-scientist partnership (STSP) where students collected standardized data from their surroundings that was used in professional research studies. Teachers introduced curricula related to these studies thereby giving students authentic hands-on discovery learning.

The need for scientists and schools to form partnerships is important and potentially beneficial for all sides (Means, 1998; Waksman, 2003; Wormstead et al., 2002), especially when engaging in an authentic scientific project. In these collaborations, students get the opportunity to learn from experts (i.e., scientists) in their respective disciplines while participating in legitimate scholarly, school-based activities. These partnerships are important because: one, they introduce students to science and the people that work in these fields; two, they may increase student interest in science; and three, scientists may serve as role models for potential future scientists.

Despite the noted importance of these partnerships, it is just as important to document the effectiveness of these collaborations and/or the subsequent student learning that results from these partnerships. For example, there are 6,314 sources in The Bibliography of Students' and Teachers' Conceptions and Science Education by Reinders Duit (2003). None of these studies addressed the question of student and teacher learning of animal behavior. However, a few conference proceedings have addressed student learning of animal behavior (Golan, Kyza, Reiser, & Edelson, 2002; Hay, Crozier, & Barnett, 2000; Margulis et al., 2001). Hay et al. found that students could participate in science by designing virtual reality models of gorillas; these authors noted that students became aware of gorilla behavior but more effort was needed for them to understand actual gorilla behavior and body postures. The use of technology, such as videos, was found to scaffold student learning, or provide support to enable learners to succeed in more complex tasks, and thereby extend the range of experiences from which they could learn (Golan et al., 2002). Videos, a way to learn in a simulated fashion (Barab & Hay, 2001), allowed students to compare animal behaviors exhibited by different species in Golan et al.'s study. Lastly, Margulis et al. found that a zoo field trip was a very good way to supplement student learning initiated in the classroom. In essence, these studies suggest that combining simulation and real-world authentic experiences are important to engage students in learning about animal behavior.

My study will attempt to answer some of these questions by engaging a study on Coyotes in high school classrooms. Therefore this dissertation will attempt to fill in gaps in the education literature by addressing:

1. Student learning of animal behavior (specifically on Coyotes).
2. Student involvement, interest, and empowerment in science issues.

Research Questions

I attempted to address and understand the following overarching research question through the curriculum intervention: How does a curriculum intervention that anchors instruction to the study of urban coyotes affect student learning and beliefs? Specifically, I examined these sub-questions related to the above inquiry:

1. What happens to students' knowledge of coyotes after participating in the curriculum unit? In essence, I examined in detail how this teacher-researcher collaboration affected high school students' perceptions of coyotes.
2. What happens to students' engagement and empowerment in science issues after introduced to our place-based intervention? What happens to student academic performance when students' participate in authentic scientific investigations on coyotes?

Educational Rationale for the Coyote Study in Urban Areas

Overall, there has been a dearth of studies that have had a primary focus on the needs of urban students and their science teachers even though 75-80% of the U.S. population resides in urban centers (Barton, 2001; Barton & Tobin, 2001). The literature indicates that providing resources (Spillane, Diamond, Walker, Halverson, & Jita, 2001) and valuing relevant active learning environments in classrooms are important for students to be able to engage in the practicing culture of science learning in urban settings (Fusco, 2001). Therefore, science learning and experimentation must take place in urban schools (Bouillion & Gomez, 2001) as well as in informal (i.e., zoos), more traditional science learning environments (Hofstein, Bybee, & Legro, 1997).

One benefit of environmentally related inquiry-based projects in urban areas is the education that many minorities (e.g., African Americans) (Barton, 2001; Seiler, 2001) and women (Rohrer & Welsch, 1998) are receiving. People of color have typically underachieved in education (Norman, Ault, Bentz, & Meskimen, 2001; Seiler, 2001) and are subsequently woefully underrepresented in many professions, particularly those related to the sciences and technical fields (Haury, 1995). There is no single explanation for the gap, but (Haury, 1995) lists two factors that have to do with the disparity: first, African Americans experience more obstacles along the path to careers in science; and second, they have fewer opportunities to see people like themselves in the sciences. Furthermore, Kahle et al. (2000) noted that African-American girls tend to outperform boys on measures of science achievement. Inner-city African-American students, especially males, often struggle between representing their own cultural norms or conforming to mainstream standards (Teel, Debruin-Parecki, & Covington, 1998). Teel et al. noted that inappropriate teaching strategies often cause poor performance. Thus not surprising from the preceding discussion, black students receive proportionally fewer degrees than their white counterparts with 73.8 versus 83% receiving high school diplomas and 13.2% compared to 24% earning college degrees (Teel et al., 1998). A way to reverse the trend is to involve students directly in real world place-based community science projects (Fusco, 2001; Rahm, 2002; Woodhouse & Knapp, 2000).

By involving urban students in the active involvement of a curriculum unit on Eastern Coyotes they will be exposed to many of the goals and objectives of education such as educating all citizens (see Goodlad, 1993 and Pine, 2002). Teachers and students have the opportunity to be part of a team participating in authentic ecological field studies that will aid in their intellectual development. The coyote study fits in well with design partnerships involving teachers, students, educational researchers, technologists, and scientists that address learning programs involving important subject matter (e.g., science and an interdisciplinary approach), are mediated by innovative technology (e.g., video equipment, coyote research equipment, computers), are embedded in everyday social contexts (e.g., classrooms), can be a tool for achieving broader reform efforts (e.g., inquiry based reasoning skills for improving performances on standardized tests), and contribute simultaneously to fundamental scientific understanding of learning and education (American Education Research Association, 1998).

In essence, this research project will attempt to involve students in an authentic project occurring close to them. Coyotes are often in the news (e.g., Nejame, 2005) and some students who normally wouldn't be interested in a science issue might be attracted to coyotes because of the publicity involved and the fact that they are a large predator that is potentially dangerous.

The Study in a Nutshell

In my view, a school-university partnership consists of a person or people from a secondary school working with at least one person from a university. It can be as small as one person working with one other person (e.g., teacher – researcher collaboration) or as large as entire secondary schools working with a university – these latter partnerships are often called professional development schools (Murray, 1993; Pine, 2002). In the case of this study, I am involved more closely with the former, where I have been working mainly with two high school teachers and their students for the past six years. This collaborative relationship uses the skills of a scientist (myself) with the educational goals of the science teachers to produce educational change in the classroom as well as to collect scientifically sound data on wild coyotes. We have collaborated on studying Eastern Coyote behavior and ecology in the wild and in captivity in two different settings: one in urban north Boston and the second on suburban Cape Cod. While the ecological and behavioral study is well developed (Way, 2001; Way, Auger, Ortega, & Strauss, 2001; Way, Ortega, & Auger, 2002; Way, Ortega, & Strauss, 2004), this study formalizes the educational component of the research project where we are developing a curriculum unit based on coyote behavior. The focus of this dissertation is to implement the current curriculum unit into two urban high school classrooms for future dissemination to larger audiences (i.e., more classrooms). The guiding methodological framework to determine the effectiveness of student learning and their perceptions of coyotes and science in general involves using teaching or design experiments (Barnett, 2003; Cobb, 2000; Dede, 2004; Kelly, 2004; Shavelson, Phillips, Towne, & Feuer, 2003).

The curriculum uses powerpoint presentations and windows media player videos of coyotes as multimedia tools (Appendix 1). The unit centers around our three study sites (wild coyotes on Cape Cod, wild coyotes in north Boston, and captive coyotes at the Stone Zoo) and covers aspects of our research such as capture techniques, handling and radio-collaring procedures, ecology in the wild, behavior in captivity, and coyote behavior around people. The unit also discusses coyotes and their value to a variety of stakeholders. A nature video on coyotes introduces the students to these issues. Additionally, a presentation on the different species of canids in North America, accompanied with video on each organism, attempts to situate coyotes with the other species that they are closely related to. The curriculum is designed to get the students involved by having them ask questions related to the material discussed and to have them answer questions based on these activities. The students read relevant literature pertaining to each of the daily activities and also participate in two in-class activities where they are virtual coyote biologists for the day. Windows media player videos are designed to visually illustrate the points discussed in class. Finally, the students are provided the opportunity to visit the Stone Zoo and directly observe live coyotes that I hand-reared.

Historical Context

In order to address and improve on some of the aforementioned gaps in science teaching and learning, I have been working closely with the Urban Ecology Institute (UEI) at Boston College (http://www.urbaneco.org) since arriving at Boston College in January 2001. The catalysts driving the UEI at Boston College consists of environmental lawyers, scientists, graduate students, educational researchers, and staff. One project that UEI is involved with is the Urban Coyote Ecology Project which takes place both on Cape Cod and up in the Boston area. I am the Principal Investigator of that project (http://www2.bc.edu/~wayjo) and plan on using this project as the basis for my dissertation.

Why Coyotes as an Educational Tool?

There is not much known about coyotes inhabiting urbanized areas (Way, 2000) so providing a curriculum unit that involves students in real-world science activities is important to teach them that science is a process of investigating into unknown phenomena. The experience of observing a predator like the Coyote can last a lifetime, especially for younger people. I still remember some of my wildlife sightings when I was a child whether it was in my own backyard, up in the White Mountains of New Hampshire, or out in Yellowstone National Park.

A collaborative educational and scientific study of Eastern Coyotes between a high school and university may provide a tremendous opportunity for urban and suburban high school students and their teachers to acquire an interest in science that they previously did not have. The Eastern Coyote is an excellent animal to use to teach about behavior and ecology because it is widespread in Massachusetts, having been documented in every county aside from Martha's Vineyard and Nantucket (J. Cardoza, MassWildlife, personal communication). In addition, it lives in 49 of the 50 U.S. states, Hawaii excluded (Parker, 1995). The Coyote is a predator that has generated a great amount of press regarding human and pet safety issues (Nejame, 2005). However, there is a poor understanding by the general public and, specifically, science students on the ecology of Coyotes in urban ecosystems (Way, 2000).

The importance of local, place-based authentic science opportunities is well noted in the literature (Bouillion & Gomez, 2001; Fusco, 2001; Rahm, 2002). Thus, studying this ubiquitous carnivore can provide generalizability (Schofield, 1990) to other areas of the country that desire to use coyotes or other widespread/common animals as a model for science education. In other words, the coyote's adaptability and widespread distribution gives this study potential scalability and sustainability (Fishman & Krajcik, 2003) that could potentially enable this research to be implemented in diverse settings. In this scenario, students could participate in a partnership where they work “at the elbows” of scientists collecting ecological data on Coyotes (Barab & Hay, 2001; Hay & Barab, 2001). Because the coyote is also a popular (sometimes in a bad sense) animal that is often in the news (for things such as killing cats or even just showing up in urban areas even though they aren’t a threat to people) makes it a very relevant issue to study in science education. This collaborative research project could serve as a model that may be used as a prototype for communities throughout North America to directly be involved in authentic, locally based environmental education projects (Bouillion & Gomez, 2001; Fusco, 2001; Rahm, 2002).

Why this Study?

I have always been fascinated with wildlife, particularly predators. My dream throughout childhood and during college was to go to some far off place such as Yellowstone National Park (in Wyoming) or Africa and study wolves, big cats, or any large "exotic" carnivore. However, as I was finishing up my undergraduate years at the University of Massachusetts at Amherst (1993-1997), I particularly became interested in wildlife closer to home - i.e., in Massachusetts. As I began conducting background readings and literature reviews on coyotes, I quickly realized that there was no scientific information available on eastern coyotes in all of Massachusetts and few studies had been conducted in all of the northeastern United States. Particularly, there was nothing known on coyotes inhabiting suburban/urban areas.

I became increasingly intrigued with the possibility of studying coyotes within the Town of Barnstable on Cape Cod, Massachusetts (my hometown), because of the lack of knowledge and misperceptions of coyote ecology in that region. Therefore, I applied, and was accepted in 1997, into the Natural Resources Management and Engineering Department at the University of Connecticut at Storrs where studying coyotes on Cape Cod was my master's thesis project (Way, 2000).

As I studied coyotes on Cape Cod I regularly involved high school students in the data collection process and, unknowingly at the time, was having them participate in authentic scientific apprenticeship programs. Studying wildlife was what captured my interest in science and it was why I went on to graduate school. The more I thought about that, the more I realized that I needed to provide the same experience for a myriad of students that worked with me. There is little doubt that if it was not for my intense interest in coyotes I would not have finished either my masters or doctoral degrees. In short, I felt morally obligated to share my love of animals with others and combining an educational with science degree was a perfect way to accomplish that.

While I was finishing my master's degree requirements and applying to graduate schools for a Ph.D. program, I quickly realized that there was scant funding available to study coyotes (or any other animal). At this time, I was informed of the Urban Ecology Institute. I was told that I might be able to get accepted into a Ph.D. program whereby I would involve students and teachers in the scientific research process. The plan was to start studying coyotes in Boston (much as I had done on Cape Cod for my masters research) and to use teachers and their students in the Boston area participating in the Urban Ecology Institute as subjects where I could involve them in an authentic project with the goal of having them collect robust data that would eventually be publishable in scientific journals. This idea was perfect for me because I had always involved students and teachers in the scientific process anyway, so why not "officially" include them via developing a formal educational component to the study? In essence, I thought that educating students on coyote actual natural history would be: one, an important start in improving the coyote's image; and two, an exciting way to get students to learn about and get interested in a science topic.

When I was accepted into the Lynch Graduate School of Education in January 2001 I began to work with teachers from Revere High School and officially began trying to accomplish three long-standing, joint goals of mine: 1) the professional development and science education provided to teachers; 2) the improvement of science content delivered to students through this project; and 3) the collection of data on coyotes in urban Boston. This dissertation is an attempt to work at the interface between the worlds of science and education (Figure 1.1). Introducing scientific knowledge on coyotes into classrooms and assessing the learning outcomes of this intervention is naturally a way for me to start bridging the gap.

Purpose and Overview of the Curriculum-based Intervention

The purpose of this dissertation is to understand the relationship between ecology and student learning. Specifically, I will look at student understanding and perceptions of coyotes, which are often an emotional species because of its predatory habits (see Parker, 1995). An overarching purpose of this curriculum intervention is to validate what I am doing professionally – i.e., to bridge the gap between the educational and scientific community.

The reasons why I did this study were to craft a partnership with high schools with the specific mission of working side by side students and teachers in designing wildlife studies, specifically on eastern coyotes. Using coyotes in an urban setting as a tool for student learning of animal behavior, I, along with students, teachers and UEI staff members, co-developed a curriculum and field based ecological study of coyote biology and behavior for inner city and suburban students. The partnership had the following components:

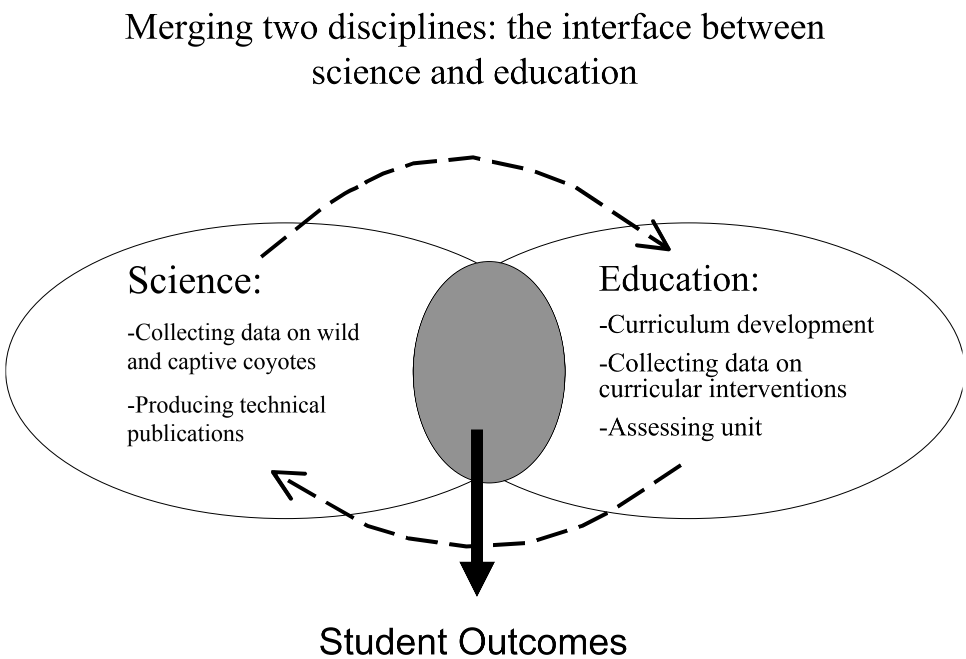
1. *Education.* Having a curriculum unit on coyote ecology in urbanized settings will hopefully empower students and teachers to study their environment.
2. *Involvement.* Collaborating with students and teachers in a curriculum guided research project on urbanized coyotes will provide an opportunity for students to experience and appreciate the natural world that is a part of where they live.

3. *Research and Inquiry*. Enabling students and teachers to learn the scientific process by collecting, recording and analyzing data obtained from curriculum guides and potentially direct research conducted on urban coyotes.
4. *Writing*. Collaborating with students and teachers in reporting findings and writing educational, scientific, and general papers.

I have two goals that I hope result from this intervention:

1. To improve student understanding of scientific content such as urban ecosystems, coyote behavior, and the scientific investigatory process.
2. To motivate and engage students from both inner-city and suburban environments to do scientific investigations that are relevant to their local community.

Figure 1.1. Diagram illustrating a researcher working at the interface between the worlds of science and education. I started with the science driving my education questions, now I am examining what education questions will drive the science.



Chapter 2

REVIEW OF LITERATURE

Introduction

In this chapter, I first delve into the field of science education. In that section, I correlate the need for collaborative partnerships (in my case, a scientist teaming up with a teacher) in order to better educate and provide curriculum for students on science issues. Later in this chapter, I examine the literature on student interest and engagement in science. In the last section, I describe environmental education and its relevance to school and society issues by providing a mechanism for meeting inquiry-based standards and as a way to promote social justice and emancipatory benefits if done in the right context (e.g., in the city). In this last section I give a rationale of why my dissertation topic, which entails studying wild coyotes and introducing a curriculum unit on coyotes into classrooms, weaves in with the goals and purposes of state and national education standards.

As a prelude to this chapter, the literature (Barth, 2001; Gibboney, 1994; Odom, 2001; Pine, Under review for publication) indicates that collaboration is strongly needed to successfully implement the curriculum intervention that I propose and will discuss more in depth in the next chapter. Change can not and will not be done alone. All constituents in a study (i.e., myself, the teachers and their students) must be involved in the process and share the same vision to successfully implement a plan (Fullan, 2001). Communication is essential; therefore, I will clearly define all aspects of the process so personnel are aware of what is expected of them at each step in the process (Love, 1999).

Thus, I will use a horizontal approach (Hall & Hord, 2001) by having all pertinent members (mainly the teachers and students) involved throughout the process. For true collaboration to occur we must have an intellectual and democratic community as identified by many researchers (e.g., Fullan, 2001; Gibboney, 1994) whereby everyone, including students, are involved in the development and carrying out of the curriculum module.

Partnerships: A mechanism to improve science education in our classrooms

Reform literature in recent years has suggested that public schools as they exist today do not adequately prepare American youth for their roles as citizens and workers in the twenty-first century (Abdal-Haqq, 1991; Kennedy, 1990). This viewpoint seems to have stemmed from the publication of A Nation at Risk in 1983 (National Commission on Excellence in Education, 1983). It has become apparent that the structure of many public schools inhibits knowledge-based teaching practice (e.g., inquiry-based learning or exploratory learning – Hay & Barab, 2001), and as a result, student learning may be inhibited to think clearly and critically, live honorably and productively, and function effectively in a social and political environment (Abdal-Haqq, 1991; R. W. Clark, 1999).

In response to public concerns about education, state and local governments have taken steps to increase children's achievement in school. Many states have adopted rigorous content standards, which describe the information that students should master (e.g., Massachusetts Department of Education and MCAS testing, http://www.doe.mass.edu). National, state, and local efforts to improve education are intended to create a fundamental shift in what students learn and how they are taught

(American Institutes for Research, 1999). The Massachusetts Department of Education (2001) has created standards and frameworks to guide education. In fact, the inquiry based learning environment aspired by the Massachusetts Department of Education is very similar to national goals in science (National Science Education Standards, 1996). For example, in their Science and Technology Curriculum Frameworks the Massachusetts Department of Education (p. 3-4) stated that:

> Investigations in science and technology involve a range of skills, habits of mind, and subject matter knowledge. The purpose of science and technology/ engineering education in Massachusetts is to enable students to draw on these skills, habits, and subject matter knowledge for informed participation in the intellectual and civic life of American society, and for further education in these areas if they seek it…Asking and pursuing questions are keys to learning in all academic disciplines. There are multiple ways that students can ask and pursue questions in (science) class. One way is to explore scientific phenomena in a classroom laboratory or around the school. Classroom investigation and experimentation can build essential scientific skills such as observing, measuring, replicating experiments, manipulating equipment, and collecting and reporting data. Students may sometimes choose what phenomenon to study, e.g., for a science fair project. More often, they conduct investigations and experiments that are selected and guided by the teacher… Scientific inquiry and experimentation should not be taught or tested as separate, stand-alone skills. Rather, opportunities for inquiry and experimentation should arise within a well-planned

> curriculum in the domains of science. They should be assessed through examples drawn from the life, physical, and earth and space science standards so that it is clear to students that in science, *what* is known does not stand separate from *how* it is known.

One way to improve student learning in science and inquiry-based activities is for schools to form partnerships with universities. In my view, an academic partnership consists of a person or people from a secondary school working with at least one person from a university. It can be as small as one person working with one other person (Handler & Ravid, 2001) or as large as entire secondary schools working with a university – these latter partnerships are often called professional development schools (Murray, 1993; Pine, 2002). In the case of this study, I am involved more closely with the former, where I have been working mainly with two teachers and their students for the past six years. Partnerships are K-12 schools that have entered into collaborative partnerships with universities to assist in the preparation of students and to serve as sites for research and development (Metcalf-Turner, 1999; Shive, 1997; Sykes, 1997). University faculty typically teach the foundation and theories of learning, along with various teaching methods while public schools provide the hands-on practice where prospective educators try out their skills in working with students (Bacharach & Hasslen, 2001). In the context of pre-service science education, the concept of a partnership centers on the collaborative relationships that are built among school faculty, students, and administration and university science education faculty and students (Westbrook, Wheatley, & Rogers, 2000).

The need for collaboration in science is important (National Research Council, 1996). Arguments for the development of partnerships in science abound (Richmond, 1996). Richmond (1996) cited a common rationale for these partnerships: In order for significant and long lasting change to take hold in the way science is taught in schools, there must be substantial interaction between those with knowledge of scientific content (e.g., university personnel) and those with knowledge of students and schools (e.g., in-service school teachers). Hence, modeling pedagogical content knowledge is an important goal of science partnerships as this may positively affect student learning and interest in science (Doster, Jackson, & Smith, 1997; Shulman, 1987). In order to address improving student learning, a number of partnerships have emerged recently in science related issues (e.g., M. R. Clark, 1996; Fradd et al., 1997; Hay et al., 2000; Lasley, Matczynski, & Williams, 1992; Sterling & Olkin, 1997; Tallman & Taylor, 1997). Providing students with authentic experiences has been a common theme and a critical component for these partnerships to succeed.

One way to provide students the opportunity to engage in authentic activities is to partner schools with scientists (e.g., Barab & Hay, 2001; Hay & Barab, 2001). In this collaboration, students can learn the scientific process through their mentors (i.e., scientists) while the scientists can provide important community outreach and at the same time receive assistance in collecting valuable data (Hay & Barab, 2001).

The need for scientists and schools to form partnerships is important and potentially beneficial for all sides (Means, 1998; Waksman, 2003; Wormstead et al., 2002), especially when engaging in an authentic scientific project. In these collaborations, students get the opportunity to learn from experts (i.e., scientists) in their respective disciplines while participating in legitimate scholarly, school-based activities. These partnerships are important because: one, they introduce students to science and the people that work in these fields; two, they may increase student interest in science; and three, scientists may serve as role models for potential future scientists.

In addition, Madsen (1996) described ways in which universities can foster environmental awareness through various partnerships. One avenue open to institutions of higher education, Madsen explained, is to introduce in-house educational programs, such as courses, curricula, programs, and centers that all have environmental awareness as their goal. Helping students learn via these means will produce a more scientifically literate and empowered population which may help improve environmental health, restore damaged ecosystems, and improve the field of science in general via important discoveries and breakthroughs in technology. Another major way that universities can fulfill their obligation to advance environmental awareness is in their research activities. Madsen (1996) noted that through these in-house environmental pedagogical and research programs, institutions of higher education should attempt to more directly influence public opinion about the environment. Extension courses, general studies programs, night schools, and weekend college programs can allow the general public to participate in and acquire useful environmental values.

With all of the money being spent on education these days we should be true to the standards (both statewide and nationally) and we should develop effective curriculum that teaches important science skills (such as inquiry-based learning) to our children.

Knapp (1997) questioned how state and national reform efforts affected classrooms, specifically what occurred in the translation from the writing and intentions of the systemic reform to actual classroom practice. One way to improve classroom practice is for schools to partner with universities.

Partnerships in practice

One particular partnership is described by Herwitz and Guerra (Herwitz & Guerra, 1996). These researchers, using interview and journal notes as their data, qualitatively described their co-study of teaching planetary science to elementary school special education students as part of a collaborative project with a university in Massachusetts. It chronicled how a partnership between an elementary school teacher and a university-based research scientist effectively shaped the teacher's understanding of values and attitudes inherent in science education (Herwitz & Guerra, 1996). Students were contributing members of a research team and the study found that students were most responsive when they were co-constructors of the learning environment. Importantly, Herwitz and Guerra concluded their study by noting that universities are centers of active scientific research communities capable of providing (elementary) school students and teachers with a model of inquiry, discovery, and accomplishment. Few school systems can afford a high technology space camp for their students, but local universities can bring the exploratory mind-state to students (Herwitz & Guerra, 1996).

In the article by Bouillion and Gomez (2001), "*Connecting School and Community with Science Learning: Real World Problems and School-Community Partnerships as Contextual Scaffolds*," the researchers described a partnership that bridged the disconnect that existed for students between science (and school) and real world everyday issues. The authors presented a real world problem (river pollution) and showed how fifth grade students and their teachers could create partnerships with the community to fix/solve a problem in a mutually beneficial way to all project participants. This study provided qualitative data to demonstrate that students improved in their ability to access information, form questions, share ideas, and analyze and compare data. Additionally, students talked about an increased sense that they matter, that their voices can be heard, and that they can make a difference in the world – essentially, the students felt empowered because they did something good for their community (Bouillion & Gomez, 2001). The feature that real-world problems have no clear answers afforded a repositioning of authority in the classroom where teachers were able to engage students as co-contributors and co-investigators (Bouillion & Gomez, 2001).

Similar studies (Fusco, 2001; Rahm, 2002) have also noted the importance of local community events to aid in students learning science. For example, in Fusco's community based urban gardening project she found that the practicing culture of science learning was important and relevant because: it was created from participants' concerns, interests, and experiences in and outside science; was an ongoing process of researching and then enacting ideas; was situated within the broader community. In this study the enactment of science included access to practical science knowledge and the opportunity to engage in science and action research that served a purpose within the community. Importantly, young people (i.e., students) were at the center of this interaction giving their work relevance and meaning to their activities.

Rahm (2002) demonstrated that people learn science in a variety of ways, for a variety of purposes, and from a variety of sources. Using an urban gardening program as her means to involve students in informal science education, Rahm found that the science that took place in the course was authentic in the eyes of the youth and meaningful in the context of their everyday lives. Most important, youth were the creators and not merely the consumers of the science curriculum.

The results from these studies underline how children can become masters of the science embedded in their everyday communities and practices if provided with opportunities to do science that is meaningful and real to them (Rahm, 2002). These reports challenge the formal model of science teaching, in which adults teach and children learn, instead emphasizing community learning, which defines every person as a learner exploring an issue of genuine concern to the community (Rahm, 2002). A conception of children as their own creators of knowledge, and of adults solely as guides in this process, is an important vision to keep in mind when crafting science education reform strategies.

In addition, Wormstead et al. (2002) described a student-teacher-scientist partnership (STSP) where students collected standardized data from their surroundings to be used in professional research studies. Teachers introduced curricula related to these studies thereby giving students authentic hands-on discovery learning. Unfortunately, the authors noted that a lack of funding can be a major barrier to implementing an STSP. Although Wormstead et al.'s paper was written essentially to develop a draft training material design criteria for STSPs, the concept could potentially be very promising for future partnerships leading to increased student learning of science.

The authentic research projects previously described are precisely the frameworks that I will use for this study which will entail a science-oriented collaboration between Boston College and three high schools (including one pilot school). However, rather than spending a short period of time with this teacher and his students (e.g., like Barab & Hay, 2001 did in their study), I plan to be involved in this project for a sustained period and hope to give the teachers and students the capacity to continue the coyote project which consists of both the curriculum unit in the classrooms and field-based activities in the wild.

It is clear that partnerships between scientists/universities and schools is important and beneficial because each setting gets to use the resource of the other where, in my opinion, the whole exceeds the sum of its parts. However, in order to be truly effective, there must be more rigorous assessments of student learning and engagement in the activities that take place. After all, improving student outcomes should be the goal of any educational endeavor.

Student understanding and engagement in science

There is mounting evidence that one component of the science education reform process must be a sustained effort toward making the study of science accessible to more students (Jones, 1997). For example, it was found that only 7 percent of all positions in science and engineering were held by minorities despite constituting 24 percent of the current United States population (National Science Foundation, 2002). Furthermore, reports have indicated that United States students rank very low in science scores with only 2 of 20 nations behind them in international tests (Glenn Commission, 2000). When race is considered, the difference is even more pronounced: while the scores of white students in the U.S. were exceeded by only three other nations, black children were outscored by every single nation (Berliner, 2001). Despite this disparity, documents clearly put forward the idea that all students, regardless of culture, gender, and/or race, are capable of understanding and doing science (National Research Council, 2002). Because 53 % of African-Americans live inside cities and 88 % reside in metropolitan areas (United States Census Bureau, 2001), it is critical to engage and motivate urban students to learn science in order to achieve many of the goals of the National Science Foundation (2002), such as diversifying the workforce.

Overall, there has been a dearth of studies that have had a primary focus on the needs of urban students and their science teachers even though 75-80% of the U.S. population resides in urban centers (Barton, 2001; Barton & Tobin, 2001). The literature indicates that providing resources (Spillane et al., 2001) and valuing relevant active learning environments in classrooms is important for students to be able to engage in the practicing culture of science learning in urban settings (Fusco, 2001). Therefore, science learning and experimentation must take place in urban schools (Bouillion & Gomez, 2001) as well as in informal (i.e., zoos), more traditional science learning environments (Hofstein et al., 1997).

Interest and Engagement

It is increasingly recognized that authentic learning opportunities are one way to make science more relevant to all students (Bouillion & Gomez, 2001; Fusco, 2001; Rahm, 2002). Odom (2001) noted that outdoor-based activities is not the exclusive domain of exotic wilderness settings, but worthwhile field projects can be done in any setting, including cities. The important thing is that inquiry-based activities allow one to experience, not just imagine, reality (Thomson & Diem, 1994). Importantly, these inquiry based activities are an important national and state framework for the science standards (National Research Council, 1996, 2002).

Kahle et al. (2000) found students in inner city areas could learn science effectively if their teachers are well prepared and use standards based teaching practices. Not surprisingly, they found that increased student involvement in inquiry-related science activities, some of which could be provided in after-school programs like the coyote study, may help increase minority interest in science. Inner-city African-American students often struggle between representing their own cultural norms or conforming to mainstream standards (Teel et al., 1998). Teel et al. noted that inappropriate teaching strategies often cause poor performance. A way to reverse the trend is to involve students directly in real world community science projects (Fusco, 2001; Rahm, 2002).

Another important benefit of environmentally related inquiry-based projects in urban areas is the education that many minorities (e.g., African Americans) (Barton, 2001; Seiler, 2001) and women (Rohrer & Welsch, 1998) are receiving. People of color have typically underachieved in education (Norman et al., 2001; Seiler, 2001) and are subsequently woefully underrepresented in many professions, particularly those related to the sciences and technical fields (Haury, 1995). There is no single explanation for the gap, but (Haury, 1995) lists two factors that have to do with the disparity: first, African Americans experience more obstacles along the path to careers in science; and second, they have fewer opportunities to see people like themselves in the sciences. Likewise, George (2003) showed that students have fairly positive attitudes about the usefulness of science but future research needs to focus on students' attitudes about the utility of science and why fewer and fewer students pursue careers in science.

Kahle et al. (2000) noted that African-American girls tend to outperform boys on measures of science achievement. African-American males, when compared with their female peers, have a disproportionate number of school suspensions, expulsions, and absences. Teachers also tend to have lower achievement expectations for African-American males than females, which can negatively affect male students' motivation to learn (Kahle et al., 2000). Furthermore, there are peer pressures for males rather than females to not succeed in order to not be perceived as "acting white." Perhaps not surprising from this discussion, black students receive proportionally less degrees than their white counterparts with 73.8 versus 83% receiving high school diplomats and 13.2% compared to 24% earning college degrees (Teel et al., 1998). Therefore, it is important to give urban students, many of them black, place-based (e.g., local) outdoor field and classroom experiences (Kahne et al., 2001; Woodhouse & Knapp, 2000), in order to attempt to empower a historically underrepresented segment of society in the field of science.

The citizenry must be scientifically literate to fill the high-tech workplace (Zady, Portes, & Ochs, 2003). Additionally, they must be literate enough to have the political will to support the scientific research enterprise. The approach of science education has shifted from the traditional memorization of facts and concepts in separate specific disciplines to inquiry-based learning in which students actively seek answers to their own questions (National Research Council, 1996). Gibson and Chase (2002) summarized the literature and noted that many studies conducted with middle and high school students found that inquiry-based science activities had positive effects on students' science achievement (including on science achievement tests), cognitive development, laboratory skills, science process skills, and understanding of science knowledge as a whole when compared to students taught using a traditional approach. Additionally, they reported that studies have shown that students who use an inquiry approach have improved attitudes towards both science and school while other studies show more negative attitudes resulting from traditional methods. In essence, these inquiry-oriented approaches could improve scientific literacy in our classrooms. But will it also improve student interest and engagement in science? Future research needs to elucidate the answers to this question

Specifically Gibson and Chase examined the long-term impact of inquiry-based science programs following a two-week summer science camp. Interestingly, although the authors found that most students enjoyed the experience with over three quarters showing an increased interest in science, they found that all students' attitudes towards science and interest in science careers decreased as they went from middle to high school.

In that study, the greatest influence on students' attitude and interest in science appeared to be their science teachers. Indeed, the authors found that teachers' instructional methods have an impact on students' attitudes towards science. Many science teachers in the middle schools of the students participating in the study used inquiry-based, hands on approaches while high school teachers used traditional teaching methods, such as lectures, note taking, and lab demonstrations rather than student-directed lab explorations. The authors concluded that when science is taught using an inquiry-based approach, students remain interested and become motivated and more engaged to put more effort into their studies. Likewise, students in the summer camp maintained a more positive attitude towards science and a higher interest in science careers than students not exposed to the camp.

Science activities tended to infuse meaning causing the students to value the learning experience. Current emphases on interactive, hands-on, or inquiry-based learning is influenced by the constructivist approach which acknowledges the student as actively making his or her knowledge (Zady et al., 2003). Zady et al. noted that a script (i.e., curriculum) that included the activities, as compared to relying on the text or a lecture, engaged students in more appropriate behavior and offered more opportunity to learn. Interestingly, the authors noted that, despite the documented importance of hands-on learning, the chief mode of teaching for high achieving students was still teacher-directed instruction.

Learning is a generative process requiring effort in which learners actively construct their own meanings that are consistent with their prior ideas rather than passively acquiring knowledge transmitted to them. If prior knowledge and disciplinary knowledge do not connect and intertwine, learning of scientific knowledge is reduced to rote memorization of facts (Chin & Brown, 2000). Chin and Brown noted that when students engage in meaningful learning, they are purposeful and constantly monitor and reflect on the process of learning to evaluate the results of their own learning efforts. A deep learning approach, they noted, is associated with intrinsic motivation and interest in the content of the task, a focus on understanding the meaning of the learning material, and personalizing the task. Using this approach, as opposed to a surface approach where a student perceives the task as a demand to be met, students were more persistent in following up on an idea with some sustained interest before moving to another one. The authors noted that when students use a deep approach to learning, they do not necessarily have to come up with correct ideas all the time. Rather, deep processing strategies could also help them direct conflicts between the evolving ideas and what is correct which would improve learning in the long run. Similarly, Crawford et al. (2000) found that learning science was constructed as a social accomplishment with students interested in topics because it had meaning for them and because they initiated science explorations under the conditions of uncertainty.

Content

I have previously discussed the benefits of partnerships earlier in this chapter. However, it is just as important to document the effectiveness of these collaborations and/or subsequent student learning that results from these partnerships. For example, although there are 6,314 sources in The Bibliography of Students' and Teachers'

Conceptions and Science Education by Reinders Duit (2003), none of these studies addressed the question of student and teacher learning of animal behavior.

A few conference proceedings have addressed student learning of animal behavior (Golan et al., 2002; Hay et al., 2000; Margulis et al., 2001). Hay et al. found that students could participate in science by designing virtual reality models of gorillas; these authors noted that students became aware of gorilla behavior but more effort was needed for them to understand actual gorilla behavior and body postures. The use of technology, such as videos, was found to scaffold student learning, or provide support to enable learners to succeed in more complex tasks, and thereby extend the range of experiences from which they could learn (Golan et al., 2002). Videos, a way to learn in a simulated fashion (Barab & Hay, 2001), allowed students to compare animal behaviors exhibited by different species in Golan et al.'s study. Lastly, Margulis et al. found that a zoo field trip was a very good way to supplement student learning initiated in the classroom. In essence, these studies suggested that combining simulation and real-world authentic experiences were important to help students learn about animal behavior.

Research findings indicated that children of about age eleven are skilled in observing phenomena, recording data, and identifying the effects of a single independent variable on a dependent variable (Keys & Bryan, 2001). However, when faced with more complex concepts, students exhibit difficulty and much poorer performance. Decontextualizing inquiry investigations into discrete process skills prohibits synthesizing and elaborating scientific knowledge, as well as causing motivational problems (Keys & Bryan, 2001). Again, meaning must be given to students or the curriculum will not be relevant to them. Without incentive or understanding of why they are collecting data, children may not strive to produce clear results.

Most new inquiry interventions have been implemented at the elementary and middle school levels while little research on inquiry-based instruction has been conducted at the high school level (Keys & Bryan, 2001). Thus, Keys and Bryan noted that studies of learning from inquiry-based approaches in the secondary classroom are necessary in light of the difficulties conducting inquiry in the more constraining high school environment.

The literature indicates that student interest and engagement in science are greatly enhanced when learning is made more meaningful and inquiry-based. Future curriculum units should strive to achieve those joint goals when teaching students science based knowledge, especially in urban, minority dominated, areas.

Environmental education: A need for place-based local studies

A discipline of science, environmental education, is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution (Stapp & et al., 1969). Environmental education is also a process with the concept of developing a world population that is aware of and concerned about the total environment and its associated problems, and has the attitudes, motivations, knowledge, commitment and skills to work individually and collectively towards solutions of current problems and the prevention of new ones (Tbilisi Declaration, 1998). Culen (1998) described the primary goals of environmental education as developing environmentally literate citizens and to promote responsible environmental behavior. Considering that some say that one of the primary goals of education is to foster societal values and promote certain desirable behaviors (Fullan, 2001), the goals of environmental education could be viewed as being very consistent with general education and societal goals. Despite this parallel, environmental education is far from the mainstream of our educational systems and in numerous states and countries it only receives sporadic attention (Culen, 1998).

Hudson (2001) noted that one of the greatest challenges for education in general is to produce measurable results (e.g., on standardized tests), which is a benchmark behind the national No Child Left Behind Act (http://www.publiceducation.org/nclb_actionbriefs.asp). Reaching this goal is neither easy nor devoid of the politics of testing and the endless philosophical debates over what constitutes marked increases in learning and knowledge (Hudson, 2001). However, environmental education provides some exciting opportunities for enhanced learning and sharpening observation and inquiry based problem-solving skills (Loucks-Horsley et al., 1990), which may help produce measurable outcomes (Bjorkland & Pringle, 2001; Hudson, 2001).

Hudson (2001) also mentioned that a clear understanding of why we are educating our children will give us guidelines on the structure of educational programs. He then commented that there is a fair consensus among all involved in debates about educational reform that one of the principal goals of education is to enhance the ability of children to become productive members of society (Fullan, 2001), as well as to advance a variety of skills that are productive for the development of the child. Therefore, the most significant benefit from environmental education may be in teaching children to become responsible and productive members of society. Environmental education, a vital component of efforts to solve environmental problems, must stay relevant to the needs and interests of the community and yet constantly adapt to the rapidly changing social and technological landscape. It requires the recognition of appropriate and meaningful strategies to help students discover more about the natural world, assemble information and facts, and solve problems (Hudson, 2001).

Madsen (1996) argued that universities have an obligation to nurture environmental awareness and education for two reasons. First, such an obligation comes from the very nature of institutions of higher education whose missions are primarily social in nature. Universities are the main places where free inquiry is undertaken in order to further the common good and there is probably no other single more important aspect of social welfare than environmental protection and restoration (Madsen, 1996). Second, universities and professional schools have an obligation to promote environmental awareness because these places are in a unique position to contribute to the environmental movement. Odom (2001) noted that the challenge to universities is to create optimal collaborative learning situations in which the best sources of science and education expertise are linked with the experiences and needs of the teachers. This will require substantive changes in science teaching at the university level.

The philosophy behind a successful environment partnership involving schools is that place-based (e.g., local) curriculum in informal (or nonformal) outdoor settings, will help participants (teachers, students, and community members at large) achieve local ecological and cultural sustainability (Hungerford et al., 1998; Thomson & Diem, 1994; Woodhouse & Knapp, 2000; Yerkes & Haras, 1997). I define sustainability as being within carrying capacity of local resources, both ecological and culturally (i.e., having an understanding of how one relates to their local environment). Informal, genuine authentic learning environments provide firsthand experiences for people of all ages (Fusco, 2001; Hudson, 2001; Schwartz, Lederman, & Crawford, 2004). A key link between informal experiences and learning is reflection, or thinking back on an experience. That is precisely why field-based experiences are complemented with teacher-instructed classroom activities. For instance, I have discussed that Rahm (2002) showed how people learn science in a variety of ways, for a variety of purposes, and from a variety of sources. Using an urban gardening program as her means to involve students in informal science education, Rahm found that the science that got done was authentic in the eyes of the youth and meaningful in the context of their everyday lives. Most important, youth were the creators and not merely the consumers of the science curriculum.

It is important to mention here that when I refer to field-based experiences I am writing about outdoor activities associated with research and data collection using the scientific method (e.g., Way, 2000); I am not referring to the traditional educational definition of field-based experiences as student teaching (e.g., Huling, 1998).

Out-of-school experiences can be effective in helping students develop accurate concepts related to the environment that they inhabit (Howe & Disinger, 1988). In addition, the concept of outdoor education relates well to many recent educational innovations, most of which I have mentioned throughout this chapter. Service learning, constructivism, problem-based learning, cooperative learning, and interdisciplinary learning all translate well to learning in outdoor settings (Disinger & et al., 1988; Heimlich, 1993; Loucks-Horsley et al., 1990; Richardson & Simmons, 1996).

A Final Word

My study will attempt to engage a study of Coyotes in high school classrooms. Therefore this dissertation will attempt to fill in gaps in the education literature by addressing two questions:

1. Student learning of animal behavior (specifically on Coyotes).
2. Student involvement, interest, and empowerment in science issues.

As mentioned at the outset of this chapter, a collaborative educational and authentic scientific study of eastern coyotes between a high school and university may provide a tremendous opportunity for urban high school students (and teachers) to acquire an interest in science that they previously did not have. I believe the reason why an eastern coyote is an excellent subject to use for science and environmental education is because it is widespread, occurring in all U.S. states except Hawaii, and is a predator that can generate much excitement, both good and bad (Nejame, 2005; Parker, 1995). Co-developing a curriculum and field based ecological study of coyote biology and behavior that can be used as a template for a wide range of schools may give this study sustainability and scalability (Fishman & Krajcik, 2003) that can be used in a variety of contexts (Squire, MaKinster, Barnett, Luehmann, & Barab, 2003) where students can participate in place-based meaningful studies (Bouillion & Gomez, 2001; Fusco, 2001).

Chapter 3

METHODOLOGY AND PROCEDURES

Introduction

The purpose of this study was to study the impact of a curriculum intervention on eastern coyotes. Developing a curriculum on coyotes inhabiting an urban setting, I assessed the learning and attitudes that students showed during the two week curriculum interventions. Specifically I focused on two teachers' classrooms and their students from two schools in the Boston area.

This study provides data on two high school classrooms' perceptions of coyotes before and after a curriculum intervention. It is anticipated that the general findings from these local, place-based studies will inform policy makers how to incorporate authentic activities into classrooms. As stated in chapter 1, I view authentic science activities as providing an opportunity for students to learn how scientists conduct their research; this could be by directly participating with scientists or in simulations (see Barab & Hay, 2001) such as videos taken from research activities (indirect participation) that are brought to schools. The simulation perspective of authenticity provides the possibility for students to engage like scientists where it is not feasible to take students into the scientists' domains for monetary and/or logistic reasons. Ultimately, this study may provide generalizability whereby this model and its' related curriculum materials could serve as a prototype for a diverse range of schools attempting to initiate a novel, environmentally-based unit on local wildlife; advanced schools may even initiate a research study on the subject (Schofield, 1990).

The crucial goal of the project is to empower students (and their teachers) by building capacity – i.e., by the end of the study the teacher and their students will have the tools to be able to use the curriculum and potentially even conduct field studies on coyotes on their own. Therefore, the goal is to make the coyote curriculum and the associated study sustainable over the long-term even without a school-university partnership in place. Having studied and published technical papers (Way et al., 2001; Way et al., 2002; Way et al., 2004) on coyotes helps ensure that accurate content is being delivered to the students via the curriculum unit.

Design of the Study

The methodological framework for this project attempts to engage in an ongoing, evolving design or teaching experiment (Barnett, 2005; Cobb, 2000; Collins, 1992; Dede, 2004; Kelly, 2004; Lesh & Kelly, 2000). Design experiments are intended to transform classrooms from academic work factories to learning environments that encourage reflective practice amongst students, teachers, and researchers (Brown, 1992). From this perspective, theory is seen to emerge from practice and to feed back to guide it (Cobb, 2000). Cobb (2000: p. 309) noted that "the basic relationship posited between students' constructive activities and the social processes in which they participate in the classroom is one of reflexivity in which neither is given preeminence over the other." Thus, neither individual activities nor classroom practices can be accounted for adequately except in relation to the other and analyzing students' activity as it is situated in the social context of the classroom should be emphasized (Cobb, 2000). Lesh and Kelly (2000: p. 201) noted that a well-designed teaching experiment creates conditions that optimize the chances that development will occur without dictating the directions that this development must take. In other words, by providing rich opportunities for investigators to express, test, and refine their evolving constructs, it is possible to simultaneously stimulate, facilitate, and investigate the development of key constructs, understandings, and abilities (Lesh & Kelly, 2000). A basic assumption that underlies teaching experiments is that there are no self-regulating systems that develop in isolation from one another – rather there tends to be a focus on development and interactions (Lesh & Kelly, 2000). Barnett (2005) stated that goals influence and co-evolve with the design/scientific process because they are often ill-defined and uncertain by nature and therefore students squarely construct rather than receive knowledge.

Teaching experiment methodology is a shift from traditional positivist epistemology of practice where theory is seen to stand apart from and above the practice of learning and teaching to one of a reflexive relationship between the two (Barnett, 2003; Cobb, 2000). Data interpretation in teaching experiments should not be left until the end of the project when all of the data collection has been completed; instead, it should occur continuously throughout the study (Lesh & Kelly, 2000). Thus, research is best conceived as a dialectical process through which both teachers and researchers work together to try new teaching strategies in the classroom and to evaluate the outcomes (Barnett, 2003). In this sense, collaboration between participants (e.g., student, teacher, and researcher) is important in order for teaching experiments to be implemented and conducted successfully. For instance, in this study, students and teachers were part of a collaborative research team developing curriculum on coyotes that involved the details of trapping, radio-collaring, and radio-tracking coyotes in the Boston area and on Cape Cod. The curriculum describes the ecology and behavior of coyotes, especially in urbanized areas. Working with multiple stakeholders will ensure that this curriculum unit is useable and potentially transferable to other settings (Cobb, 2000; Fishman & Krajcik, 2003). Similarly, practioners and researchers will work together to evaluate the efficiency of the instructional instrument that is created through the teaching experiment. Despite the quest for making our curriculum unit usable to other settings, it should be noted that this investigation is likely to collect different information, and different patterns or regularities are likely to be emphasized than what other researchers might find conducting a similar study (Lesh & Kelly, 2000). That is the nature of a teaching experiment.

We worked together to seek solutions and identify problems and to use our research findings to help solve problems. The purpose of this study is to understand the relationship between student learning and the coyote curriculum unit. The reason for doing this study is to try and promote social change by educating a wide array of people ranging from community members to project participants through the influence of the information that we collected on coyotes (Rossman & Rallis, 1998). Furthermore, teachers and students will be more able to solve their own problems, renew themselves professionally, find their voice, and develop a sense of agency using this research guide (Pine, Under review for publication).

Accordingly, this study relied on mixed methods but was largely a naturalistic, qualitative study (Lincoln & Guba, 1985; Rossman & Rallis, 1998; Schram, 2003) with some quantitative components. Using these methods as a source of data collection, the specific research question that served as the focus of this study was:

- How does a curriculum intervention that anchors instruction to the study of urban coyotes affect student learning and beliefs? Specifically, I examined these sub-questions related to the above inquiry:
    1. What happens to students' knowledge of coyotes after participating in the curriculum unit? In essence, I examined in detail how this teacher-researcher collaboration affected high school students' perceptions of coyotes.
    2. What happens to students' engagement and empowerment in science issues after introduced to our place-based intervention? What happens to student academic performance when students' participate in authentic scientific investigations on coyotes?

The Pilot Study

Prior to collecting data, I used two of Peter Auger's (no pseudonym) Ecology classes and his students at Barnstable High School, on Cape Cod, as a pilot for this study. I was in his classes for 3 full weeks from 20 September to 8 October 2004. We covered all 10 of the daily lesson plans (see Table 3.4) during the three week unit.

Pete has taught in the Science Department at Barnstable High School (BHS) for over 25 years. I took his class during the 1992-1993 academic year when I was a senior at BHS. He has a Ph.D. in Biology from studying diamondback terrapins. He is also an adjunct professor at Boston College. Pete teaches all upper-level elective courses, specializing in Ecology and Independent/Advanced Studies at the high school and teaches similar courses at the college level. The curriculum that we developed for this study complemented his courses. Previously students received credit in the advanced studies course that he taught for conducting field research on many animals, including coyotes. However, that class is no longer taught and instead he now (for the 2004-05 year) teaches a seminar for struggling upper-classmen and women trying to graduate from high school. This class is very similar to the two Urban Ecology classes that I studied at Wolf High School (see below). In addition, he is teaching three college preparatory classes. For this project, I introduced the curriculum to the low level seminar class and one of the college preparatory courses that was back to back with the seminar class; Pete taught the other two CP classes. I have worked with Pete since I was in high school and know that his classes directly reach ~100 students a year. Barnstable, with 47,000+ residents, is a multi-cultural suburban town located in the middle of Cape Cod, Massachusetts. There are 796 people per square mile within Barnstable's 60.1 mi^2 (United States Census Bureau 2000 estimates). The town ranges from rural-like in character in the village of West Barnstable to urban in Hyannis. In Barnstable, 91.9% of its residents are Caucasian, 3% are African American, 1.7% are Hispanic, 1.1% are Asian, 1.1% are Native American, and 2.3% are listed as two or more races (United States Census Bureau 2000 estimates). Being from Barnstable, the 2.3% listed as two or more races gives the impression of a higher percentage (i.e., ca. 7-8%) of minorities residing in the town. In addition, the town is becoming increasingly more diverse especially in its urban core of Hyannis. Six percent of the town's residents are below the poverty line. Because I know the area so well I found this a perfect location for a pilot study.

Barnstable has 12 public schools: 8 are elementary schools, three are middle schools including one Horace Mann charter, and one is a public secondary school (Goetz, 2003). There are more than 7,000 students in the school system; 600 teachers and 400 members of the non-teaching staff (Goetz, 2003). In addition, there is one Commonwealth Charter School (Sturgis High School, located in Hyannis) that is independent of the public school system and six private schools in the town (http://profiles.doe.mass.edu/search.asp?mode=g&county=Barnstable&town=465). There are ~140 teachers and 2,000 students at Barnstable High School (http://www.schoolmatch.com/search/school.cfm?school_lea=00116&lea=2502310). In spring 2000, Massachusetts Comprehensive Assessment System (MCAS) scores at Barnstable High was 232 for English Language Arts, 230 for Mathematics, and 230 for Science/Technology compared to statewide averages of 229, 228, and 226, respectively (Massachusetts Department of Education – http://www.doe.mass.edu).

The students had a quiz and an examination as Pete typically gives them on each Friday. One of their in-class activities also counted as a quiz grade. Because Pete taught three levels of students, the examinations were developed that had different levels of question probing based on the same material covered. I gave four pre and three post-interviews.

The pilot was very successful in enabling me to assess the effectiveness of the curriculum unit. I quickly discovered that the amount of participating that the teacher does greatly affects how much material can be covered in the unit. For example, Pete, very familiar with the study, constantly interrupted and asked questions. While it made the class much livelier, it also made it difficult to fit into a set time-frame. Likewise, this three week experience taught me to be adaptable in time spent on issues and the order of topics covered based on student and teacher interest in particular topics. This process of reflecting and revising was in accord with the aforementioned design experiment technique. The varying length of classes (from 60 – 86 minutes), both in terms of true length (i.e., from bell to bell) and usable time (i.e., when the teacher was not taking care of other things like attendance) made it imperative to make the curriculum adaptable. For example, on some days Pete was talking about something not related to coyotes at all (like the amazing absence rate at BHS) and I would only have 30 minutes on that day. Then on other days, he would be busy and I would have virtually the entire 60 minute segment to teach. Thus, the pilot study was necessary because it let me practice teaching the material in varied time frames. Additionally, I was able to practice focusing on assessing the students (e.g., field/classroom notes) in design experiment fashion before I actually entered my two focal classes. In other words, it would have been very challenging to focus on assessment strategies at Coyote and Wolf High Schools if I had not previously taught/practiced the unit.

I discovered that the varied structure of the class (for example, lecture, activity and field trip to the Stone Zoo) was very desirable. Different students like different parts (e.g., mostly lectures versus mostly hands-on related learning) of the curriculum unit making it important to give them multiple learning opportunities. Most importantly, it seemed like the students liked the curriculum unit. They asked lots of questions, loved the videos, and told me that they thought the videos (in windows media mpeg format), illustrated what we talked about very well during the powerpoint part of the lectures. Because of these comments, I concluded that the curriculum was authentic to the students. Many students commented that they liked the coyote project and were intrigued by the Cape Cod component of the study because it sometimes occurred literally in their backyard (for example, if a coyote ran through someone's yard). Students often asked questions related to the videos and often caused a reformatting of my lecture outline because they asked so many questions. They told me that the videos made them feel like they were there, which is similar to Barab and Hay's (2001) description of simulated authenticity. In other words, while students wrote down information from the powerpoint slides, the video-clips gave them a somewhat hands-on approach to learning even though they weren't directly participating in the study. Because of the students' interest in the videos I made sure to add more questions to the pre and post interviews for the two high schools that I studied for this dissertation in order to better uncover why and how the videos helped students learn.

I discovered that the combination of explaining in depth about our research along with having a couple of general lectures describing different types of canids and stakeholders associated with coyotes was invaluable (see curriculum description below; Table 3.4). The background information helped to set the stage for how coyotes fit into our society and the natural world. The specific information gave students an authentic glimpse into our study (e.g., such as seeing us trap, collar, then monitor an individual coyote). The pilot study allowed me to refine some grammatical errors and to add information as I saw fit in individual lectures.

The pilot also showed how effective some of the hooks were. For example, the full sized life-like posters of the five captive coyotes shown throughout the class certainly added to the experience of the coyote curriculum unit. Because the posters were roughly life-sized, students were able to see what a real coyote looked like. The videos made the lecture descriptions seem more realistic which the students certainly liked. Two in class activities (one on tracking wild coyotes; the other on studying captive coyote behaviors) gave students the opportunity to authentically see how research is carried out on coyotes. Finally, Wile E. coyote video clips, shown in 30 – 60 second clips nearly each day, provided an entertaining break for the students while still covering the coyote theme. Although this might not have had much of an impact on student understanding of coyotes, they did get to think about coyotes in a different vein and to realize that the coyote that is portrayed (e.g., Wile E) is often very different than the actual creature.

The pilot also demonstrated to me the importance of adaptability on the teacher's part. Student questions frequently altered the presentation of the lecture which, in design experiment fashion, I tried to answer in order to maintain their interest and to satisfy their curiosity. For example, if a student asked a question about a topic that I was going to cover I tried to answer the question(s) in the order of how it was brought up. A student once asked, "Why do coyotes howl?" I naturally answered that question and made them responsible for the material before moving on; however, I was going to originally cover the howling topic later in that class anyways. These experiences informed my research design such that I only focused on relevant student comments related to the daily activities. If students asked random questions I told them that we could discuss that later or that we would cover it during a different day. I believed this strategy was important in order to try and maintain student interest and active involvement in the unit while also providing some structure to the class periods. For instance, if someone asked me how many coyotes are on Cape Cod and we were talking about coyote ecology, then that question allowed me to expand on the coyote home range and territoriality component of the unit. But if I was talking about how to catch a coyote and someone yelled, "Do coyotes make good pets?," I then told them that that wasn't an appropriate time to discuss that.

The teacher's involvement or lack thereof made a big difference in how much material was covered. When Pete wasn't in class (personal days) I covered considerably more information than when he was in class. In my classroom observations I frequently noted how difficult it is to cover a set amount of information when Pete actively participates in the class dialogue – like asking questions pertaining about coyotes. While the added dialogue certainly enriched much of the class discussions as previously mentioned, it was also frustrating when a fraction of a given amount of an entire days worth of agenda was covered. While not a focus of this dissertation, co-teaching can certainly present some interesting dilemmas like covering more material or getting more in depth in a given topic. For the purposes of this dissertation, I realized that this would be a huge wild card in the amount of material that I would cover in my two focus classrooms. Thus, I prioritized my lectures to ensure that if this happened in the two other settings, that I would at least cover the lectures which I felt were the most important.

I also learned that it was important to try and fit in my curriculum unit with the particular teacher's teaching style. From my experience with Pete, he wanted the students to be responsible for everything covered in class. So while I had a set agenda, it often took unexpected turns when Pete and/or a student(s) asked questions, literally steering us in a different direction. On one of the days I picked up a road killed coyote and put it in his freezer at the high school. The next day the students were very lethargic and were not active in the class discussion. Using a teaching moment that was not originally planned, I (with Pete's approval) took out the coyote and dumped it on a vacant laboratory bench and started talking about this coyote from Centerville, right where a few of the students were from. They initially did not believe us that there was actually a coyote in the freezer. The actual body proved beyond reasonable doubt that we did indeed have a coyote carcass in the classroom. The students were then responsible for this spontaneously provided information on examinations. This experience lead me to try and produce spontaneous information to the class to keep them on their toes and to also work with the teacher to meld my lectures and activities into their teaching scheme. For instance, if the students were responsible for material in a certain way (e.g., tests versus journals), then I would try to work with the teacher to ensure that we made the students responsible for the appropriate information.

The students also visited the Stone Zoo and saw me interact with the live coyotes that I hand-raised. This was important for the students to get to learn and see real coyotes and to ask questions about them. The students already knew a lot about the coyotes based on the previous lectures and it was at this point that I knew the curriculum unit was successful in providing active (hands-on) and authentic learning opportunities. While at the zoo they asked more in depth questions like, "Why did Cane do this or that to Caon?" as opposed to something like, "Which one is Cane?" This experience demonstrated the importance of students' directly seeing the coyotes and the hands-on involvement that stemmed from this trip. The students seemed to take ownership of the coyotes because they were familiar with the coyotes and knew them individually. This empowerment has been found to be an important outcome of involving students in authentic research projects (Bouillion & Gomez, 2001; Fusco, 2001). The hands on nature of a zoo trip is consistence with the importance of informal field trips that supplements school-based activities (Hofstein, Bybee, & Legro, 1997). Following this success, I immediately contacted the other teachers to arrange a field-trip as part of the interventions.

By the end of the unit students knew quite a bit about our study including the cast of characters that make up our radio-collared and captive coyote research subjects even though they were not actively tracking and catching the coyotes (most have never even seen one). Students seemed to feel involved in the study because they learned about individual coyotes (like Casper, a very large female from the village of Cummaquid on Cape Cod) which informed us that the local, place-based nature of the study was very important. These findings are in accord with other studies (Barnett et al., 2004; Rahm, 2002).

In summary, a key part of the pilot study was just testing the efficacy of the curriculum unit. The pilot did not significantly change my research; rather, it informed me as to where to make slight changes in my research design. My work at Barnstable was successful in showing me that the curriculum unit was legitimately liked by the students; I only really had to revise or add minor things in the lectures and assessment pieces (e.g., revising survey and interview questions) which fine tuned it for the actual classes that I visited in this dissertation. In true teaching experiment fashion I was adaptable to the nature of the classroom environment by being cognizant of what the students wanted to learn along with what content needed to be covered. This pilot study also demonstrated that things can be quite variable in time and energy depending on the days. Some days I covered a lot; other days I barely seemed to get going before the class ended. Technology problems (like my computer not displaying on Pete's two televisions) and student and teacher participation all made this pilot experience quite challenging but essential to ensure greater reliability of the curriculum piece in subsequent interventions.

Settings and Participants

Access and Entry

This research project was conducted at two schools in the Boston area. The two participating schools are public high schools that the Urban Ecology Institute (UEI) has been collaborating with for about five years each. I received permission as well as support from the administration of all of these schools before each intervention occurred. In addition, I obtained approval from the Institutional Review Board (Protocol Number 05.047.01) at Boston College to conduct this research.

The participants in this study were the students of the two high school science teachers that taught environmentally based courses at their respective schools. The north Boston school (Coyote High School, pseudonym) was urban, and the South Boston school (Wolf High School, pseudonym) was inner-city based. I focused on studying one (Coyote High School) and two classes (Wolf High Schools) ranging from low level (Wolf High) to intermediate (Wolf High) to advanced placement (Coyote High). The teachers were chosen to be the focus of this study based upon their past active involvement with UEI. The Coyote High School teacher has participated in the coyote study and is well versed in coyote biology and behavior. He is overwhelmingly in favor of teaching about the coyote's importance in our environment (no matter how human influenced, like Boston) and feel like this study is one big step towards doing that. The teacher from Wolf High School has not participated in the coyote project and is not familiar with the details of the research that has been conducted. Therefore, one reason for choosing this teacher was to see how usable the curriculum is in different contexts.

Settings

Coyote High School

The town, with 44,000 residents, is a multi-cultural city located on the north edge of a large northeast city. Sixty percent of the city's total 4,054 acres (6.3 mi^2) is developed for industrial, commercial, residential, and transportation uses and of this total 70 percent is used for housing. For its size, this small city is a more complex community than most, which is the result of its multi-cultural and diverse population, its older residential neighborhoods and housing, and the numerous specialized regional facilities that are located within its borders.   Ninety-one percent of its residents are Caucasian, 3.8% are Hispanic, 3.5% are Asian, 1.3% are African American, 0.2% are Native American, and 0.2% are listed as other races (Revere High School brochure, 2001-02). There are 6984 people per square mile in the city.

The area is predominantly a blue-collar city that is dominated by several industries, the largest being services, followed by wholesale and retail trade, finance insurance, and real estate. The community's current unemployment rate is 4.2 percent. The town has eight public elementary schools, two of which also house the city's middle school programs, one public secondary school, and two private elementary/middle schools. Coyote High School consists of 1,338 students, 43 percent of which are from families with incomes at or below the poverty level. There are over 140 teachers at Coyote High. In spring 2000, Massachusetts Comprehensive Assessment System (MCAS) scores at Coyote High was 228 for English Language Arts, 224 for Mathematics, and 222 for Science/Technology compared to statewide averages of 229, 228, and 226, respectively (Revere brochure, 2001-02).

Wolf High School

Wolf High occupies the third floor of a school building that formerly housed an entire high school. The building has been split up into three separate schools that stay largely separated, creating a small school community of about 350 students in each school. The schools were created just over three years ago. The school is a small learning community school in Boston with 390 enrolled students that is theme-based on environmental science. However, like the rest of the Boston Public School (BPS) student population, many students are considered at risk for school drop out, unemployment after high school and adult life poverty due to factors including low academic achievement, minority status, and being a parenting teen (Odyssey High School, 2003).

At Wolf High, at least 14% of the students are single parents with young children of their own. Over 85% of the students are from racial/ethnic minority backgrounds (50% black, 30% Latino, 10% white, and the remaining 10% is a mixture of Pacific Islander, Native American, Cape Verdean, and other racial classifications); 13% speak English as a second language; 20% of the students have disabilities; and, all students are from low-income families and 28% live in Boston's federally designated empowerment zone neighborhoods, areas considered to be the most impoverished with the highest rate of unemployed adults and the lowest rate of Boston residents with high school diplomas (Odyssey High School, 2002 information).

To engage and motivate students, Wolf High School focuses on promoting equity by providing a broad spectrum of experiences around environmental science topics. It has chosen to focus on environmental science because "by focusing on the environment students will be engaged in activities that foster and support a richer understanding of how school work can impact and connect to their everyday lives" (Odyssey High School, 2003).

Participants

The participants in this study were the selected high school students and teachers at Wolf and Coyote High Schools. A core group of two classes and one teacher from Wolf and one class and one teacher at Coyote High School participated in this study.

Table 3.1 compares the MCAS competency scores between Coyote and Wolf High Schools.

Doug

Doug Endicott (pseudonym) teaches a multitude of classes in the Science Department at Coyote High School covering all grade levels. Currently, students participating in the coyote study have to volunteer and do the study outside of class time. We have had about 25 (never all at once) of his students involved with the coyote project in the last year or two. Some of his students that have graduated have even expressed interest in continuing to work with us during summer. Doug has been teaching for 10 years at Coyote High. He has always had a strong interest in wildlife, especially locally, and jumped at the chance when he learned of our project in north Boston. It is a perfect fit because the school is basically in the central portion of our >6 town north Boston study area. I would classify Doug as a very advanced, gifted, and motivated teacher that goes beyond the call of duty. For example, he has worked with UEI since its inception in 1998 and frequently is the organizer of his school's science fair. The coyote study now takes up a large amount of his time despite his regular occurrences at other venues. Doug is someone that could definitely get an advanced/graduate degree in a science related field. In fact, we have discussed the possibility of possibly using some of the data that we have collected in north Boston to achieve that goal.

I did the curriculum intervention in Doug's 14 student advanced placement Environmental Studies course for two weeks from October 19 – 22 and 25 – 29, 2004. On

25 October we met at the Stone Zoo's coyote exhibit and I gave a presentation to the class in the coyote exhibit with the three resident eastern coyotes.

I pre-interviewed 11 of the 14 students in the class (79%; 7 girls, 4 boys) and post-interviewed 10 (71%) of the students (6 girls, 4 boys); of which 9 (6 girls, 3 boys) of the post-interviews were the same students from the pre-interviews (Table 3.2). A total of 12 of the 14 students were interviewed. On 1 February 2005 students took the post-delayed survey under Doug's guidance. This was over three months after the completion of the two week curriculum unit and the post-survey.

Tanya

Tanya Ortiz (pseudonym) teaches Advanced Placement Biology and Urban Ecology in the Science Department at Wolf High School. Tanya has been teaching for 19 years in the BPS system and has been lead teacher at her school since 2001. She has worked with UEI since its inception in 1998 and forged the collaboration in order to, "engage students in protecting and restoring urban natural resources." She has been actively involved in providing hands-on opportunities to her students. For example, she piloted the first Massachusetts eelgrass bed restoration project and has participated, along with her students, in many other projects. However, despite her experience in field studies, she has not participated in the coyote study and knew little about it before I introduced the curriculum unit to her two Urban Ecology courses.

I gave the curriculum unit to two class periods (which occurred back to back at the end of the academic day) in Tanya's Urban Ecology courses from November 29 – December 3 and December 13 – 17, 2004. Both courses were basic level survey courses.

According to Tanya, most students taking this class were trying to obtain the three credits in order to graduate; in other words, as Tanya told me, "they weren't there by choice."

Before the curriculum unit began, I was involved in a field trip on Cape Cod on 5 November 2004 with these students. I pre-interviewed 10 students before this field trip occurred. In addition, a field trip is also being planned to take the students to the Stone Zoo in winter/spring 2005 but this did not occur during the curriculum unit like which occurred at Coyote High School. The two classes greatly fluctuated in size with people routinely coming and going, almost like the course was optional (which of course it was not). Combining the two class periods, on average 20 people were regularly in class on a consistent basis; about 40 where signed up according to Tanya. I did not take daily attendance because of my focus on the curriculum and assessments (classroom observations) but also because students frequently left or entered the class.

I pre-interviewed 10 of the students in the class (5 girls, 5 boys) and post-interviewed 10 of the students (7 girls, 3 boys); of which 4 (3 girls, 1 boy) of the post-interviews were the same students from the pre-interviews (Table 3.3). Compared to Coyote High where I took about 15-20 minutes per interview after school or during a free period, interviews at Wolf High were rushed and I often conducted five interviews in a 50 minute class period. (Note: I could not take students out of class or lunch for the interviews). Sixteen students in total were interviewed. I attempted to post interview the students that were most often in class during the 10 day unit. On 3 March 2005 students took the post-delayed survey under my and Tanya's guidance.

Summary

Wolf and Coyote High schools have different racial make-ups and sizes but both are definitely diverse, despite being in different economic and urban areas. The differences and similarities of these settings provided valuable opportunities upon which to compare and contrast the challenges and learning that occurs amongst teachers and students in different contexts (Barnett, 2003). That is precisely why I studied two low level classes in an inner city environment and an upper level class in an urban school. Barnett (2003) noted that inquiry-related studies have not examined classrooms across different contexts, choosing rather to focus on a single teacher or school. However, examining students' perceptions and knowledge of nature in different contexts is important in order to design appropriate and meaningful curriculum that meets local needs while adhering to national standards and reform strategies.

The Curriculum piece

Curriculum Development

Background work began during summer 2004 when I developed the core of the curriculum. The curriculum was then co-developed in an evolving way, typical of design experiments, as I went into the respective classrooms during fall and early winter 2004. The curriculum had components that met state and national standards by focusing on things such as inquiry based components of coyote behavior and ecology, but the unit was not developed following those guidelines. It was developed in a multi-media fashion, including the use of computer, videos via mpegs on windows media player, written material, and activities (Appendix 1). I used student and teacher input (especially during the pilot study) to reflect on and revise the curriculum (e.g., the content and order of the powerpoint presentations). It was hoped that the topics that were introduced and the associated skills that the students (and potentially teachers) acquired while participating in the curriculum unit of the coyote study during this collaborative project with Boston College got them excited and interested to do science.

The curriculum unit was designed for 2-3 weeks. It was developed to make the intervention flexible in order to meet the needs of a wide array of classes and schools. For example, I was at Barnstable for three full weeks and only at Wolf and Coyote High Schools for two weeks each. Daily exercises, objectives, goals and activities were developed along with appropriate questions for pre/post surveys and interviews. The lessons in the curriculum unit acted as a guide towards these measurement tools, while the students dictated the flow of the presentations and their involvement in the learning process. For example, I stopped and spent much more time on a given subject if a student(s) expressed interest in something in particular.

During all phases of the research process the students and teachers were provided the opportunity to voice their interpretations and perceptions of the curriculum. In design experiment fashion, I then reflected upon and revised the curriculum according to the comments made (for example, if there was something the students wanted to learn about I tried to include it in the curriculum). The curriculum unit was designed to be used as classroom exercise through lectures, reading, activities, and testing materials without any active involvement in the field. Thus, the curriculum component was intended to make the study more scalable (Fishman & Krajcik, 2003) where other interested schools could still participate (albeit indirectly) in the coyote study by using the curriculum that was produced. With adequate instruction and collaboration, it was intended that students/teachers that have experienced the unit could reach a point where they will be knowledgeable of the curriculum and could help implement it in other classrooms. For purposes of this dissertation, I just focused on the assessment of the in-class curriculum developed during this study – i.e., I did not focus on the field-based activities of studying coyotes in the field. A major goal of this study was to introduce students on how to study coyotes in the wild and to give them the tools and empowerment to conduct these studies.

The outdoor field component of the study (through field trips or using existing data) was incorporated into classroom curriculum activities. Students and teachers saw how to record and enter collected data for eventual publishing of information into scientific journals and possible comparison of databases with other high schools.

The Unit

The unit centers around our three study sites (wild coyotes on Cape Cod, wild coyotes in north Boston, and captive coyotes at the Stone Zoo) and covers aspects of our research such as capture techniques, handling and radio-collaring procedures, ecology in the wild, behavior in captivity, and their behavior around people. The unit also discusses coyotes and their value to a variety of stakeholders. A nature video on coyotes introduces the students to these issues. Additionally, a presentation on the different species of canids in North America, accompanied with video on each creature, attempts to situate coyotes with the other species that they are closely related to. The curriculum is designed to get the students involved by having them ask questions related to the material discussed and to have them answer questions based on these activities. The students read relevant literature pertaining to each of the daily activities and also participate in two in-class activities where they are virtual coyote biologists for the day. Windows media player videos are designed to visually illustrate the points discussed in class. Finally, the students are provided the opportunity to visit the Stone Zoo and directly observe live coyotes that I hand-reared.

The curriculum unit was developed with the flexibility of teaching to diverse audiences covering a variety of learners. Therefore, some classes (like at Coyote High) got in depth in a certain topic, while other class periods (like at Wolf High) had just the minimal amount covered in a given topic before the bell rang. Table 3.4 describes the different activities that took place during the curriculum unit.

Because of student interest in the project all of the classes took two full days to get through the first introductory lecture. Many questions were asked causing this longer time commitment. Days 3 - 5 turned out to also be relatively longer and took about 1.5 class periods each mostly because each topic covered more material than could reasonably be taught in a 60 minute class. Thus, the complete 10 day unit was not covered in each class. For instance, at Coyote High, I covered (in order) lesson plans 1, 2, 3, 9, 7, 6, and 4 (Table 3.4). Because of the visit to the Stone Zoo we were not able to cover Coyote Capture Techniques (Day 5) during the two week intervention. At Wolf High School, we covered days 1, 2, 3, 4, 5, 6, and 7. Students did not go to the Stone Zoo during the curriculum unit. In both classes we did not have time to get in depth about Coyote Ecology in the Wild (Day 8), which was disappointing to me. The respective teachers provided their own review period. Doug reviewed the material (e.g., what they would be responsible for on the test) after I left his class. Tanya's classes wrote 10 journal entries for each day that I was in class as their assignment.

My Role

For this project I was an active participant in the study. In other words, I sought to understand an emic (insider) view of the classroom in order to uncover their perspectives and viewpoints of participants (Pine, Under review for publication; Rossman & Rallis, 1998). Because I have been studying coyotes for years, I have many preconceptions on how to study and teach about coyotes. This insider perspective allowed myself to immerse into the classroom's curriculum and work directly with my human study subjects. I feel that being an active participant was essential for a project such as this; however, I also remained an observer and constantly noted the progress and success of the team members in using the curriculum on urban coyote ecology. Thus, through interviews and field notes on classroom observations I acted as an outsider (etic perspective) examining the efficacy of the coyote curriculum (Barnett, 2003; Rossman & Rallis, 1998). Thus, as an outsider in this sense, I was in the position to relate the participants' experiences to a larger audience (Barnett, 2003).

Squire et al. (2003) stated that researchers should shift their role from one of experts to ones of collaborators, where researchers serve, support, and collaborate with teachers who are the local experts at conceptualizing curriculum to meet local demands. In accord with that statement, curriculum development should use a collaborative action research approach advocated by Pine (Under review for publication: p. 77), "that values teachers' knowledge; accentuates their capacity to conduct their own research in their own interests; emphasizes problems from their own perspectives; and liberates their mental dispositions for critical reflection, questioning, and the continuous pursuit of inquiry contributing to the development of inquiry as a lifelong stance." Accordingly, I used input from teachers and students to guide additional development of the curriculum unit during the classroom interventions.

Data Collection Procedures

In early sections of this chapter and in chapter 1 I outlined the purposes, goals and research questions of this study. To address those questions, I used specific techniques to obtain the data: notably, interviews, reflexive journals and field notes (i.e., classroom observations), and pre/post/post-delayed surveys.

Data Collection

Data collection occurred during the fall 2004 academic year. This study relied on mixed methods as data collection strategies but was largely a naturalistic, qualitative study (Lincoln & Guba, 1985; Rossman & Rallis, 1998; Schram, 2003) with some quantitative components. The underlying approach for qualitative data collection is that dialogue and reflection can reveal the essence of some aspect of shared experience (Schram, 2003). By studying two high school science teachers' classrooms (not including the pilot class), I obtained a description of these teachers' students' perceptions and knowledge of coyotes. I also used tenets of ethnographic research such as observation and participation where I studied and contributed to the culture of the classroom involved in the assessment of the coyote curriculum. Culture captures the beliefs and values shared by members of a group that guide their actions and their understandings of those actions (Rossman & Rallis, 1998; Schram, 2003). Using the traditions of ethnographic researchers, I conducted interviews and created a reflexive journal where I recorded classroom observations.

I also collected quantified data from a traditional positivist perspective (Scriven, 2000). This was accomplished by giving pre-post content surveys to survey students' knowledge of coyotes before and after the curriculum intervention and by assigning rubric values to some of the interview questions. A follow-up post delayed survey was given 2-3 months after the intervention to quantitatively assess student retention of the curriculum.

In this project, I triangulated information from multiple sources (Yin, 2000) of evidence by using direct observations and associated reflexive journals, interview techniques, documents/data recovered during the project, and pre-post and delayed surveys. I was a participant observer in this project because I worked directly with and observed the students using the curriculum. Observation were an important component of this program (Stake, 2000). Therefore, I was able to formatively note the progress of the participants during the implementation stage of the curriculum unit. Because of the integrated nature of this project, I was clearly a member of the social group or program being evaluated.

This study recovered a richness of data because the project was intended to examine a phenomenon in its real-life context. The methodology (mixed methods) used in this study was advantageous to evaluating the coyote curriculum because I understand the content and context of the project very well - i.e., conducting research on coyotes and accurately describing coyote behavior. Stake (2000) noted that it is important to reveal the multiple reality of an educational experience. In essence, I tried to generate a vicarious experience for the reader of my dissertation where I conveyed the holistic impression, the mood, even the mystery of the experience of participating in the coyote curriculum unit (Stake, 2000). I used a descriptive approach of evaluating this collaborative program by documenting, describing, and analyzing how the teacher and students respond to the curriculum through interviews, observations and associated field notes and journal entries. By being a member of the culture of each classroom I had an insider's (emic) view to the life of the classrooms; in my reporting of the data, I tried to present an objective outsider's (etic) view of the classrooms (Schram, 2003).

Research Instruments

This section describes the specific techniques and methodology that I used for each data collection tool including pre, post, and post-delayed surveys, pre and post-interviews, and classroom observations/reflexive journal.

Surveys

In order to assess students' understanding of science and their perceptions of coyotes I gave the students a survey at the beginning and end of each unit then 2-3 months after the intervention ended (February – March 2005). This survey was a modified form of a previously validated one given to students by the Urban Ecology Institute (Barnett et al., 2004) that was originally administered by Moore and Foy (1997). It used a five-point Likert scale (strongly disagree – mildly disagree – no opinion –

mildly agree – strongly agree) and consisted of three sections, two of which were developed and used by UEI. It was multiple choice-based with five possible answers each. The themes of the three scales used were:

1. I want to be a scientist – 11 questions. This scale examined the perceptions and attitudes that people have being a scientist.
2. Scientific methodology – 9 questions. This scale investigated students' understanding of the scientific method and their viewpoints of how scientists use it.
3. Perceptions of coyotes – 15 questions. This scale, specifically designed for this study, intended to uncover students' attitudes, understanding, and knowledge of coyotes. It ranged from general questions like coyote distribution and range to specific questions on their sociobiology.

By using part of UEI's previously validated scales (groups of question or themes) I had some initial reliability associated with the survey. Table 3.5 displays the questions given in the survey. The survey had 35 total questions and was identical for the three testing periods (i.e., pre, post, and post-delayed). Students circled the best answer and I entered the raw grades into a Microsoft excel spreadsheet, as described in the analysis section below.

Interviews

I informally interviewed participants, including the teachers, throughout the project to assess the intellectual development during the different stages of implementing the curriculum into the classrooms. Interviews were on-going and formatively documented the observations and experiences that they had during the course of the coyote unit. These informal interviews were recorded as classroom observations in my laptop. However, I also kept available paper (in a binder) and jotted down important comments in that notebook so they were not forgotten (for example, specific questions asked by students, or where each class finished off at the end of each day). These comments were then weaved into the daily classroom observations.

In addition, I conducted semi-structured interviews (Merriam, 1998) with 10 students from each class before and after the curriculum unit was implemented (at similar time periods that I give the pre and post survey). For consistency, I attempted to use the same 10 students per class for both interviews; in reality, this did not always occur (see Tables 3.2 and 3.3). Interviews were digitally audio-taped and data was backed up in a personal computer. I brought an interview sheet with me that consisted of the questions in three major sections: one, general science interest; two, general coyote knowledge; and three, specific coyote knowledge (Table 3.6). In addition to taping the interview I occasionally jotted down important notes (such as critical parts of the interviews) that helped me in the data analysis section.

I used escribe software (Express Scribe, Canberra, ACT 2601 Australia, http://www.nch.com.au/scribe/) to transcribe the entire lengths of the interviews into a laptop computer. This will be described in more detail in the analysis section of this chapter.

Classroom Observations/Reflexive journals

In accord with design experiment methodology mentioned at the outset of this chapter, I co-taught the curriculum units with the participating teachers. I taught the day to day lectures (i.e., most of the content) and the teachers listened and actively participated by asking their own questions relating to the unit. They usually started off the class periods, like settling the students down or writing down the daily objectives and/or itinerary. They even disciplined the students when they were disrupting the class.

Due to my active involvement in the classes, I was a participant observer in this study (Merriam, 1998). I kept scrap paper in a notebook during class sessions and jotted down phases of important classroom events so I would not forget them. At the end of each class I sat down and summarized my observations of each class in a laptop computer. If classes were back to back, I summarized both classes after the last one finished. I saved each class (i.e., Barnstable, Coyote, and Wolf) as a separate Microsoft Word document. In this way I was easily able to retrieve all data from a given class. I did not use any software programs (e.g., File Maker Pro) to enter data because of the limited time frame of this study. However, I recognize that I may use these programs in the future if this study becomes larger in scope (e.g., different schools and/or classes).

For each classroom summary I focused on providing a synopsis of each class, describing important things or interactions that occurred, and making any interpretations or emerging hypotheses that I thought were occurring. I analyzed my classroom notes (usually just short phrases written down) made into my curriculum binder and added those thoughts to the summary of each class. I dated each journal entry for ease of locating specific entries in a file. Included in this summary was the students' involvement as well as my interactions with the participating teacher on a given day.

Data collection strategies for each question

This section describes the techniques and strategies in relation to each research question (see Table 3.7 below, for a summary). Summer 2004 was devoted to fleshing out the curriculum and associated interview and survey questions that were used to assess student understanding and conceptions of coyotes. In the following discussion, I individually present the particular techniques used to address each question:

Research Question #1: What happens to students' knowledge of coyotes after participating in the curriculum unit?

Data collection for this question was accomplished through classroom activities and observations and pre, post, and post-delayed content surveys. This was a core question to address in order to assess the efficacy of the curriculum that we developed. A great deal of time was spent developing appropriate survey questions that accurately reflected knowledge of coyote biology and behavior. I made classroom observations to formatively document my impression and observations of how students were learning the curriculum and any special challenges that they were facing.

Research Question #2: What happens to student engagement and empowerment in science issues after introduced to our place-based intervention? What happens to student academic performance when students' participate in authentic scientific investigations on coyotes?

By having the curriculum unit based on local wildlife studies we authentically had a place-based model for the students. Additionally, a field trip to the Stone Zoo enabled students to engage in the captive coyote component of the coyote project. Interviews assessed students' attitudes and perceptions of the curriculum unit. Additionally, the pre/post/post-delayed survey assessed students' perception of coyotes. This data complemented the interview data. For example, I gave all students (range = 8-30) in each class the pre/post survey from each class, but only interviewed a select group (10) of them.

Data Analysis

The purpose of analysis is to gain insight and to determine if the curriculum unit was relevant and helpful to participating teachers and students. It is hoped that this analysis lays a foundation for future ecological based school - university collaborations and the production of curriculum materials on urban ecology.

I used a naturalistic evaluation approach to analyze the qualitative data collected (Table 3.7). Naturalistic evaluations center on activities, transactions, and effects occurring within the program rather than on program goals (Madaus & Kellaghan, 2000). Their focus is not determined in advance. Rather, evaluation design and focus emerge through observation of program transactions; eventually, through an iterative process, themes or issues surfaced that I and other interested parties agree should be addressed (Madaus & Kellaghan, 2000). Similarly, this assessment approach has also been called responsive evaluation by other people, such as Stake (2000). Naturalistic evaluation aims to provide a rich, thick, illuminating, comprehensive, contextual, and qualitative description of the model under investigation (Madaus & Kellaghan, 2000). This approach is a paradigm of value-bound inquiry that is a pattern for how constructivist learning should be modeled (Guba & Lincoln, 2000; Hay & Barab, 2001). Therefore, as Guba and Lincoln (2000) noted, naturalistic evaluation is much more than just being carried out in a natural setting, or utilizing a case study or phenomenological format, or relying on qualitative methods. Rather, this approach to evaluation offers a contextual relevance and richness that is unmatched; it displays a sensitivity to process virtually excluded in paradigms stressing control and experimentation; it is driven by theory grounded in the data - the naturalist does not search for data that fit a theory but develops a theory to explain the data (Guba & Lincoln, 2000). As Guba and Lincoln noted, naturalistic evaluation takes full advantage of the not inconsiderable power of the human-as-instrument, providing a more than adequate trade-off for the presumably more objective approach that characterizes rationalistic inquiry. However, because more objective quantifiable data is not used, naturalistic evaluation has its biases because different people may come up with different theories from the same data.

In accordance with teaching experiment methodology, considerable data analysis occurred throughout the data collection process (Barnett, 2003; Cobb, 2000). I reflexively analyzed notes and interviews to place these events in a broader context thereby framing them in such a way as to illuminate the key characteristics that defined the phenomena under study (Barnett, 2003). This gave the material a more holistic perspective on a day-to-day basis.

Interview and reflexive journal/classroom observation data were coded as described by Strauss and Corbin (1998). Open coding enabled relationships to be identified and similarities amongst the codes to be recognized. I looked for similarities in the data when coding and grouped similar responses by codes. Subcategories were used where codes were similar yet slightly different. For instance, responses might have been similar because of behaviorally related responses to an answer. Thus, all behavior answers were coded for in a similar manner (like using a "B"). However, some answers might have been more related to social ecology, or communication (e.g., howling), or how the captive coyotes behave around me. These subsets of behavior would be marked B.1, B.2, B.3, with the 1 meaning things related to social ecology or a 2 related to communication. Table 3.8 provides an example of some raw sample data and the associated codes ascribed to it.

Triangulation amongst data collection sources enabled an analysis between the different types of data in order to give a more thorough investigation of the information obtained (Silverman, 2000). I did all of the coding by hand – i.e., I did not use a software program to analyze data.

For interviews, I listened to each of the dialogues after they occurred then transcribed the entire interview for eventual inclusion in my dissertation. I used escribe software to digitally download the files to an audio-file on my laptop computer. For two of the questions related to knowledge of coyotes, I initially created a rubric from 1-5 and scored those questions based on appropriateness of response. For each score (i.e., 1, 2, 3, 4, or 5) I wrote a sample answer to aid in the scoring process. The rubric is based upon

Barnett and Morran's (2002) categorization scheme except that I use 1 – 5 instead of 0 – 4 in order to be used more easily in SPSS. In order to obtain a reliability index of the rubric that I created, a graduate student in the Urban Sciences Research and Learning Group (USRLG) at Boston College then scored the same answer. Poor correlation (some sections, like the pre-interviews at Wolf High for one of the questions, were 40 %) on the first reliability index between me and the scorer resulted in a modification of the rubric into four categories (Tables 3.9 and 3.10). I used correlation analysis to examine consistency in response between myself and the other USRLG scorer. This second iteration of the rubrics (Tables 3.9 and 3.10) produced better correlations, with an average of 77 % (81 % for Table 3.9 rubric and 73 % for Table 3.10) agreement between the two scorers (Table 3.11). For purposes of the analyses in Chapters 4 and 5 I took the scores that I obtained (i.e., not the other scorer), then used a paired t-test (SPSS Inc., Chicago, IL) to compare rubric scores from the interviews before and after the curriculum intervention at each school.

I entered the raw scores of all pre, post, and post-delayed survey scores into an excel spreadsheet. The five possible answers were converted from a – e to 1 – 5 depending on desired answer (i.e., either strongly agree or strongly disagree) for each question. These data were then converted into an SPSS file. I used analysis of variation (ANOVA) for comparing the pre, post, and post-delayed surveys and Tukey's post-hoc test when ANOVA revealed significant differences in order to examine differences amongst the three testing periods. Due to the low sample size, I considered $p < 0.10$ to be significant for all of the tests described herein.

During all phases of the research process I gave participating members opportunity to voice their interpretations and perceptions of the curriculum unit. This occurred regardless if it were data on individual coyotes or data that I took on participants during interviews, assessments, experiences, or other means. Using multiple voices in this study helped to ensure greater validity

Limitations of the study

Despite the aforementioned (Chapters 1-3) importance of this study, and its future contribution to the field of education, there are some obvious limitations with this study. First, I only studied two high school teachers' classes after the pilot project. Despite the potential usability and generalization that this curriculum might provide, this particular study can not demonstrate conclusive and widespread results with such of a small sample size; successive, future studies will have to do that. Second, I was only in each of the classes for a few (2-3) weeks each. Thus, I had a very focused and narrow window for assessing student learning. While it is potentially beneficial to limit this curriculum unit to about a week (e.g., so more schools/classrooms can fit it in with existing curricular units), I certainly would not be able to assess any long-term learning gains except for information obtained from the follow-up post survey. Third, I taught the unit to different audiences ranging from inner city to suburban. These students clearly had different levels of experience with nature. Fourth, my mere presence may affect the future usability of this material. Being a content specialist on coyotes I will most likely predict and be able to respond to any potential problems that arise. Though this material is in effect a pilot for my future aspirations of implementing this curriculum to more venues, my absence might make implementing this unit difficult in other classrooms where I am not the teacher.

Cross-case analysis

I have focused the preceding discussion on describing how I plan to examine the case studies (i.e., chapters 4 or 5). At the conclusion of this dissertation (chapter 6) I compared the two cases in order to make interpretations. The purpose of examining multiple cases is to increase generalizability (Schofield, 1990), reassuring one that the events and processes in one well-described setting are not wholly idiosyncratic, and to deepen understanding and explanation of the research under study (Miles & Huberman, 1994). I examined data from chapters 4 and 5 and searched for themes that cut across cases. I listed important or main themes from each dataset and looked for similar groupings of themes between the two cases and used the established codes to help me in this process. I used the six main categories (e.g., coyote knowledge, coyote beliefs) established in chapters 4 and 5 in order to summarize and group the important concepts into a partially ordered meta-matrix. The conclusions (chapter 6) stem from this analysis.

Summary

This chapter detailed the mixed methodological framework that I used for this study. This study described the methodology used to assess the learning and empowerment of having students involved in an authentic curriculum unit where they were provided an opportunity to learn about a predator that lives close to them. A pilot study was conducted before data was collected. Herein, I introduced the participants of this project, the locations where this research was conducted, and the techniques used to collect data. Finally, I described the techniques used to analyze the data that was collected. In the proceeding chapters, I will document how successful the curriculum unit on coyotes was in helping students learn about the species.

Table 3.1. Comparison of competency determination (CD) of Coyote and Wolf High Schools' classes of 2004 & 2005 for the 2004 MCAS test. For ELA (English Language Arts) and Math tests the percentages refer to percent passing each test. Source: http://www.doe.mass.edu/mcas/2004/results/0604cdprogrpt.pdf

School	Class	Sample size	ELA %	Math %	CD %
Coyote	2004	262	95	94	93
Coyote	2005	265	87	86	83
Wolf	2004	72	78	78	75
Wolf	2005	60	75	73	63

Table 3.2. Students (pseudonyms herein) interviewed from Coyote High School, in urban north Boston during October 2004. Note: only students that were interviewed (12 of the 14 students in class) are included herein.

Pre-Interviews		Post-Interviews	
Girls:	Boys:	Girls:	Boys:
Katie	Matt*	Samantha*	Matt*
Nicole*	Tim*	Michelle*	John
Samantha*	Rick*	Nicole*	Rick*
Rachel*	Brad	Robin*	Tim*
Michelle*		Jen*	
Jen*		Rachel*	
Robin*			

*Interviewed both Pre and Post

Table 3.3. Students (pseudonyms herein) interviewed from Wolf High School, in urban south Boston during November and December 2004. Note: only students that were interviewed (n = 16) are included herein.

Pre-Interviews		Post-Interviews	
Girls:	Boys:	Girls:	Boys:
Melissa*	Jermaine	Melissa*	Jack*
Marcy*	Chad	Marcy*	Dave
Nadia	Jack*	Lisa	Jamal
Evelyn	Derek	Keisha*	
Keisha*	Bob	Eve	
		Beyonce	
		Carol	

*Interviewed both Pre and Post

Table 3.4. Curriculum created and implemented at Coyote and Wolf High Schools.

Day	Topic & Activities	Objective(s)	Assignment(s)
1	**Introduction to the coyote study** - Describe my background. - Showing full size (real life) coyote posters. These posters are subsequently displayed each day. - Introduce coyote terms and actual coyotes we have tracked. - Showing mpeg videos on actual coyote footage.	1. To become familiar with the coyote project. 2. To introduce students to terminology. 3. To answer student questions about coyotes.	1. Read the Stokes' Field Guide on coyotes. 2. Give students a list of all of the coyotes (wild and captive) that we have known/ studied.
2	**Introduction to coyotes continued:** - Watch Wile E. Coyote video clips. - Discuss why I am interested in coyotes: coyotes in captivity, cultural issues, coyote behavior and ecology in the wild, capturing coyote and the	1. To have students more familiar and responsible for terms related to our coyote study. 2. To engage their interest through multiple video segments and questioning time.	1. Read John Steinback's The Mojave. 2. Answer questions based on the readings assigned. (students receive a handout of questions related

	hands-on approach to science. - Naming the captive and wild coyotes. - Discuss howling.		to the readings)
3	**Different views towards coyotes** - Show video from a Nature (1993) clip on coyotes. - Discuss different stakeholders views and opinions towards coyotes using powerpoint then windows media player clips.	1. To have students familiar with various stakeholders associated with coyotes. 2. To have students formulate opinions on their views about coyotes.	1. Read editorials on coyotes from newspaper. 2. Write a ~1 page opinion piece on coyotes.
4	**Canids of North America** - Discuss the 8 species of wild canids (gray wolves, red wolves, coyotes, and 5 species of fox) and domestic dogs; illustrate much of the discussion with video segments. - Talk about exploitative competition.	1. To have students familiar with the various types and species of wild dogs that live on our continent. 2. To have students see how domestic dogs fit in the equation.	1. Upper level classes read: Way et al. 2002. Eastern coyote home range, territoriality and sociality on urbanized Cape Cod. Northeast Wildlife 57: 1-18.

			2. Seminar classes – no homework.
5	**Coyote capture techniques** - Discuss the different ways that we have captured coyotes including box traps, netlaunching and by hand. Illustrate the discussion with a rich array of video. - Students also learn how we radio-collar then release the coyotes. - This topic takes ~1.5 days.	1. To have students familiar with how to capture wild coyotes. 2. To have students see how researchers handle wild coyotes.	1. To read a short story on an experience that I had tracking the coyote Kett and his group on Cape Cod.
6	**Coyote Tracking Activity** - Students learn how to track coyotes in the wild by participating in an in-class activity of picking up index cards and mapping coyote home ranges. - Students learn terminology associated with coyotes	1. To have students participate in an authentic activity. 2. To have students learn how biologists map coyote home ranges. 3. To have students learn the different social classes of coyotes and	1. To read a short story on an experience that I had tracking the coyote Fog in Boston. 2. Summarize findings from the story in a paragraph.

	including social statuses and home range and territoriality. In upper level classes, we discuss the Home range paper that was assigned. - Video segments show students the actual coyotes that they tracked in the simulated activity. - Two handouts are related to this activity.	correlate social status to home range use.	
7	**Captive coyote study** - Students learn more specifics about the captive coyote study and they participate in an activity of recording behaviors shown during a 5 minute video clip. - Students record data using instantaneous spot sampling every 15 seconds. Thus the students have 20 data points	1. To have students learn specific information about captive studies, especially on the captive coyotes at the Stone Zoo. 2. To have students learn techniques to study the behavior of captive animals.	1. To study for test or to create a portfolio of the coyote curriculum (for alternate measurement techniques rather than a test)

	after 5 minutes and they compare that data with other students. - A handout is related to this activity.		
8	**Coyote ecology in the wild** - Students learn about results of our study of wild coyotes including movement and activity patterns, home range sizes, territoriality, and group (pack) sizes. - Powerpoint and videos illustrate these points.	1. To have students learn about some of the results from our study on wild coyotes. 2. To be able to remember important terminology associated with coyotes.	1. Same as Day #7.
9	**Visit to Stone Zoo** - Students visit the zoo and ask questions and hear a lecture about our captive coyotes. - They get to see the coyotes up-close while I interact with them in their exhibit.	1. To give students the chance to see coyotes in real life. 2. To give students the chance to ask questions about coyotes while directly observing coyote behavior.	1. To write down all questions asked at the zoo and interesting facts from the zoo visit (mainly to have for my records).

10	**Review for Final** - Provide the opportunity to have students review for an end of the unit test. - Answer questions that students have related to the curriculum.	1. To provide students the opportunity to review and answer questions related to the curriculum unit.	1. Study for test/exam.

Table 3.5. Pre, post, and follow-up (delayed) survey questions given to students in this study. For all questions, students had the option of circling: strongly disagree, mildly disagree, no opinion, mildly agree, or strongly agree.

Scale: I want to be a scientist
I would enjoy studying science in the future
I like to learn about new birds and animals
Scientific work would be too hard for me
I would like to work with other scientists to solve scientific problems
Students like me can use science to answer questions about the world around us
I may not make great discoveries, but working in science would be fun
I would like to be a scientist
Working in a science laboratory would be fun
I hope I can stay involved with science
We need to have a lot more science in our schools
Working as a scientist in the field would be fun
Scale: Scientific Methodology
Scientists are always interested in better explanations of things
Scientific questions are answered by observing things
Good scientists are willing to change their ideas
Ideas are the important result of science
A major purpose of science is to produce new medicines and save lives
Scientists must report exactly what they observe

Science tries to explain how things happen

A major purpose of science is to help people live better

The senses are one of the most important tools a scientist has

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Perceptions of coyotes

Knowledge related questions:

Wild coyotes exist on Cape Cod

Wild coyotes exist in metropolitan Boston

Coyotes live most of their adult lives alone

Coyotes often move long distances

Coyotes are mostly active at night

Coyotes howl to scare people away from them

Coyotes are more like foxes than wolves

Coyotes in the eastern U.S. are different than coyotes in the western U.S.

Coyotes are very difficult to trap

Belief related questions:

Coyotes are accurately depicted in the media

Coyotes are important

Coyotes are dangerous to people

Coyotes are interesting

Coyotes can be tamed and raised like a domestic dog

Coyotes should be eliminated from where people live

Table 3.6. Interview questions (both pre and post) for the coyote curriculum unit.

General Science Interest:

Do you like science classes in general? What do/don't you like about them? What classes?

Do you like learning any particular way?

Do you like animals? Which ones? Do you have a pet? What kind(s)?

Do you want to pursue a career in a science oriented field?

General coyote knowledge:

What question(s) would/might you want answered about coyotes?

What do you find interesting about coyotes?

For pre interview: Would you be interested in going to a zoo to see captive coyotes? Why would you?

For post interview: Now, after experiencing the curriculum unit, would you be interested in going to a zoo to see and learn about captive coyotes? Why for either Yes or No?

What do you think would be the most interesting/ideal/best way to learn about coyotes?

Would you rather watch a television/nature program about coyotes or home/actual videos on coyotes?

Specific coyote knowledge:

Do you think that all coyotes behave/act the same? Why

Some people think that coyotes should be eliminated from human areas, what do you think? Comments on this – in other words, why do you believe what you believe?

Do you think coyotes can be eliminated from human areas? Give some reasons?

Can you give some recommendations for cat/pet owners that live near coyotes?

Do you think that coyotes occur in or near about your backyard? Why?

If you could study coyotes, what question(s) would/might you be interested in looking at?

Are you scared of coyotes? Have you seen one before?

For post interview only:

What did you like about the curriculum unit?

What didn't you like?

Why did you like the videos? How did they help you learn?

Do you have any suggestions or comments about the unit? For instance, comments on how to improve the unit or how to revise certain things – or what not to do?

Table 3.7. Research questions and corresponding data collection and analysis techniques.

Research Question	Data Collection Techniques	Data Analysis Strategies
How does students' knowledge of coyotes change after participating in the curriculum unit?	Classroom activities, observations & journal notes, and pre-and-post content surveys	Naturalist evaluation for qualitative data: coding notes, statistical tests of pre/post surveys
How do students become more engaged and empowered in science issues?	Interviews, classroom observations/reflexive journal, pre/post test/survey	Triangulate data sources, coding of interviews, analyzing surveys

Table 3.8. An example of some sample interview data and the associated codes ascribed to it.

Line	Interview transcript	codes
1	They definitely act differently because of dominance within the	b.1
2	pack, stuff like that. How aggressive they are, how they act. Behavior.	b.1
3	Yeah, if we really want to target and terminate them, yeah, we could	a.1
4	do it. It would take a lot of power, a lot of resources to do it.	a.1
5	You know, why are they here? Why are they spreading so much? It	e.2.3
6	seems like really urban places, I will see one in my life, based on	e.2.3
7	where I live. Like I think the population is going to keep increasing.	e.2.3

Codes: b.1 = No coyotes do not act the same (b); examples provided (.1).

a.1 = Yes, coyotes can be eliminated (a); it would be difficult (.1).

e.2.3 = Ecology based (e); habitats (.2); population questions (.3).

Table 3.9. Rubric for the question “Explain why coyotes do or don’t all act the same.”

(1) No conception, confused, or short response: Students are unable to articulate a response to the question or students lack knowledge of basic concepts. They give short answers without any supportive statements. For example, students say yes/no without any reasoning.
(2) Incomplete/Inaccurate Understanding: Students do not have a good understanding of the question. They use poor terminology to explain their answer such as saying that coyotes are communal animals, coyotes are a breed, or that one population has similar individuals but as a whole they differ from other areas. Students often conflict their statements saying that coyotes are different (do not act the same) in one statement then they say that coyotes are the same in another point.
(3) Partial Understanding: Students know the basic concept that coyotes do not all act the same. They either give examples like dominance related, behaviorally related, etc. or they explain that coyotes are individuals (many say like people are). However, they do not give a complete answer giving both accurate examples and explaining that coyotes are individuals; i.e., they display variation.
(4) Complete Understanding: Students understand that all coyotes do not act the same. They explain that coyotes are individuals and provide examples relating to other animals (such as humans) in their response. For example, they give examples of individual variation such as dominant and submissive coyotes, variation in communication, and/or different roles that they play. Statements can be short and to the point as long as they include both examples and individual variation.

Table 3.10. Rubric for the question "Why do or don't you think that coyotes can be eliminated from an area?"

(1) No conception, confused or short response: Students are unable to articulate a response to the question or they give brief responses without providing any details. Students lack knowledge of basic concepts.

(2) Incomplete/Inaccurate Understanding: Students do not have a good understanding of the question. For example, they explain why coyotes can be eliminated from a given area when in actuality it is very difficult. For example, students note that if we kill them, then they can be eliminated. Or they state that we have done that with many other animals in the past. Or students correctly answer that coyotes can not be eliminated but students do not describe how this can happen. For example, students use a questionable rationale that has nothing to do with recolonizing a territory or that it is difficult to kill each and every coyote.

(3) Partial Understanding: Students know the basic concept that coyotes can not be eliminated from a given/general area but do not explain how coyotes can quickly reach new areas or that although individuals can be killed it is difficult to get all coyotes. Their answer is missing key terms and lacks a full, detailed and completely accurate understanding.

(4) Complete Understanding: Students understand that coyotes can not be eliminated. They mention that they are difficult to kill and if one is killed another coyote will

quickly move (disperse) into that territory. Thus, people can kill individual coyotes but it is very difficult to eliminate (or extirpate) a population in a given area.

Table 3.11. Correlation during pre and post-interviews between the researcher and an independent scorer for the second iteration of the rubrics described in Tables 3.9 and 3.10. Values refer to percent correlation. All pre and post-interviews consisted of 10 students per section except Coyote High School's pre-interviews which had 11 pupils. Overall reliability was 77 %.

School	Coyote High	Wolf High
Pre for Table 3.9	82	100
Post for Table 3.9	70	70
Pre for Table 3.10	73	100
Post for Table 3.10	60	60

Chapter 4

CASE STUDY #1 – COYOTE HIGH SCHOOL

The following is an account of the research that I did with Doug Ernest's 14 student Advanced Placement Environmental Science class at Coyote High School. This chapter will use the techniques described in chapter 3 (mainly surveys, interviews, and classroom observations) to assess student learning and empowerment. This chapter is divided into six sections: coyote knowledge, beliefs/affective components, interest and perceptions of science and coyotes, student learning and preferences, applied knowledge of coyotes, and students' perceptions of the curriculum unit.

I will focus more in depth on the survey questions of the coyote scale (n = 15 of the 35 questions) in this chapter. The other 20 questions were related to a scale developed by the Urban Ecology Institute. I will also present the results from these two UEI scales but will not focus on this data in this dissertation. I use this data as a comparison between the coyote questions and the more general UEI survey questions. The post delayed survey was given on 1 February 2005, two and a half months after the curriculum unit finished.

Coyote Knowledge

Survey questions related to coyote knowledge

Nine of the survey questions were related to knowledge of coyotes. Of these, four produced statistically significant results with another two marginally significant (p = 0.10 – 0.20; Table 4.1). As is evidenced in this section, students' knowledge of coyotes increased significantly after the curriculum unit and students retained much of that knowledge well after the unit finished (i.e., during the post-delayed surveys – Figure 4.1).

Not surprisingly, nearly all students strongly agreed on the question, “Wild coyotes exist on Cape Cod.” We talked about coyotes on Cape Cod, I showed video, and they read about them. Differences were very strong between pre and post surveys ($p < 0.001$) and between pre and post delayed surveys ($p < 0.001$). Thus students retained knowledge for an extended period of time related to this question.

Compared to the pre survey, more people agreed in the post delayed survey ($p = 0.043$) that, “Coyotes often move long distances.” Part of the reason why this difference was significant seemed to be related to the fact that they scored low during the pre-survey, which was barely above no opinion (Table 4.1). Going into the curriculum unit, students had relatively low scores during some of the coyote knowledge related questions. After the unit, students agreed that they move long distances which appeared to be translated to them through our discussions about coyote movement and activity patterns during the unit. Surprisingly though, only a marginal difference existed between pre and post surveys ($p = 0.106$); thus students retained at least as much knowledge about coyote movement patterns two and a half months after the curriculum unit finished than when the unit finished and they took the post survey ($p = 0.909$).

After the curriculum unit students strongly disagreed with the question, “Coyotes howl to scare people away from them.” I commonly noted in my classroom observations that many students asked questions about howling and why coyotes do it; following the commonly asked students questions, I produced a powerpoint slide that explicitly indicated the reasons coyotes do it, and that they do not howl at people to scare them away. Large differences existed between pre and post surveys ($p = 0.002$) and pre and post delayed surveys ($p < 0.001$) yet no difference existed between post and post delayed surveys ($p = 0.640$) meaning that students remembered the information after the curriculum unit finished. Given that students learn well with multiple performance opportunities (Teel et al., 1998), such as participating actively in the unit (Fusco, 2001; Rahm, 2002), it is not surprising to see good learning outcomes from these questions.

A difference existed between pre survey and post delayed surveys ($p = 0.075$) for the question “Coyotes are more like foxes than wolves.” Three months after the unit more students disagreed with that question; there was no difference however between pre and post surveys ($p = 0.557$) and post and post delayed surveys ($p = 0.453$). We discussed at length how the eastern coyote is probably a hybrid between western coyotes and wolves. For them to have a somewhat neutral response of 2.5 intrigued me during the post surveys. Because students saw video of foxes, which are in the same family (Canidae) as coyotes, I hypothesize that students viewed them as similar creatures as coyotes. In addition, foxes and coyotes live much closer to people than wolves do. Maybe Doug cleared up this question after I left the class potentially explaining the appropriate post delayed responses? Future research, asking more specific questions on this subject, might better elucidate student understanding on this subject.

There was only a marginal difference between surveys for the question, “Wild coyotes exist in metropolitan Boston (Figure 4.1).” Numerically more people agreed with the question during the post delayed compared to the pre surveys ($p = 0.134$). Three reasons might explain this non-significance:

1. Students scored high during the pre-surveys on this question (however, they did not score much higher than the question, “Wild coyotes exist on Cape Cod”).
2. Students were thinking of downtown Boston, not the Revere area (i.e., greater Boston) when interpreting the question.
3. Students already knew that coyotes were in Boston before the class especially since Doug Ernest, their teacher, studies them.

To be more clear to students the question should be revised to say something like, “Wild coyotes exist in the Greater Boston area.” This may affect results in the future.

During interviews, the perspective of some of the students was notable when ask if coyotes occurred in their backyard: two students during pre and three during post interviews said that coyotes do not occur in their backyard but that they are nearby. Throughout the course I was trying to get that point across, that coyotes have large ranges and even if they are not physically in your backyard, they are most likely not far away from anyone living in Massachusetts. Samantha’s comment is representative of how I expected students would think of coyote distribution in urbanized eastern Massachusetts:

> Samantha: Not in my backyard, because I live in a parking lot. But I am aware that there are coyotes in the marsh nearby because I have seen them. I saw one with my friend near the Jewish Cemetery. My friend lives right there in Malden.

Samantha seemed to indicate that despite living in a highly residential area, coyotes are not far away. I get the impression that most people (not just students) think of their yard as their physical backyard. I stressed that coyotes often travel long distances and if you (a person) did the same (traveled long distances) you would surely be in coyote country, or close to it, without much effort – even if one lived in the middle of Boston.

One reason why students may not have scored higher on the question of coyotes living in Boston might be because some of responders have never observed coyotes before. Because participating in science activities is very meaningful for students (Barab & Hay, 2001; Barnett et al., 2004), maybe students have just never considered the question of coyote presence in the city? For example, Nicole, although very positive about the presence of coyotes in her area, judged that they were not around her yard because she has not lost any cats:

> Nicole: Not in my backyard because I live right next to the marsh behind the Necco factory .....and we have...my cat stays out all night sometimes in the summertime and she's never been attacked or hurt and we also have a lot of feral cats in the yard and they are fine and my dog never got hurt or anything.

For the survey question, "Coyotes in the eastern U.S. are different than ones in the western U.S.," marginal differences (Table 4.1) resulted with numerically more people agreeing after the curriculum unit that they are different. The curriculum stressed the difference between the two types of coyotes with powerpoint slides explaining the difference. Strong student responses favoring the difference during the pre surveys might explain why there was no significant difference. Doug had talked about coyotes before the curriculum intervention which possibly affected student knowledge of coyotes and subsequent answers.

There were no differences for three of the questions asked during the surveys that related to knowledge of coyotes. For all three surveys most of the students believed that coyotes were not solitary. They seemed to have preconceptions of coyotes as social animals which surprised me. Many people that I talk with think of them as more solitary creatures but not these students. Nicole's pre-interview response to the question of "What do you find interesting about coyotes?" was typical of the students' comments about the social nature of coyotes:

> Nicole: I like how they live as a family unit and how kind of they take control and help the others just you know how they help each other survive.

Also, most students agreed that coyotes were mostly active at night but numerically more thought that they were more nocturnal during pre surveys (Table 4.1, Figure 4.1). This might be attributed to the fact that many of the in-class videos showed coyotes during early morning hours when it was light out (note: I did show video of coyotes active at night but it was difficult to project a good image with low amounts of light available). So even though we talked about how coyotes are generally mostly active at night, simply watching them active during the daytime may have altered students' views. Plus, we discussed that the coyote social group near their high school is sometimes active during the daytime.

Finally, to my surprise there was no difference in the survey answer to, "Coyotes are difficult to trap." I talked at length about how much time and effort we spend in trying to catch coyotes in order to collar them, yet they gave the most neutral pre (3.21) and post (3.36) and post delayed (3.14) responses of any question (Table 4.1, Figure 4.1). Similar to some of the other questions that I have talked about, it seems that students watched videos of the coyotes, saw them being collared, and just assumed because we have done it that they are not that difficult to catch.

Barab and Hay (2001) discussed the difference between simulation and participation models to authentic science learning. In the current study, a major advantage to the simulation model is that video can be taken from the field and brought into the classroom, therefore giving students the opportunity to learn about the science being taught without having to spend the time directly participating in the research. This strategy can greatly facilitate the content being delivered to students. However, a major disadvantage is that students do not appreciate the effort and time that it takes to get that data/video and for trapping that can literally be months just to capture one coyote.

Rubrics related to coyote knowledge

In addition to the three surveys (pre, post, and post-delayed), two of the questions during the interviews were scored based on a rubric (Chapter 3) in order to determine student learning of coyote concepts. As shown in Table 4.2, both questions produced significantly different responses.

Despite all students in the pre (n = 11) and post (n = 10) interviews appropriately answering, "No," to the question, "Why do or don't coyotes all act the same?," students provided more detailed answers during the post interviews. They provided more examples (9 versus 4 for post and pre interviews, respectively) compared to pre interview answers (Appendix 2). Most answers during pre interviews scored either a 1 (n = 4) or a 2 (n = 6) to the question, "Do all coyotes act the same?" During the post interviews, scores dramatically improved (Figure 4.2).

The following excerpt from Samantha is representative of students' reasoning during pre interviews:

> Samantha: No, I think any animal would be an individual in itself but they probably do have very similar patterns of behavior because they are communal animals. You know?

During the pre interview Samantha contradicted herself. At one point she thought that coyotes were individuals (which is the correct view) yet she then said they are probably similar because they are communal. In addition, coyotes are not communal. They are social, group living carnivores. In fact, many of the students during pre interviews did not recognize the difference that all coyotes are different because of individual variation. Students that gave poor reasoning during the pre interviews is also evident in Rick's statement, which lacked sophistication:

> Rick: I think that any other animal shows a range of behaviors based on their survival, like factors on the outside, you know, like how they would act, but overall, like, I think that if you are looking at one specific coyote they would act differently but if you are looking at a whole then they would act pretty much the same to keep each other surviving.

After the curriculum intervention students generally seemed to gain a better understanding to the question. Matt's answer indicates that the responses did not have to be long, they just had to be accurate; being concise was fine:

> Matt: No, they definitely behave differently. For example, dominance wise, they have different roles within the groups.

A more complete answer, given by Rachel, gave examples and mentioned individual variation. These were the two important components that they needed to include in their response in order to receive a good score:

> Rachel: No, they definitely act differently because they are different individuals. They have different ways of expressing. Like when they want food or like you said when they howl. But they all have individual howls.

Initially (i.e., during the pre interviews) most students inaccurately answered the question, "Why do or don't you think that coyotes can be eliminated from an area?" (Table 4.2). Meanwhile, after the curriculum unit was finished (i.e., during the post interviews) the students seemed to comprehend the question better and hence scored significantly higher than during pre-interviews on the rubrics (Figure 4.3). Because of the short length of the curriculum intervention I could not have expected them to understand coyote terminology completely accurately (like discussing dispersal, territoriality). Yet we were able to talk about coyote ecology and reasons why they are successful around people such as elusiveness, amazing colonization potential, living in low densities, and territoriality, among others. The answer I was looking for was, "No, they can not be eliminated. They are difficult to kill. If you kill one, another coyote will quickly disperse into that territory. Thus, while you can kill individuals you generally can not eliminate (or extirpate) the population in a given area."

Pre interview answers commonly included the belief that coyotes could be easily removed from an area. In addition, inappropriate terminology was often used. For example, Matt's inappropriate use of the word terminate instead of extirpate is a case in point:

> Matt: Yeah if we really want to target and terminate them, yeah, we could do it. It would take a lot of power, a lot of resources to do it.

In addition to not using appropriate terminology in wildlife ecology jargon, I am not sure to what kind of power Matt is referring to because I failed to ask him directly. I suspect he means man-power and a lot of effort to eradicate coyotes. Other students thought that coyotes could be eliminated from a general area, they just did not agree with that occurring. In other words, many students initially had a positive view towards coyotes but did not understand coyote ecology, as demonstrated by Tim's comments, to explain why coyotes could not be eliminated:

> Tim: I think the coyote species is limited enough in heavily populated areas that they could be eliminated but I just think that it would be wrong.

Furthermore, several students just did not know much about coyotes. They seemed confused when I asked the question and did a mediocre job describing their answer, as evidenced in Michelle's pre interview response:

Michelle: I don't know, I think we could try, but...I think...I don't even know how they got here. If we killed them off I am sure some other species or other form of coyote or something would get back.

In general, student understanding of coyote ecology increased after the curriculum unit. Some students understood that coyotes could not be permanently eradicated from a landscape but could not precisely explain why. For example, Nicole seemed to understand the concept better once I prodded her a bit:

Nicole: Possibly, if you wanted to eliminate all the coyotes then it would be difficult. If you eliminated just some of the coyotes in an area then more would just move in.

Interviewer: So localized control potentially, but not in the long-run?

Nicole: Right.

Interviewer: Yeah, because it is hard to get rid of them in a big area but maybe locally you could, or at least temporarily.

Nicole: Yeah, but more would just move in.

Other students, however, had a complete understanding of coyote ecology by the end of the unit and thus explained their results in an accurate and complete way during the post interviews. Rachel's response was particularly notable among the interviewees:

Rachel: No, because of what you told us in class. Was that if you eliminate a certain pack then other packs are going to come in. So, no I don't think that you can eliminate them.

Interviewer: So you can get rid of an individuals but not coyotes in general?

Rachel: Correct.

During the intervention I noticed that some students were grasping some of the important concepts of the course, and thus I was not surprised that students better understood the concept of the futility of killing coyotes. For example, on 22 October, Samantha asked an important question when we were talking about coyote home range and territoriality. My response was somewhat similar to many of their answers from the interview question:

Samantha: If coyotes are killed won't others just move in?

Researcher: Yes, that is precisely why control efforts are useless unless specific animals are causing unacceptable damage or are a threat to people. It is amazing how basic of an ecological concept that is but how little people understand that simple concept. The scientific paper that I will be giving you folks (on home range and territoriality of Cape Cod coyotes), although technically written, is precisely stating that same thing.

The survey and rubric questions indicated that the curriculum unit improved students' knowledge of coyotes and helped defeat some of the students' preconceived notions about coyotes and coyote behavior. Robin's answer to "What do you find interesting about coyotes?" is representative of this mind change:

Robin: The way they (coyote) behave around you I thought was interesting, the way they behave in captivity. And to compare that with how they behave in the wild. I thought that it would be a lot different (i.e., the behavior of wild and captive coyotes) but it really wasn't.

Interviewer: Ok, cool. Hmm, in terms that it really wasn't that different between wild and captive circumstances besides obviously one being in a fence?

Robin: Yeah.... yeah...yeah.

This section indicates that students improved their understanding of important coyote concepts covered in course. In addition to the presented data, students scored an average of 83.4 ± 8.7 % (SD) (range = 70 - 98 %) on a test summarizing the unit and prepared by Doug. Doug derived the test questions from his notes of the curriculum unit. Their participation in the unit through both discussion and lecture based activities seemed to make a difference in their performance on all assessments.

The need for scientists and schools to form partnerships is important and potentially beneficial for all sides (Means, 1998; Waksman, 2003; Wormstead et al., 2002), especially when engaging in an authentic scientific project, either through direct participation or simulated studies (Barab & Hay, 2001; Hay & Barab, 2001). Evidence from this section demonstrates that students were capable of learning important terminology taught by a scientist. The advantage for the students was students getting the opportunity to learn from experts (i.e., scientists) in their respective disciplines while participating in legitimate scholarly, school-based activities. This study is important because there is mounting evidence that one component of the science education reform process must be a sustained effort toward making the study of science accessible to more students (Jones, 1997), including the urban-based students in this study.

Beliefs/Affective Components

No significant differences existed amongst any of the belief related questions (Table 4.1, Figure 4.4). Student opinions were very positive of coyotes from the start and students did not change those viewpoints over time. A large number disagreed that coyotes are accurately depicted in the media and that coyotes are dangerous to people. However, I am somewhat frustrated that more people did not strongly disagree with the statement, "Coyotes are dangerous to people." It was made abundantly clear during the lectures (especially during the windows media player videos) that coyotes are not dangerous; however, student scores (1.79 for post-survey) were considerably closer to just "mildly disagree" than "strongly disagree."

However, when examining student interview responses (see Appendix 2) to the question, "Are you scared of coyotes?," interesting trends appeared which might explain the lack of any difference being detected in the survey question, "Coyotes are dangerous to people" (Table 4.1). The majority of people were not scared of coyotes. However, the same two people (Tim and Matt) were both scared of coyotes before and after the unit and Rick remained unsure, because he had never observed one in the wild. Thus, the two week unit, where they no doubt knew that coyotes were not dangerous, still did not change their opinions, as is evidenced by Tim's remark:

> Tim: If I came into contact with one, I would be scared but only because the whole coyote is like a dog factor (he is scared of dogs).

Interviewer: Contact, meaning, seeing one directly or coming up face to face?

Tim: Face to face, if I saw one running around I just wouldn't go near it.

Interviewer: What do you think you would do if you saw one?

Tim: I would stay away from it. If it was really close to me I would stand still because running is the worst thing that you can do. If it was kind of far away I would just walk away and avoid it.

Interviewer: So you are relatively scared of them but it wouldn't keep you away from doing something like hiking in the marsh?

Tim: No, it wouldn't keep me from doing it.

Most people agreed that coyotes were important and interesting (Table 4.1) with all averages for those two questions over mildly agree (4.0) during each survey (Figure 4.4). Thus, students unanimously agreed that coyotes are an important component of our natural heritage. Judging by their positive responses during the interviews, the curriculum unit seemed to indicate that students thought that coyotes were important. Rick, after the post interview, summed up these feelings when talking to me about the captive coyotes at the Stone Zoo:

Rick: I just wanted to go into the cage and pet one. To me, the relationship that you have with them is amazing. I understand, of course, that you have been with them since they were puppies. They are like wild things that no one will ever like...that people are afraid of. Like how did they react to you? Like you wanted them to react the same way with you.

Students were not quite so sure with the question, “Coyotes can be tamed and raised like a domestic dog.” Students scored mediocre results both during pre and post-surveys (Table 4.1, Figure 4.4); all surveys produced average values between the “slightly disagree” and “no opinion” answers. It appeared that students were confused by this question because I hand-reared the captive coyotes at the zoo and those coyotes are as close to me as any domestic dogs is to a person. However, some students also probably listened to my comments that despite being hand-reared the coyotes behave much differently than dogs; for instance, the coyotes live in an outside enclosure and would surely tear my house apart if they were kept inside. Since coyotes can not really be raised like domestic dogs, it would be more appropriate to better word it for the students. For instance, I could ask, “Coyotes can be socialized to humans if raised at a young age.” In this question, I would hope for a “strongly agree” answer. Or I could word the question, “Coyotes could easily be raised inside a house just like a domestic dog,” where I would expect a “strongly disagree” response. Finally, I could say, “Taming coyotes to people in a zoo setting is important in order to study their behavior,” and I would hope for “strongly agree” as their response.

Students had very strong opinions from the outset that coyotes should not be eliminated. This strong belief continued throughout the unit and all the way to the post delayed surveys where almost every person strongly disagreed that coyotes should be eliminated (Table 4.1, Figure 4.4). Right from the start of the curriculum intervention (i.e., during the pre interviews) students had positive views towards coyotes (Appendix 2). In fact, only 1 of 21 (5 %) interviews did not say, “They should not be eliminated.”

This response was neutral, where the student, Katie, gave no opinion. Brad's response was on par with how most students felt about coyotes being eliminated:

> Brad: I don't agree with that at all, because it is their environment too. It is ours, and birds', and plants', and everything. It all interacts. Every other species has just as much right to it (the environment) as we do.

Rick's view, whether he knew it or not, also hints at a much larger issue of the balance of nature and the fact that coyotes are just another species, as Brad indicated, in the delicate web of life. These students obviously were pro coyote in their response to the question, "Should coyotes be eliminated?" Rick's statement is a case in point:

> Rick: No, I disagree with that I think that coyotes are like a great thing to study and just for the simple, you know, sake of science. I guess, you know, if you eliminate something from somewhere else you just mess up the whole environment basically. What if coyotes end up having a positive affect on the environment? People don't realize that.

This section illustrates that the students, even in an urban setting, had very favorable views towards coyotes. The students' positive statements about coyotes suggests that this curriculum unit has the potential to empower the students into caring for the coyotes and our project, in effect giving the students a sense of ownership of the project (Barnett et al., 2004; Bouillion & Gomez, 2001; Fusco, 2001). The very real effect of their compassion for these creatures came in late March/early April 2005 when a group of three (all radio-collared) coyotes died of poison. Doug informed me that when he told the students they quite literally were in or close to tears, to the point where he did not want to make eye contact with them and fear that he would also break down. As educators and scientists we need to harness the energy of these students to promote the message that our local environment is important and that community members have a stake in these issues.

Interest and perceptions of science and coyotes

Table 4.3 depicts the statistical results from the "I want to be a scientist" scale. There were no significant differences from any of the eleven questions indicating that the students in general did not become noticeably more interested in being a scientist during the surveys (Figure 4.5). These data and the lack of any differences detected are particularly intriguing given the favorable stance that the students had towards coyotes. However, four questions scored over a 4 (agree) during the post-delayed survey meaning that they did have at least some interest in being a scientist (Figure 4.5).

Table 4.4 depicts the average scores and results from the "Scientific Methodology" scale. In this section, of the nine questions, one was significant, one was marginal, and eight had final (post-delayed test) values over 4 (agree). The question, "Scientific questions are answered by observing things," scored a 4.6 during the post-delayed survey compared to a 4.0 during the pre-survey ($p = 0.011$). Another question, "Science tries to explain how things happen," was marginally significant ($p = 0.161$) with a post-delayed score of 4.8 (Table 4.4). Despite the lack of many differences between the surveys, students had a good perception of the scientific method as evidenced by the eight (of nine) questions scoring over a 4 (Figure 4.6). Scores were high during the pre-surveys, effectively precluding detecting significance during post-surveys. Learning is a generative process requiring effort in which learners actively construct their own meanings that are consistent with their prior ideas rather than passively acquiring knowledge transmitted to them (Chin & Brown, 2000). This survey showed that students at Coyote High seemed to perceive the role of scientists as active members of the scientific community. This lends support to the notion that scientists might be good sources for teaching students content matter, considering that they might be good mentors to get students actively involved in science.

Overall, students in Doug's class had favorable views towards science during the interviews with all but one student from the 21 (95%) combined interviews replying, "Yes," to "Do you like science classes in general?" The most common answers to, "What do or don't you like about them (science courses)," was liking life sciences, disliking chemistry and disliking physics (Appendix 2). Brad's statement summarized the classes' general feelings towards science:

> Brad: Yes, I like biology and environmental science. I like any type of science that you can interact with, like you can learn from interactive experiences. I don't like something like physics or math related science. I more or less like studying the world around me.

Brad's statement hints at hands-on learning being an important component of the learning process for students. Kahle et al. (2000) found students in inner city areas could learn science effectively and became more involved when using inquiry-related science activities. Importantly, inquiry based activities are an important national and state framework for the science standards (National Research Council, 1996, 2002). Likewise, the practical nature of science was important to many as reflected in Matt's statement after experiencing the curriculum unit:

> Matt: I like they way they (science classes) relate to real life situations, like the field studies (taught by Mr. Ernest) course. Chemistry was really hard for me. I didn't mind it, it was just difficult.

Teel et al. (1998) noted that inappropriate teaching strategies often cause poor performance. A way to improve student outcomes is to involve students directly in real world community science projects (Fusco, 2001; Rahm, 2002) where students can feel involved in the learning process.

Although I previously gave examples of why students liked science, not all wanted to pursue a career in science. This is not surprising given the declining rate of urban students (especially minorities) in science-based careers (National Science Foundation, 2002). Six students in each interview section wanted to pursue a career in science with four and three not wanting to for pre and post-interviews, respectively. One student wasn't sure during each interview. As Appendix 2 indicates, no answers predominated. One student, Samantha, wanted to pursue a career in field biology or zoology, doing things similar to studying animals. No students changed their opinion after the 2 week unit – i.e., the curriculum unit did not appear to inspire anyone to want to take on this line of work.

Many of the students when asked, "What do you find interesting about coyotes?," answered with behavior related comments consisting of four types of questions: social, communication (i.e., howling), coyotes around me (i.e., the captive coyotes and myself at the zoo), and how they are scared of people. A similar number of behavior related responses were discussed during pre (n = 5) and post (n = 6) interviews. However, only two of the groups of responses (social and communication) were mentioned during pre interviews while all four sets were observed during the post interviews (Appendix 2). Thus student responses did not change dramatically as representative of Rachel's (pre interview) and Michelle's (post interview) comments:

> Rachel: How they, like, … the communication aspect and how they interact with each other. I like how you think that they have feelings and stuff like that and that they interact with each other so that they can do things and be happy and stuff like that.
>
> Michelle: Their behavior, now I see how they interact with you, so like if humans can play a part from younger ages. Like you said, they can't be domesticated but they can be tamed in a sense. That is interesting.

These statements indicate that students maintained their interest in the social nature of coyotes through the course. During the post interviews students used specific examples from the curriculum to make their point indicating that they were learning from the unit and basing that interest in the creatures with information that they learned during the curriculum unit.

During the pre interviews a couple of responders mentioned that wild coyotes live close to people and associated wild coyotes living in urban areas as interacting or living around people. A more scientifically sophisticated answer would be to say that wild coyotes inhabit urban areas – but that does not mean that they interact with or are dependant on people. Most coyotes in urban areas actually eat natural foods such as mice, rats and rabbits. Jen's comment is representative of the student's inaccurate statements and hints at the need to better educate them to actual coyote behavior and biology. However, the statement does indicate Jen's interest of coyotes being found in urban areas:

> Jen: In general, I find coyotes very interesting. They are so close to where we live and such. They live in cemeteries and people can interact with them.

When asked what interested them about coyotes, many students did not say anything in particular. However, as Rick's statement depicts, their enthusiasm for coyotes was readily apparent despite their lack of a clear focal interest:

> Rick: Now that we studied them, everything. They are just like...I had no idea what they are like....It was amazing seeing them at the zoo in real life. You see them in pictures and don't get that much of an idea about them until you see them in real life. Their actions, the way they are. I wish the unit was longer. I even told (Ernest), 'hey can we go to the zoo again.'

All students during pre (n = 11) and post (n = 10) interviews, when asked "If they would be interested in going to a zoo to see coyotes?," answered the question saying, "Yes." Not surprisingly, the main reasons were to see them or observe behaviors directly (Appendix 2). But some students also wanted to be able to compare what they looked like to dogs, to be more involved or hands-on (this is something I think that many students meant by being able to see them, but they did not say it out loud when answering the question). Three wanted to go back again after the curriculum unit finished. Nicole's statement summarized why we have the captive coyotes for educational purposes:

> Nicole: Yeah, because then you can see like how they interact with each other. And, like, if you go out into the wild to look for them you might not find them but in the zoo they are right there.

Tim's statement also understates the importance of providing authentic learning experiences (Barab & Hay, 2001; Bencze & Hodson, 1999; Chinn & Hmelo-Silver, 2002) which were clearly an important part of his experience during the curriculum unit:

> Tim: Yes I would like to go to a zoo… Well, you can observe them and see how they behave instead of just being told something. Sometimes when you are told something it doesn't register as easily. Going to the zoo is almost like the hands- on learning like I said before. Like to be there watching.

The post interviews were similar to what was said in the pre interviews except a few students hinted at furthering their knowledge of coyotes by going back to the zoo, and potentially doing some experiments and/or data collection. Samantha's statement is representative of this advanced thinking after the unit concluded:

> Samantha: I would very much be interested in being more involved in the captive coyote study and learning more about them. I have had exposure to it (the captive coyotes) over a while (the two week unit) and it is a hands-on thing that I like to do. And because the coyote is an animal that I haven't really given much thought to, so it is like interesting that

> there is so much stuff going on. It is the type of information that I want to be learning about an animal that I have never really considered.

Science activities that tend to infuse meaning cause students to value the learning experience. Current emphases on interactive, hands-on, or inquiry-based learning is influenced by the constructivist approach which acknowledges the student as actively making his or her knowledge (Zady et al., 2003). Students in this study indicated that direct involvement with coyotes, such as going to the zoo, was important to maintain their interest in the curriculum. As educators, it is our job to listen to the students and provide learning opportunities that meshes with their interests.

There were no significant differences from any of the eleven questions in the "I want to be a scientist" scale, which indicated that the students in general did not become noticeably more interested in being a scientist during the surveys (Figure 4.5). These data and the lack of any differences detected are particularly intriguing given the favorable stance and interest that the students had towards coyotes. Future work must be geared to trying to get students more interested in wanting to become scientists. Significantly, students at Coyote High seemed to perceive the role of scientists as active members of the scientific community, as evidenced by the high scores given during the Scientific Methodology survey scale (Figure 4.6). This lends support to the notion that scientists might be good sources for teaching students content matter, considering that they might be good mentors to get students actively involved in both science and in pursuing science as a career trajectory.

Student learning and preference

Student involvement in the learning process can affect student interest in science (Bouillion & Gomez, 2001). Thus knowing how students like to learn is important.
In this study, the most desired way of learning was through hands-on activities and visual mechanisms, although a diverse array of answers including lecture/notes, multiple ways, reading, and videos were given (Appendix 2). Advocating hands-on learning and many other learning instruments, Matt epitomized the multiple learning approach method:

> Matt: Hands-on, field studies, that's really great. Like labs. Something where you can see a more visual thing. Simple reading, that is no problem. I am good with that. Probably like powerpoint presentation, anything visual. Like technology.

However, traditional forms of learning were still prevalent in some of the students as demonstrated by Nicole's response:

> Nicole: I like when teachers give you notes so you can copy them down and take them home to look at. I don't like to work in groups really because then, like, more people do more stuff than others and so you don't get the same experience as others.
>
> Interviewer: So you like the format of the powerpoint presentations that we are doing in class?
>
> Nicole: Yeah.

Keeping a curriculum unit diverse is critical to engage as many students as possible. Students advocated learning in different ways. For instance, as Nicole likes the lecture format for learning, Samantha advocated a more hands-on approach:

Samantha: I prefer field work if that is what you mean. I collect bones and study anatomy and skeletal structure. I prefer going to the beach and look at a dead thing and sketch it out, and say hey look a dead thing. Then to bring it home, clean the bones and study it that way.

Interviewer: So you like doing hands-on active stuff but it certainly sounds like you don't mind reading?

Samantha: I like to research things before I actually get onto it, but….that is for like background reading. But you can actually remember more by doing hands-on learning because that is an experience that you can remember.

Interviewer: Cool

The question "What would be the best way to learn about coyotes?" was purposefully open-ended. I deliberately gave them no examples in order to see what they came up with on their own. The most frequent answers was to see them or study them, either in the wild or in captivity. A segment of Matt's interview is indicative of this:

Matt: Probably, studying them in the wild, like tracking them with the radio-collars. Like actually seeing them in the wild."

Interviewer: And so going to a zoo and seeing them in...

Matt: Yeah, that would also help, there is no guaranteeing seeing them in the wild.

Interviewer: Great point, one of the main reasons why I have the captive study is for that (i.e., for people to get to see what coyotes look like).

In addition to the importance of observing coyotes, five people during post interviews thought that movies (videos) on coyotes were important whereas only one thought that was the case before the unit began (i.e., during the pre interviews). It seemed that students answered with movies because they enjoyed the windows media player videos that I showed with the powerpoint slides (Appendix 2). As the following dialogue with John indicates, the videos connected important concepts in a visual manner:

John: Seeing them definitely, like going to the zoo and seeing them. Like watching the home videos and seeing what they are like. It is one thing to read about them in a book but it is another thing to actually see them in person or on video.

Students thought that reading about coyotes, learning in multiple ways, and having a person with experience studying them would be valuable ways to learn about coyotes. Michelle's statement reflects the importance of learning about coyotes in multiple ways:

Michelle: I think the way we did it for the past two weeks was the best way for me to learn about coyotes.

Interviewer: So, hands-on?

Michelle: But also classroom material at the same time.

Finally, three students (1 during pre and 2 during post interviews) thought that interacting with coyotes like having a live animal in a classroom would be an important way to learn about coyotes. It was very apparent through these interviews that not only did students have an interest and a desire to see real coyotes but it also was a way to contribute to their learning of the unit. Students seemed to like coyotes and the unit in general even if they were not extremely interested in science.

The personalized, meaningful place-based learning of the local coyote study was important to these students as indicated by Tim:

Tim: Definitely going to see them at the zoo. To see them in real life.

Interviewer: Why do you think that seeing them in real life would be so important?

Tim: Well since I'd seen them now, I mean, you can show us as many pictures of the coyotes as you want but it is so hard to distinguish the coyotes but when I was at the zoo I, by the end of the field trip, could easily distinguish them even with their backs towards me. I saw their different behaviors like when Lupe wanted your attention and how he did it.

This section makes additional arguments beyond the previous section on student interest in science and coyotes advocating that we must listen to students in order to appease their learning preference. Here we learned that multiple ways of learning, ranging from reading to hands-on activities are crucial to maintain student interest in science. Having a curriculum that is diverse will reach a larger and more assorted audience. For example, students learned best when they watched videos, saw the coyotes at the zoo, and got to learn about them with traditional, lecture based materials (e.g., powerpoint presentations). Lastly, some students noted that bringing a live coyote to the classroom would be a great way to see and learn about coyotes up-close. To me, this last scenario seems like a special type of simulated learning discussed by Barab and Hay (2001) where the science is brought into the classroom. Future research should investigate the effects of these types of learning environments.

Applied Knowledge of Coyotes

Results from this section focus on using knowledge of coyotes and applying that understanding in order to answer important questions related to their ecology and behavior. For example, when asked what questions the students would want answered about coyotes, a diverse array of answers were presented during both pre and post-interviews (Appendix 2). A common answer before the curriculum unit began (i.e., during the pre-interviews) was wondering why/how do coyotes live in the city. Matt's statement exemplifies that thought:

> Matt: I want to know why....like.. like....I have never heard about them, like populations in Revere and anywhere in greater Boston until recently. It kind of seems like, like their population has shot up. Like, I don't know if the environment is getting better for them.
>
> Interviewer: Recently being how long… like a couple of months, a couple of years?

Matt: Like, since I haven't really heard much about them until four years ago maybe. So, I am just guessing that their population is getting bigger and that, that they are making strides.

Interviewer: That is a very basic and important question that we will try and answer.

Being an advanced placement course, many of the student's in this class had advanced levels of thinking and a good curiosity towards science. From the outset, Rick was very curious about coyotes, as evidenced in this quote about coyotes:

Rick: What are they? Why are they..... what factors of the environment allow them to live here? What is their effect on humans? You hear on the news evil things like coyotes are dangerous and this and that but then you hear from like a person like Mr. (Ernest) who has been with the coyotes that says they are not a threat because you know, basically they are like....they will leave you alone and don't want to interact with humans. I just want to know what the real story behind all that is.

Those statements, and others from the students, indicated that the student's initially expected coyotes to be found in more rural or wilderness like areas. Many of their initial assumptions seemed to suggest that it is not normal to have wildlife in urban areas, at least not a predatory species like a coyote. The students learned that coyotes inhabit the city because of natural dispersal and colonization into vacant territories. Thus, after the curriculum unit concluded they then asked more specific questions about coyotes that would have only been obtainable through experiencing the program. Samantha's comment is a case in point:

> Samantha: I like in particular their hunting habits. You talked before about their style of where they hunt mice, you know, looking and pouncing. I used to have a German Shepard that like hunting flies near it. I also like other hunting habits like the way that they hunt deer and stuff, you know like pack behavior for group hunting and stalking techniques.

In addition, Jen's comment drives at not only what she learned by participating in the curriculum unit, but also the importance of the place-based (Hungerford et al., 1998; Woodhouse & Knapp, 2000) nature of the study where she got to experience coyote behavior directly:

> Jen: Basically like with the whole dominance, when we went to the zoo and saw them and like how Cane was so dominant to Caon but when you did the initial group howl, Caon ran up next to you (referring to me; I was in with the coyotes while the students watched me) and Cane didn't drive her away or attack her. Most of the time the dominant female (Cane) drove her (Caon) away. So I want to know about group interactions.

Jen's interview transcript gives meaning to the importance of local studies. She described important components of coyote behavior (dominance and social interactions) but was referring to the local actors (the captive coyotes) to illustrate her points. This learning strategy is consistent with Rahm's (2002) vision of doing place-based meaningful activities. The results from these studies underline how children can become masters of the science embedded in their everyday communities and practices if provided with opportunities to do science that is meaningful and real to them (Rahm, 2002). I can't think of a better way to illustrate this point then the way that Jen applied her knowledge of the captive coyotes to discuss dominance in canids.

Students gave numerous recommendations for cat/pet owners living in coyote country (Appendix 2). Both during pre and post interviews students seemed to have a good understanding of how to avoid unnecessary encounters with coyotes and pets. Tim's pre interview response illustrated this knowledge:

> Tim: Just don't leave your pet outside. If you have a dog just be happy to have it live inside or if you do have it outside make sure you have it in a fenced-up (in) area where it is not accessible by (to) coyotes.

Samantha's post interview response reflects not only her understanding of how to avoid unnecessary coyote encounters but it also sarcastically illustrates how ignorant some people can be about coyotes and their lack of responsibility with their pets:

> Samantha: Don't like wonder around in the middle of night with your dog with straps of meat attached to it. Or with a trail of bait dragging behind you. It is just common sense. Like (Ernest) once said that he wished that if they put down problem animals that they would put down problem pet owners. Not to be that extreme but if you have an animal then you should be responsible... If you have a small dog have it in a fenced in area and monitor it if it is going to be outside, like there are predators in the world and you can't just eliminate every predator in

the world and have a little haven where nothing is ever going to go wrong. Cats can be left indoors and they do have little cat leashes like used for dogs. It seems like with the cat in the video (that a collared coyote didn't kill) that they can handle themselves. They saw other animals affect other animals.

Student opinions on preventative ideas to avoid coyote – pet conflicts are important. Coyotes are often in the news for causing depredations on pets and an important component of coexisting with these creatures is to know how to avoid encounters before they occur. Samantha and Tim's comment illustrate some of these preventative measures that can be taken.

Most students, when asked what would be some research questions if they could study coyotes, answered with ecology or behavior-based answers (Appendix 2). There were no noticeable changes from pre to post interviews; that is, students did not seem to come up with more sophisticated responses over time. For example, Nicole's pre interview response is on par with Rachel's post interview answer:

Nicole: I guess more with the behavior and why do some become dominant. Like, maybe not because of size. Maybe there is another reason like maybe they are more aggressive than the others.

Interviewer: Alright so the social aspect is something interesting to you, so make sure you focus on asking questions and stuff and why did I say this or do this or that because we will be talking about coyote sociality and stuff.

Nicole: Okay.

Rachel: I would definitely like to see how they interact and how different behaviors mean different things especially from the alpha to the beta coyote. I thought that that was really interesting.

These students had fairly good concepts of coyotes coming into the unit. A beneficial project for these advanced students would have been to require them to design and possibly implement a mini-research project on coyotes. In this fashion, students' could test their questions in the field with many of these questions being able to be examined at the zoo.

This section indicates that students had a fairly good amount of common sense about coyotes at the beginning of the curriculum intervention. They gave many responses that were on par with their post interview answers. Doug taught them some information about coyotes before I arrived which appeared to affect some of the student's initial perceptions and beliefs about coyotes. Also, being advanced placement, they seemed to have well developed thought processes that helped them when replying to my initial (i.e., pre interview) responses. These thought processes should serve them well as they go from straight memorization of facts towards generating their own studies or questions about coyotes.

Students' perceptions about the coyote curriculum

Throughout the unit, but especially at the end of the intervention, students were encouraged to give their opinions on the curriculum unit. As indicated throughout this chapter, students learned a lot about coyotes in a short period of time. However, uncovering reasons why students liked or disliked certain aspects is important to make the curriculum more usable in the future.

Videos and other positive outcomes of the curriculum unit

When asked "Would you rather watch a TV program on coyotes or home videos on them?" students overwhelmingly wanted to watch home videos on coyotes rather than a nature video or documentary on them (20 of 21 responses; Appendix 2). The students thought that the videos were more authentic or meaningful and they were not biased. However, three students during pre and one during post interviews wanted to see both videos and one student (Katie) wanted to see nature videos during the pre interviews. However, the fact that only one student during the post interviews wanted to see a nature video over a home video indicated very strongly that the personalized nature of the home videos (i.e., actual video that we have taken in the field) was very important and meaningful to the students as indicated by John's statement:

> John: Home videos. They are much more personal. (Nature) videos are edited, they are manipulated at times. Videos are like this is actually what happened. They are more personal.

Tim's comments drive home the students' surprisingly negative views towards nature videos:

> Tim: Nature video is all fraud. The home video is just the way that they are acting themselves. It is the way that they are acting. I think that nature videos show you only what they want to show you based on the focus of that video.

However, some students did advocate both types of videos. The nature videos, while maybe not as authentic, no doubt aided the students in making certain points from the powerpoint videos. Samantha's comments illustrate this view:

Samantha: I like how if you watch the home videos you have the person who was there and saw it first hand, they can explain it and then you can make your own conjectures about it too. But with things that are assembled, like documentaries and stuff, sometimes it is opinioned and marketed like a TV show type thing. This provides a lot of information to the viewer. So I think at this point I would have to say home videos, but not by a whole lot.

Most students seemed to like the curriculum unit. The students especially liked the videos which prompted me to ask them a follow up question to why they liked the videos so much. The majority of their responses to this question centered on the fact that the videos brought the coyotes closer to them, the videos were a step between the real thing and the notes, and that the videos illustrated the concepts that we talked about. My dialogue with Samantha clearly indicates these points during my post interview with her:

Samantha: I liked how it was having a window into an interesting study. Like having someone like you that has been doing it (the research) and sharing it with us. It was something that I felt involved in. It wasn't like watching on TV about a new coyote study. It isn't so far away, you can actually have your hands in it.

Interviewer: Cool, so the hands on approach…

Samantha: Nods, yes. I liked the videos because they also again, brought the coyotes closer to you. You could actually see it as opposed to hear about it. It is more like being able to get some of the information (from the powerpoint slides) then have the hands-on as a bulk of your knowledge (from the videos).

In the last sentence, I think that Samantha was trying to say that the videos are interactive and that she can actively learn about coyotes without having to go do her own studies. This statement hints at Barab and Hay's (2001) discussion of authentic science in a simulated manner. Rather than learning science in field or natural settings (Bouillion & Gomez, 2001; Fusco, 2001), students in this study participated with data brought into the classroom. This could make the curriculum unit more generalizable (Schofield, 1990) in the future where the unit could be brought into many classrooms as opposed to the unfeasible goal (because of time, logistics, and costs) of trying to bring those classrooms into the field.

Liking the videos was a consistent theme throughout the intervention. The videos seemed to give the students a more hands-on feel to learning in the classroom. In addition, the placed based localized nature of the study was attractive to many of the participants. I could tell at the beginning of this unit and during the pilot study that many students liked the videos very much. For example at the beginning of the intervention on 20 October 2004 I noted:

> The students seem very interested in the video from windows media player. Almost like they are anticipating what we are going to show them next. The

Wile E clip was a great example. Then we moved into the wild coyotes video clip and showed them some of our actual video. They seem very attentive and I look forward to getting into finishing the introductory stuff and getting into the actual coyote curriculum.

These observations are consistent with what some of the students said in their post interviews. Not surprisingly, in addition to the videos many of the students also liked visiting the zoo as reflected in John's comment:

John: I thought the coyote unit was fun… it was different from what I usually do. I got to go to the zoo. It was just more fun, it was different, I guess it was exciting to do something else. The videos were more personal, they were home videos that you made. They weren't some nature documentary. They were real home videos.

In my opinion, this was one of the most important sections in the whole research study. Finding out what students liked about a learning experience and capitalizing on that in the future is critical in order to support teaching and learning gains and positive experiences. For example, John's comment strives at keeping the unit diverse by having powerpoint and videos as a core part of the curriculum but also to allow time for informal experiences such as the visit to the zoo. Tim's comments captured some of the reasons why students' liked the curriculum unit:

Tim: I thought it was kind of well done with the videos. Like you introduced the topic then showed videos to support the topic and you brought up questions which you wanted us to ask. I think about some of the questions that you wanted us to ask and the fact that you did it purposely as part of the curriculum. I liked how you added Wile E. Coyote to it. It was an interesting feature to it. Kind of like catching our attention, keeping us interested. I thought that was kind of clever… The video is the next best thing to hands-on learning. I am big on visual learning and I think if you see something it is almost as good as experiencing it.

Finally, to finish up with student interest in the project I would like to share's Jen's comment about the curriculum. The unanimously positive experience from the curriculum unit is worth sharing with one last quote. The videos and hands-on involvement of going to the zoo illustrated many of Jen's points of emphasis:

Jen: I liked going to the Stone Zoo and getting the visual up close attractions and I liked the videos that you showed, the ones that like had the capturing of the coyotes, and how you put the collars on the coyotes. The videos give a better understanding of how you guys study them and the whole general process of studying them, and how they were sedated.

By the end of the intervention it was very clear that students thought that the hands on nature of the videos brought the coyotes to life. They very much liked this simulated mode of learning about coyotes – when I showed these video clips, it seemed to mentally take them into the field. However, providing informal learning opportunities was also important underscoring the importance of creating a diverse and varied curriculum unit.

Student dislike of the unit

After asking students what they liked about the curriculum unit I focused on also understanding what they disliked about it. The results even surprised me because the most common answer to this question was nothing really (7 of 10 students, Appendix 2). Most students liked it all and thought the unit was easy to comprehend. Robin summed up those feelings nicely:

> Robin: I actually like everything. I thought that the way you did it was awesome. I learned a lot from it.

In addition, one student did not like the unit because I was leaving so soon, one thought that we talked too much about other canids (e.g., foxes and wolves) and should have focused more on our coyote study, one did not like the notes that much but realized that they were important, and two thought that Mr. Ernest and I distracted the class with too many side conversations related to coyotes but not specifically about the lecture at hand. Samantha's comments lead to some interesting correlations with my classroom observations:

> Samantha: Sometimes you went off on tangents, like (Ernest) described things that didn't have much to do with what was going on. But other than that I thought that the information provided was very well taught.

I noticed that it was difficult to manage a class period when the normal classroom teacher was actively involved in the class. On the positive end more sophisticated conversation and new ideas were often generated when Doug became involved in the class. But, as my observations indicated, it definitely affected the structure of unit, especially when we only had a set amount of time (i.e., two weeks) to complete the unit. As Samantha's post interviews noted, that was also a problem for some students as they noticed that we (Doug and I) would quickly get off the topic or have side conversations that they could not follow. I noted that a couple of different times in my journal. One such incident was on 20 October:

> Today, we talked a lot about taxonomy and (Doug) chimed in with some of things that they have already discussed in class in order to relate it to them. We also ended up talking about early Boston and the geography of the area before it became a city and the wildlife (mostly canids) formerly around here. The students were good at listening and asking some questions – it is really amazing how fast the class goes (54 but basically 50 minutes after attendance and the start of class) especially with the cooperating teacher there that adds much dialogue to the topic.

These side conversations are precisely what Samantha complained about in her post interview. She seemed very eager to learn new things yet did not feel that it was necessary to ask us what we were talking about during these side conversations. She believed that it was a distraction to her learning the unit. This issue should certainly be discussed before a curriculum unit is implemented in a school because true co-collaboration (Pine, Under review for publication) between teacher and researcher might make it frustrating for the students. However, a researcher coming into a classroom and essentially having no teacher participation might frustrate the teacher especially considering that it is his or her class that the researcher is entering.

Similar to when students were inquired to say what they disliked about the curriculum unit, when asked to provide suggestions about the unit, most students responded by saying that it was a really good lesson. Four students suggested that I make the unit longer (like three weeks instead of two). Two people loved the videos and how they related to the slides and two liked the hands-on classroom activities and told me to continue with that (Appendix 2). One student thought that the unit had to be more focused following up on her comment that Mr. Ernest and I went off on tangents. John's comment was the most typical of the responses:

> John: I like the way you did it, it was very well done. It could've been longer. I am sure you could think of more to say.

Robin's quote also sums up not only her suggestions for the unit but how she felt about the intervention in general:

> Robin: I thought the way that you did it was awesome. Just the way that it went like slide, then the videos. You could see the slides and write the information down then you got to see the video.
>
> Interviewer: Great, then the classroom activities, those were…
>
> Robin: Yeah, I liked those too, because they were like hands-on stuff. We got to see what you did. And it helped me understand the (home range and territoriality) paper too because I didn't really understand your measurements and when we saw, like how you showed us on paper how you did the polygons, it, like, I liked that.

Apparently, the curriculum unit was liked by the majority of the students as evidenced by many of the students' enjoying the unit and complaining that I was leaving too soon and that I could make the unit longer if anything. However, there are still some things that could be modified such as deciding the level of cooperation between teacher and researcher. Overall, though, keeping the unit diverse and illustrating the materials with videos were important factors in the curriculum's success.

Summary

Barab and Hay (2001) discussed the difference between simulation and participation models to authentic science learning. In the current study, a major advantage to the simulation model is many of the scientist's activities can be captured by video then taken from the field and brought into the classroom, therefore giving students the opportunity to learn about the science being taught without having to spend the time directly participating in the research. This strategy can greatly facilitate the content being delivered to students. Student knowledge of coyotes did increase during the curriculum unit. Six of the nine coyote based knowledge questions on the survey produced at least marginally significant improvements after the curriculum unit took place. Much of that knowledge was retained, as indicated in the post-delayed surveys (Figure 4.1).

The need for scientists and schools to form partnerships is important and potentially beneficial for all sides (Means, 1998; Waksman, 2003; Wormstead et al., 2002), especially when engaging in an authentic scientific project, either through direct participation or simulated studies (Barab & Hay, 2001; Hay & Barab, 2001). Evidence from this chapter demonstrated that students were capable of learning important terminology taught by a scientist. The advantage for the students was giving them the opportunity to learn from experts (i.e., scientists) in their respective disciplines while participating in legitimate scholarly, school-based activities. This study is important because there is mounting evidence that one component of the science education reform process must be a sustained effort toward making the study of science accessible to more students (Jones, 1997), including the urban-based students in this study.

This chapter illustrated that the students, even in an urban setting, had very favorable views towards coyotes. The students' positive statements about coyotes suggests that this curriculum unit has the potential to empower the students into caring for the coyotes and our project, in effect giving the students a sense of ownership of the project (Barnett et al., 2004; Bouillion & Gomez, 2001; Fusco, 2001). As educators and scientists we need to harness the energy of these students to promote the message that our local environment is important and that community members have a stake in these issues.

The students indicated that hands-on learning is an important component of the learning process for students. Kahle et al. (2000) found students in inner city areas could learn science effectively and became more involved when using inquiry-related science activities. Importantly, these inquiry based activities are an important national and state framework for the science standards (National Research Council, 1996, 2002).

Science activities that tend to infuse meaning cause students to value the learning experience (Zady et al., 2003). Many of the students' comments underscored the importance of the place-based (Hungerford et al., 1998; Woodhouse & Knapp, 2000) nature of the study where they were able to experience coyote behavior directly.

Students in this study indicated that direct involvement with coyotes, such as going to the zoo, was important to their learning experience. As educators, it is our job to listen to the students and provide learning opportunities that meshes with their interests.

Students in general did not become noticeably more interested in being a scientist during the surveys. These data and the lack of any differences detected are particularly intriguing given the favorable stance and interest that the students had towards coyotes. Future work must be geared to trying to get students more interested in wanting to become scientists. Significantly, students at Coyote High seemed to perceive the role of scientists as active members of the scientific community, as evidenced by the high scores given during the Scientific Methodology survey scale. This lends support to the notion that scientists might be good sources for teaching students content matter, and for getting students actively involved in both science issues and in pursuing science as a career trajectory.

Student involvement in the learning process can affect student interest in science (Bouillion & Gomez, 2001). Thus knowing how students like to learn is important. This chapter advocated that we must listen to students in order to appease their learning preference. Here I learned that multiple ways of learning, ranging from reading to hands-on activities are crucial to maintain student interest in science. Having a curriculum that is diverse will reach a larger and more assorted audience. For example, students learned best when they watched videos, saw the coyotes at the zoo, and got to learn about them with traditional, lecture based materials (e.g., powerpoint presentations). Future research should investigate the effects of these types of learning environments. For instance, new learning techniques such as bringing a live coyote to the classroom would be a great way for students to see and learn about coyotes up-close.

One of the major findings from this chapter was the students' interest in the videos shown throughout the unit. The videos were interactive giving the students' a hands-on feel to learning, they illustrated the concepts and material well, and allowed students to actively learn about coyotes without having to go do their own studies. This statement hints at Barab and Hay's (2001) discussion of authentic science in a simulated manner. Rather than learning science in field or natural settings like other studies discuss (Bouillion & Gomez, 2001; Fusco, 2001), student interest in this study allowed them to obtain data driven inquiry in the classroom. This could make the curriculum unit transferable in the future where the unit could be brought into many classrooms as opposed to the unfeasible goal (because of time, logistics, and costs) of trying to bring those classrooms into the field.

Table 4.1. Average scores and statistical differences between pre, post, and post-delayed surveys at Coyote High School for each coyote related question. For all comparisons degrees of freedom (df) between groups (i.e., the different surveys) was 2 while within groups the df = 39. For all questions a score of 1 = strongly disagree, 2 = mildly disagree, 3 = no opinion, 4 = mildly agree, and 5 = strongly agree.

			Pre		Post		Delayed	
Question	F =	P =	M	SD	M	SD	M	SD
Knowledge related questions:								
Wild coyotes exist on Cape Cod	13.24	0.000	4.0	0.9	4.9	0.3	4.9	0.3
Wild coyotes exist in metro. Boston	2.13	0.133	4.1	1.1	4.6	0.9	4.7	0.6
Coyotes live most of their adult life alone	1.46	0.244	1.9	0.8	1.8	0.9	1.4	0.8
Coyotes often move long distances	3.60	0.037	3.4	1.0	4.1	0.9	4.3	0.8
Coyotes are mostly active at night	0.30	0.743	4.1	1.0	3.9	1.0	3.9	1.0
Coyotes howl to scare people away	11.48	0.000	2.1	1.0	1.2	0.4	1.0	0.0
Coyotes are more like foxes than wolves	2.54	0.092	2.9	1.1	2.5	1.0	2.0	1.2
Coyotes in the eastern U.S. are different than coyotes in western U.S.	2.41	0.103	4.1	0.7	4.6	0.9	4.7	0.6

Coyotes are very difficult to trap	0.21	0.813	3.2	0.9	3.4	0.9	3.1	0.9
<u>Belief related questions:</u>								
Coyotes are accurately depicted in the media	0.19	0.831	1.4	0.6	1.4	0.6	1.5	0.9
Coyotes are important	1.17	0.321	4.2	0.7	4.6	0.5	4.3	0.7
Coyotes are dangerous to people	0.03	0.971	1.7	0.9	1.8	0.7	1.8	1.1
Coyotes are interesting	0.56	0.575	4.4	0.5	4.6	1.1	4.7	0.5
Coyotes can be tamed and raised like a domestic dog	0.48	0.625	2.1	1.0	2.6	1.0	2.4	1.5
Coyotes should be eliminated from where people live	0.10	0.910	1.2	0.6	1.1	0.4	1.1	0.5

Table 4.2. Rubric scores (1-4) and statistical values from the pre and post content related interview questions at Coyote High School.

	Pre Interview		Post Interview			
Question	M	SD	M	SD	T value	P =
Why do or don't coyotes all act the same?	2.6	0.52	3.5	0.53	-3.857	0.004
Why do or don't you think that coyotes can be eliminated from an area?	1.9	0.32	3.4	0.70	-6.708	0.000

Table 4.3. Average scores and statistical differences between pre, post, and post-delayed survey questions at Coyote High School for the "I want to be a scientist" scale. For all comparisons degrees of freedom (df) between groups (i.e., the different surveys) was 2 while within groups the df = 39. For all questions a score of 1 = strongly disagree, 2 = mildly disagree, 3 = no opinion, 4 = mildly agree, and 5 = strongly agree.

			Pre		Post		Delayed	
Question	F =	P =	M	SD	M	SD	M	SD
I want to be a scientist questions:								
I would enjoy studying science in the future	0.016	0.985	4.0	1.2	4.1	1.2	4.1	1.3
I like to learn about new birds and animals	0.552	0.580	3.9	1.1	4.1	0.9	3.6	1.3
Scientific work would be too hard for me	0.017	0.983	2.1	1.2	2.1	1.1	2.2	1.3
I would like to work with other scientists to solve scientific problems	0.017	0.983	3.5	0.8	3.6	1.3	3.5	1.4
Students like me can use science to answer questions about the world around us	1.659	0.204	4.3	1.1	4.5	0.5	4.8	0.4

I may not make great discoveries, but working in science would be fun	0.277	0.759	3.9	1.0	4.2	0.7	4.1	1.3
I would like to be a scientist	0.083	0.920	3.4	1.3	3.6	1.4	3.4	1.5
Working in a science laboratory would be fun	0.189	0.828	3.7	1.1	3.5	1.4	3.4	1.3
I hope I can stay involved with science	0.200	0.820	3.9	1.1	3.9	1.3	4.1	1.3
We need to have a lot more science in our schools	0.58	0.944	3.6	1.0	3.7	1.1	3.6	1.3
Working as a scientist in the field would be fun	0	1.000	3.9	1.1	3.9	1.3	3.9	1.4

Table 4.4. Average scores and statistical differences between pre, post, and post-delayed survey questions at Coyote High School for the "Scientific Methodology" scale. For all comparisons degrees of freedom (df) between groups (i.e., the different surveys) was 2 while within groups the df = 39. For all questions a score of 1 = strongly disagree, 2 = mildly disagree, 3 = no opinion, 4 = mildly agree, and 5 = strongly agree.

			Pre		Post		Delayed	
Question	F =	P =	M	SD	M	SD	M	SD
Scientific Methodology questions:								
Scientists are always interested in better explanations of things	1.025	0.368	4.4	0.9	4.6	0.5	4.8	0.6
Scientific questions are answered by observing things	5.056	0.011	4.0	0.7	4.2	0.4	4.6	0.5
Good scientists are willing to change their ideas	0.112	0.894	4.3	0.9	4.4	0.5	4.3	1.2
Ideas are the important result of science	0.241	0.787	3.9	0.9	3.9	0.8	3.7	1.1
A major purpose of science is to produce new medicines and save lives	0.796	0.458	4.3	0.9	3.9	0.9	4.1	0.8

Scientists must report exactly what they observe	0.324	0.725	4.6	0.6	4.4	0.9	4.6	0.6
Science tries to explain how things happen	1.915	0.161	4.4	0.5	4.6	0.5	4.8	0.4
A major purpose of science is to help people live better	0.339	0.714	4.4	0.6	4.1	0.9	4.1	0.8
The senses are one of the most important tools a scientist has	0.364	0.697	3.9	0.8	3.7	1.1	4.0	0.8

Figure 4.1. Average scores for pre, post, and post-delayed survey questions at Coyote High School addressing coyote knowledge.

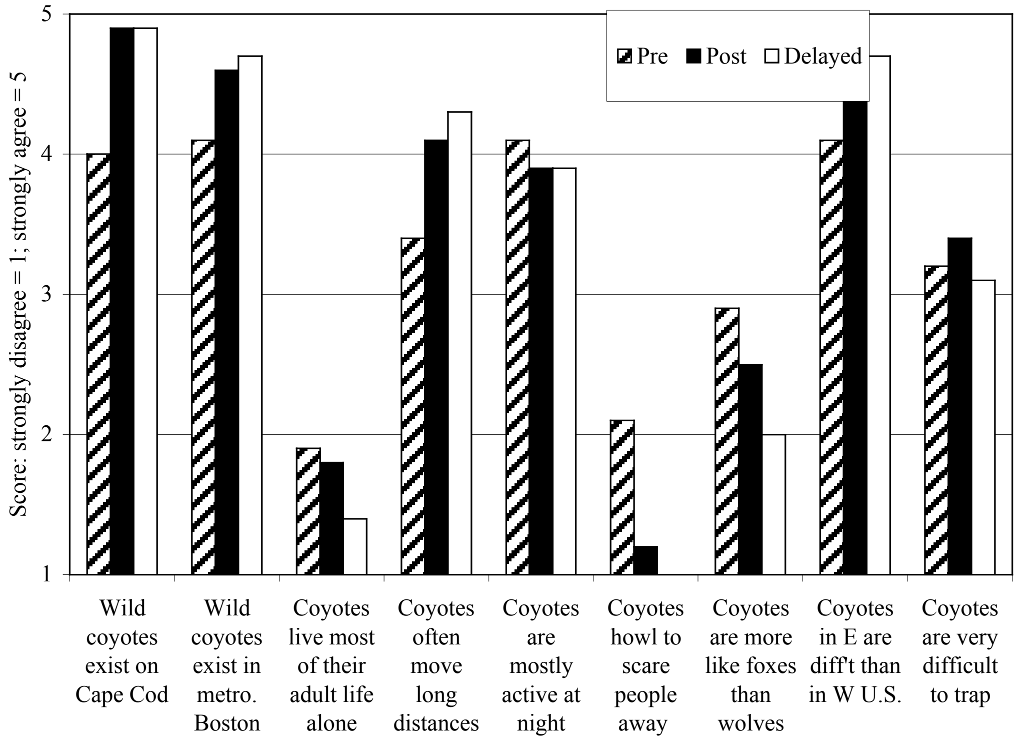


Figure 4.2. Frequency of rubric scores at Coyote High School for the pre and post interview question, “Why do or don’t all coyotes act the same?”

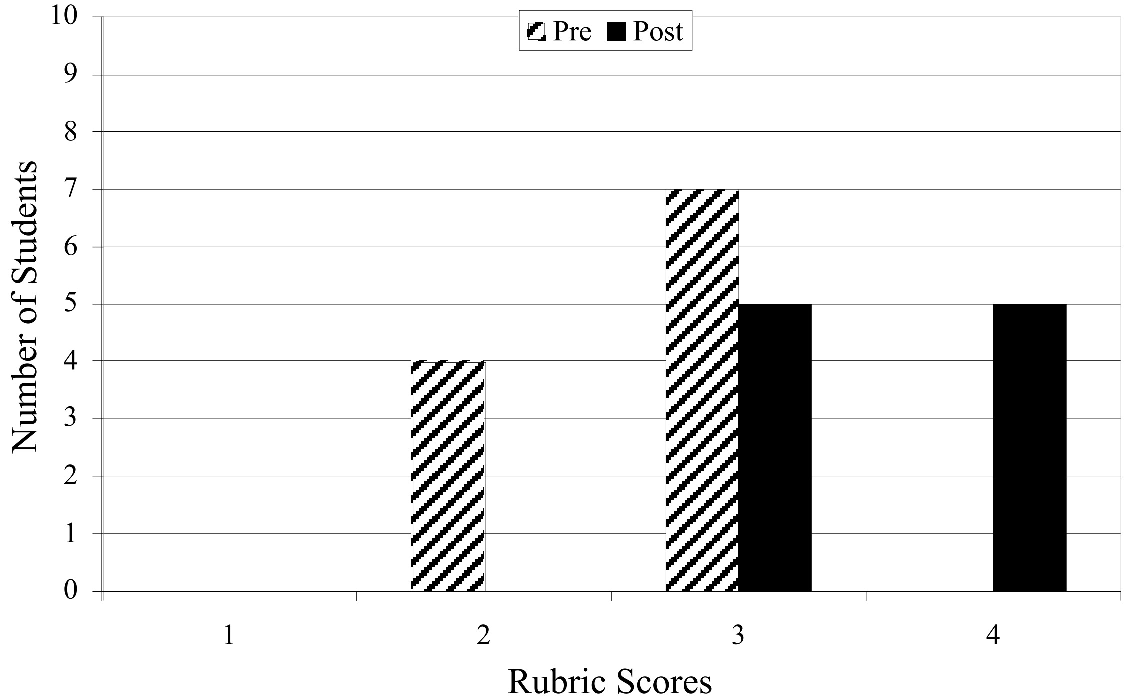


Figure 4.3. Frequency of rubric scores at Coyote High School for the pre and post interview question, "Why do or don't you think that coyotes can be eliminated from an area?"

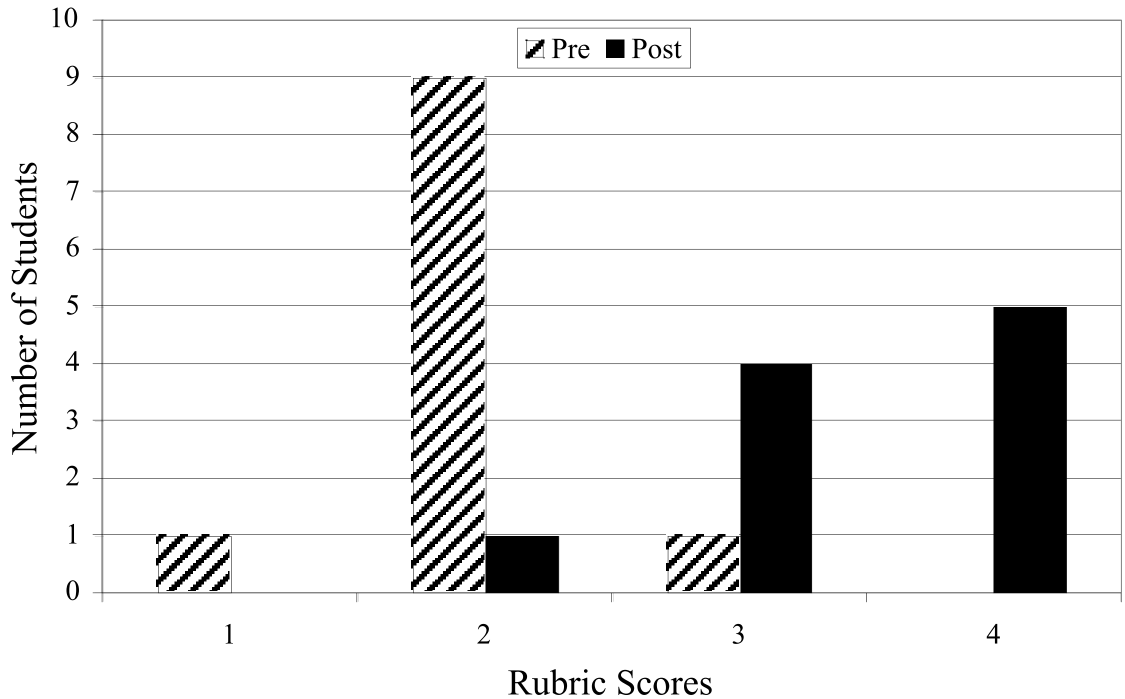


Figure 4.4. Average scores for pre, post, and post-delayed survey questions at Coyote High School addressing coyote beliefs.

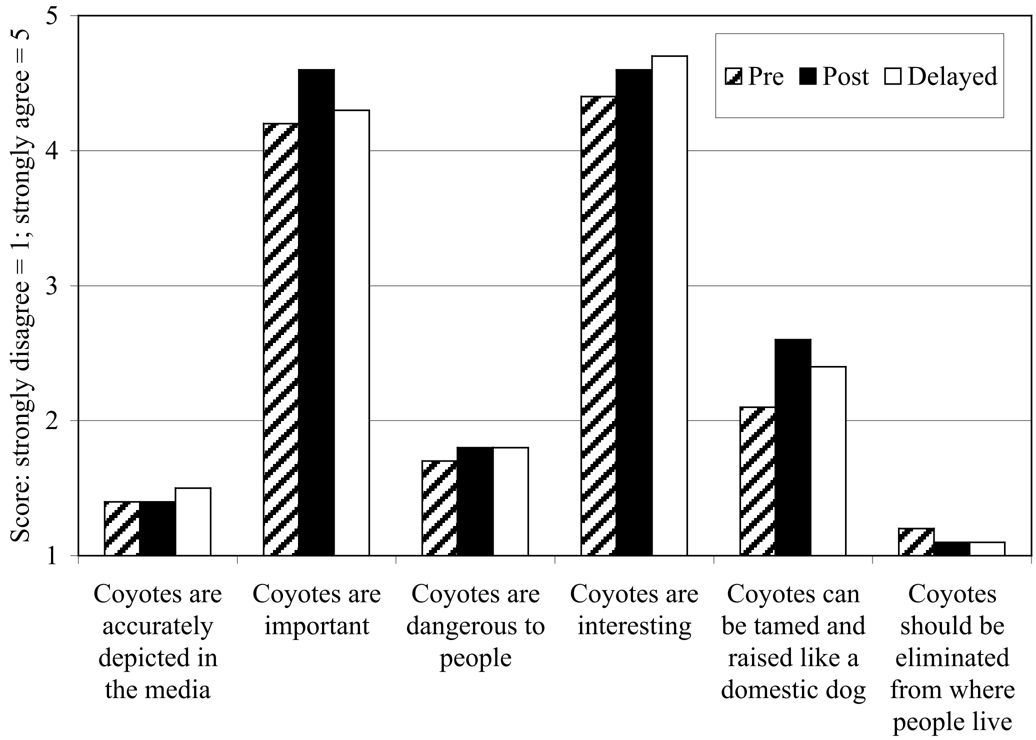


Figure 4.5. Average scores for pre, post, and post-delayed survey questions at Coyote High School for the "I want to be a scientist" scale.

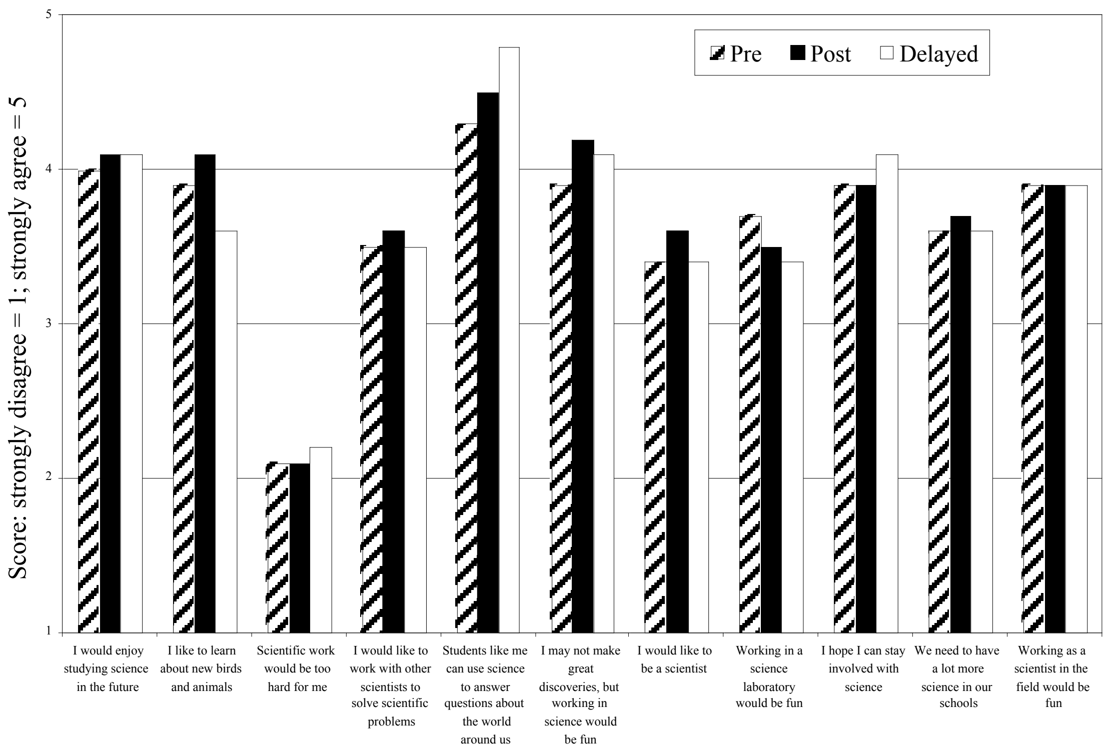
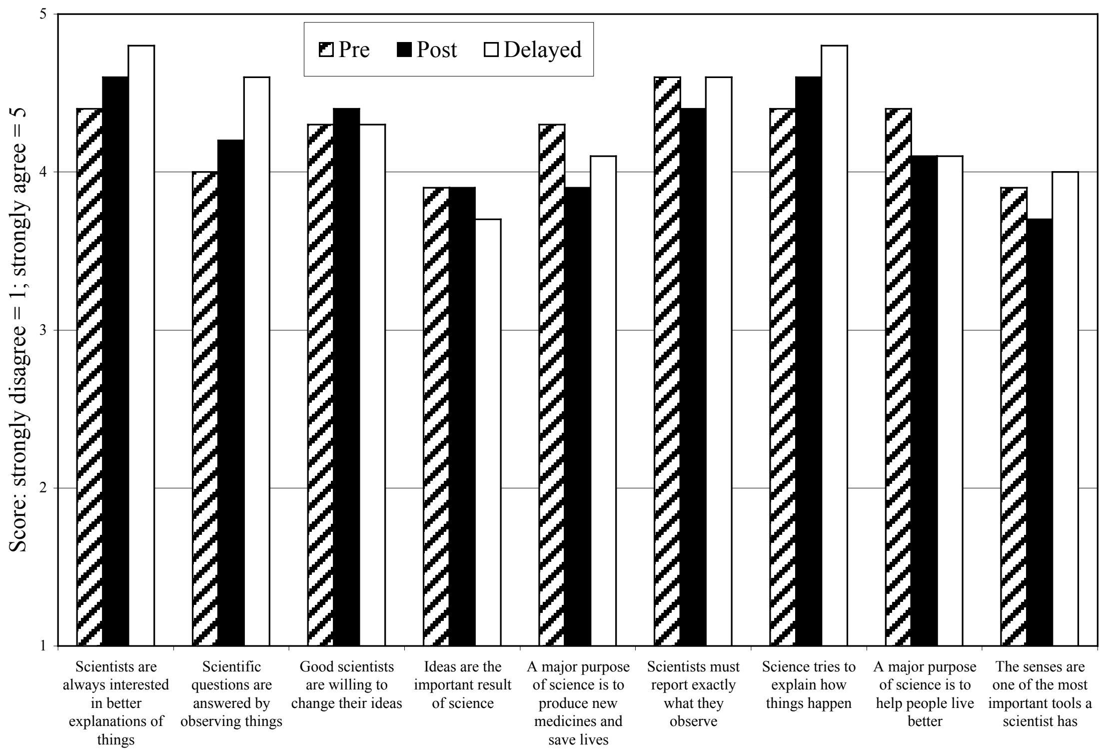


Figure 4.6. Average scores for pre, post, and post-delayed survey questions at Coyote High School for the "Scientific Methodology" scale.



Chapter 5

CASE STUDY #2 – WOLF HIGH SCHOOL

The following is an account of the research that I did with Tanya Ortiz's two Urban Ecology classes at Wolf High School. This chapter will use the techniques described in chapter 3 (mainly surveys, interviews, and classroom observations) to assess student learning and empowerment. This chapter is divided into six sections: coyote knowledge, beliefs/affective components, interest and perceptions of science and coyotes, student learning and preference, applied knowledge of coyotes, and students' perceptions of the curriculum unit.

I will focus more in depth on the survey questions of the coyote scale (n = 15 of the 35 questions) in this chapter. The other 20 questions were related to a scale developed by the Urban Ecology Institute. I will also present the results from these two UEI scales but will not focus on this data in this dissertation. I use this data as a comparison between the coyote questions and the more general UEI survey questions. Number of students taking the surveys varied with 27 taking the pre, 21 the post, and 22 the post delayed survey (on 3 March 2005). Not all students took the three surveys because of the high absence rate; however, many (ca. 15) did take all three (note: their names were not written on the surveys).

Coyote Knowledge

Survey questions related to coyote knowledge

Five of the nine survey questions related to knowledge of coyotes produced statistically significant results with another one marginally significant (P = 0.10 – 0.20;

Table 5.1). Students' knowledge of coyotes increased significantly after the curriculum unit and students retained much of that knowledge well after the unit finished (i.e., during the post-delayed surveys – Figure 5.1). However, many of the low pre survey scores aided in the differences shown (i.e., it was easier to detect significant changes because the students had little knowledge of coyotes before the curriculum unit began).

Not surprisingly, nearly all students strongly agreed on the question, "Wild coyotes exist on Cape Cod." We talked about coyotes on Cape Cod, I showed video, and they read about them. Students would have had to have missed the entire curriculum unit (although some in these two classes came close to that) to not agree with this question. Differences were very strong between pre and post surveys ($p = 0.028$) yet there was no difference between pre and post delayed ($p = 0.349$) or post and post delayed ($p = 0.477$) surveys meaning that some of the students were not so sure three months after they were given the unit if coyotes exist on the Cape. Although I did not ask them about the Cape in the interviews, I strongly suspect that students believed that the Cape was wooded and that is why coyotes live there. Bob's statement reflects this image:

> Bob: If you live in the city, then no (coyotes aren't around you), but if you live where there is woods, then… I don't think they live near me.

Compared to the pre survey, more people agreed in the post survey ($P = 0.060$) that, "Coyotes often move long distances." Part of the reason why this difference was significant seemed to be related to the fact that they scored low during the pre-survey, which was slightly above no opinion (Table 5.1, Figure 5.1). After the unit, students agreed that they move long distances which appeared to be translated to them through our discussions about coyote movement and activity patterns during the unit. Surprisingly though, no difference existed between pre and post delayed surveys ($p = 0.302$); thus students did not retain considerably more knowledge about coyote movement patterns nearly three months after the curriculum unit finished than before the unit began. Additionally, there was no difference between post and post delayed survey ($p = 0.716$).

There was a difference between pre and post ($p = 0.034$) surveys and a marginal difference between pre and post delayed ($p = 0.108$) for the question, "Coyotes are nocturnal." Students were more apt to agree with that statement after the curriculum unit and the students retained that knowledge from post to post delayed survey evidenced by lack of a difference ($p = 0.882$) between those surveys. I was somewhat surprised by these results considering that most of the video shown in class was taken during the daytime. Yet the curriculum unit did stress that coyotes were mostly nocturnal and some of the students' responses might have helped them understand this concept:

Chad: They are real sneaky. Kind of like me, sneaky.

After the curriculum unit it became apparent to students that they strongly disagreed with the question, "Coyotes howl to scare people away from them." I commonly noted in my classroom observations that many students asked questions about howling and why coyotes do it; following the commonly asked students questions, I produced a powerpoint slide that explicitly indicated the reasons coyotes do it, and that they do not howl at people to scare them away. For instance, one student asked me during the first day of class:

Student: Mister, mister, why do coyotes make them noises?

Researcher: You mean howling?

Student: Yeah, howling.

Strong differences existed between pre and post surveys ($p = 0.005$) and pre and post delayed surveys ($p = 0.018$) yet no difference existed between post and post delayed surveys ($p = 0.895$) meaning that students remembered the information provided about howling after the curriculum unit finished. In addition, Tanya required them to take notes, so I am not surprised that most strongly or mildly disagreed with that question. Given that students learn well with multiple performance opportunities (Teel et al., 1998), such as participating actively in the unit (Fusco, 2001; Rahm, 2002) and asking questions, it is not surprising to see good learning outcomes from these questions.

A highly significant difference existed between pre survey and post delayed surveys ($p = 0.015$) and post and post delayed surveys ($p = 0.088$) for the question "Coyotes are more like foxes than wolves." No difference existed between pre and post surveys ($p = 0.829$). We discussed at length how the eastern coyote is probably a hybrid between western coyotes and wolves. For them to have a somewhat neutral response of 3.1 intrigued me during the post surveys (Figure 5.1). Because students saw video of foxes, which are in the same family (Canidae) as coyotes, I hypothesize that students viewed them as similar creatures as coyotes. I have no explanation as to why students slightly disagreed with the question during the post delayed survey; however, the score was still relatively neutral at 2.4 (Table 5.1). A future survey should ask if coyotes are more *closely related* to foxes rather than are *like* foxes. In this scenario I would expect them to disagree with the revised question.

The question, “Coyotes in the eastern U.S. are different than ones in the western U.S.,” produced marginal differences (Table 5.1) with numerically more people agreeing after the curriculum unit that they are different (Figure 5.1). The curriculum stressed the difference between the two types of coyotes with powerpoint slides explaining the difference. I very clearly discussed how the eastern coyote is probably a hybrid between western coyotes and eastern wolves and students had great interest in the whole dog, coyote, and wolf relatedness issue. Jamal’s and Dave’s comment reflect the interest in the family Canidae:

> Jamal: I like how coyotes are connected to dogs. They are dogs. It is interesting how you have domestic dogs then wild dogs.
>
> Dave: I like how they (coyotes) look like wolves. Lupe (a captive coyote that I hand reared and he saw on video) looks like one.

However, relatively neutral values during the post (3.8) and post delayed (3.7) surveys failed to detect any differences in students’ beliefs about this question after the curriculum unit concluded to a few months later.

There were no differences ($p > 0.20$) in three of the questions asked during the surveys that related to knowledge of coyotes. Students produced relatively neutral answers during all surveys (Table 5.1, Figure 5.1) to the question, “Wild coyotes exist in metropolitan Boston.” Despite seeing videos of coyotes from urban areas around Boston, students did not seem to believe that they inhabited Boston. I believe this to be because they have never observed coyotes before. Because participating in science activities is very meaningful for students (Barab & Hay, 2001; Barnett et al., 2004), maybe students have just never considered the question of coyote presence in the city? For example, during the interview question, “Do coyotes occur near your backyard?,” Beyonce’s answer was characteristic of the students’ responses:

Beyonce: No, because I live in South Boston projects and I don’t really think there is many coyotes around.

Interviewer: So, too developed?

Beyonce: Yeah, its like, all buildings, there is really no trees and stuff in South Boston, so…

Some of the students’ answers to this question were interesting. Jack, in his answer, grasped the point that I was trying to get across, that coyotes have large ranges and even if they are not physically in your backyard they are most likely not far away from anyone living in Massachusetts:

Jack: I know they have been around but just not in my backyard.

Additionally, Dave made an interesting comment explaining why coyotes might live near him:

Dave: I have seen raccoons so I am pretty sure there is coyotes. They are good at hiding.

To be more clear to students the question could definitely be revised to say something like, “Wild coyotes exist in the Great Boston area.” This may affect results in the future as students might think of the locations where I took some of the videos from as being in that region.

For all three surveys most of the students gave neutral or no opinion responses to the question, “Are coyotes solitary?” The lack of difference between pre and the post ($p = 0.675$) and pre and post delayed ($p = 0.936$) surveys was surprising considering that, during the post interviews, many (five) students answered that they found coyotes interesting because they were social animals (Appendix 3):

> Melissa: I like the way they interact with each other and how they can be together forever. Like if they mate they can be together forever. How they raise puppies and stuff.

Student responses during the interviews did not translate to the survey question on coyote solidarity. The larger number of students taking the exams, many of which were not regularly in class, probably contributed towards not detecting significant differences. However, Beyonce, who was regularly in class, almost exactly answered the question about coyotes not being solitary, when discussing what she found interesting about coyotes:

> Beyonce: I like how they travel in groups. I always figured that they would be more by their selves, like one coyote for their self, instead of traveling in groups. I didn’t even think they traveled in groups. That was shocking for me.

There was no difference in the survey answer to, “Coyotes are difficult to trap.” I talked at length about how much time and effort we spend in trying to catch coyotes in order to collar them (including a lecture that lasted one and half class periods), yet they gave some of the most neutral pre (3.11) and post (3.62) and post delayed (3.19) responses of any question (Table 5.1, Figure 5.1). Similar to some of the other questions that I have talked about, it seems that students watched videos of the coyotes, saw them being collared, and just assumed because we have done it that they are not that difficult to catch.

Barab and Hay (2001) discussed the difference between simulation and participation models to authentic science learning. In the current study, a major advantage to the simulation model is that video can be taken from the field and brought into the classroom, therefore giving students the opportunity to learn about the science being taught without having to spend the time directly participating in the research. This strategy can greatly facilitate the content being delivered to students. However, a major disadvantage is that students do not appreciate the effort and time that it takes to get that data/video and for trapping that can literally be months just to capture one coyote. For example, regarding the preceding section on coyote capture techniques, it would be interesting to see how students felt after they were in the field trapping with us.

Rubrics related to coyote knowledge

In addition to the three surveys, two of the questions during the interviews were scored based on a rubric (Chapter 3) in order to determine student learning of coyote concepts. As summarized in Table 5.2, both questions produced significantly different responses.

A good scientifically-based answer to the first question was, “No, all coyotes do not act the same.” Along with that, describing individuality and providing examples would have yielded a high rubric score (Table 3.9). Most interviewees (n = 16) said that they do not act the same while two said that they did; two were not sure (Appendix 3). Comparing coyotes to humans, individuality was the most frequent answer during pre (n = 4) and post interviews (n = 5). Providing examples during the post interviews (n = 4 responses) and incorrectly describing coyotes as being different only in different localities (n = 3 during pre and n = 2 during post interviews) were also common responses. Students provided better and more richer examples during post-interviews, hence the significant difference observed (Figure 5.2).

The following excerpt from Marcy is representative of students' reasoning during pre interviews:

> Marcy: No they don't act the same, just 'cause coyotes in Boston act differently from the ones in the Midwest; it depends where they are in the country.

Marcy's answer was not technically correct because not all coyotes act the same locally. In fact, individuals in a given locality could be quite different yet particular individuals could potentially be very similar to some coyotes in disparate regions. Evelyn came close to describing individuality in coyotes but she still failed to talk about coyotes and give examples related to coyote biology.

> Evelyn: No, I think they are just like us humans. 'Cause I know my parents don't act the same and I figured that other species don't act the same too.

After the curriculum intervention students clearly gained a better understanding to the question. Jack's statement is representative of their reasoning:

> Jack: They are all different. They are not the same. In general, probably some have different characteristics.

Beyonce, in the post interview, provided a detailed answer where she gave good examples, explained individual distinctiveness, and compared their (coyote's) behavior with humans:

> Beyonce: I think some are like, more aggressive. It depends on how, like, they live. Like what they've been through. Just like humans, kind of in a way. Like if coyotes have been through fights, or injuries, they might be more aggressive, when... if it comes to something or anything coming more near them.

Initially (i.e., during the pre-interviews), students gave poorly scored answers to the question, "Can coyotes be eliminated from an area" (Table 5.2; Figure 5.3). After the curriculum unit finished (i.e., during the post interviews) the students seemed to comprehend the question better and scored significantly different compared to the pre-interview scores (Table 5.2); however, the post-interview average score of 2.5 was still relatively low for the rubric (Table 3.10). The appropriate answer that I was looking for was, "No, they can not be eliminated. They are difficult to kill. If you kill one, another coyote will quickly disperse into that territory. Thus, while you can kill individuals you generally can not eliminate (or extirpate) the population in a given area." During the pre-interviews, no students said they can not be eliminated while four said the same thing during post-interviews. The majority during both interviews (pre = 7, post = 6) said that they can be eliminated, with people might kill them being the most frequent response (Appendix 3).

A number of students during pre interviews answered with, “I don’t know” or gave short responses basically saying, “Yeah they can be eliminated if people kill them.” Jack however gave an interesting response considering what humans have done to other species:

> Jack: Very easily. It has happened so many times in the past; like grizzly bears, they are almost gone.

Jack seemed to not realize the difference between coyotes and bears and how coyotes can quickly colonize new areas, have high reproductive potentials, and don’t need as much space as larger predators do. Other students initially thought that less woods meant less coyotes:

> Evelyn: Umm, hmmm (yes), Industrialization can eliminate coyotes. When they build buildings and such I guess they get rid of coyotes. Like where they live at...I figure they live in the woods. They don't live in like Ashmont station or something like that. So when they cut down the trees and stuff like that, then they try and eliminate the coyotes. So there will be less and less coyotes.

While in a very local situation Evelyn was correct in her statement, she does not accurately indicate what is actually occurring – coyotes colonize the more wooded areas in urban landscapes and that it is difficult to remove coyotes solely because there are less trees. During the post interviews most of the students used a similar rational to students in the pre-interviews. Lisa’s remark is typical:

Lisa: Yeah, they can 'cause some people don't like animals around their homes and they think they are disruptive around them. So I think they can be eliminated. If they (people) wanted to they could.

Lisa's statement indicates the prevalent thought that people can do what they want to nature. I was trying to argue to the students that this is not the case with coyotes. Two of the student's understood the concept, as Melissa demonstrated:

Melissa: No, they can't be eliminated. I think people could try but I don't think it would work. Because you said that they reproduce fast and I don't think that you would get all of them if you tried to kill them or move them.

The need for scientists and schools to form partnerships is important and potentially beneficial for all sides (Waksman, 2003; Wormstead et al., 2002), especially when engaging in an authentic scientific project, either through direct participation or simulated studies (Barab & Hay, 2001; Hay & Barab, 2001). Evidence from this section demonstrates that students were capable of improving their knowledge content when taught by a scientist. Similarly, Kahle et al. (2000) found students in inner city areas could learn science effectively if their teachers are well prepared and use standards based teaching practices. However, the results from this study should be treated conservatively because many of the students' responses (Table 5.2; Figures 5.2 and 5.3) were still fairly low compared to the design of the rubrics (Tables 3.9 and 3.10). This study is important because there is mounting evidence that one component of the science education reform process must be a sustained effort toward making the study of science accessible to more students (Jones, 1997), including the inner-based students in this study. Even though results were not overwhelmingly high on the rubrics, the positive gains achieved by the students in a short time period is noteworthy.

Beliefs/Affective Components

Three of the six questions produced significant differences amongst the belief related questions (Table 5.1, Figure 5.4). Compared to the pre survey, more people thought that coyotes were important after the unit ended ($p = 0.087$; Table 5.1); however, the post ($p = 0.194$) and post delayed ($p = 0.112$) surveys detected only marginally significant differences compared to pre surveys but when compared to each other (post vs. post delayed; $p = 0.961$) there was no difference. Similarly, most students agreed that coyotes were interesting, however high pre survey scores (the highest pre-survey score of all the survey questions; Table 5.1, Figure 5.4) precluded any differences between post ($p = 0.952$) and post delayed ($p = 0.201$) surveys. It is possible that the students' apathetic stance toward school (Tanya Ortiz, personal communication) caused many of the student's to say "No opinion" or "Disagree." However, many students were interested in coyotes, especially after the curriculum unit finished, as Dave's statement is representative of:

> Dave: I would be amazed if I saw one, like, "Wow, there is a coyote." I have seen them at zoos, I think Franklin, Bronx Zoo, and San Diego Zoos but not in the wild (my note: I am familiar with these zoos and do not think that they all have coyotes; however, they may have a similarly related species of wild dog there).

Most students strongly or mildly disagreed with the question, "Coyotes are dangerous to people." The curriculum unit showed numerous video-clips of the coyotes from our study and students often asked how dangerous coyotes were throughout the curriculum unit, so I expected this answer to be different during post ($p = 0.008$) and post delayed ($p = 0.001$) surveys than the neutral average score given in the pre-survey (Table 5.2). The post-interviews were also indicative of students learning the true, non-aggressive nature of a typical coyote:

Lisa: I think I would be a little bit, but now knowing that they really don't harm humans then I really wouldn't be that scared. Maybe a little bit cause they are like wild.

Interviewer: Yeah, but not that scared.

Lisa: Yeah.

Interestingly, Lisa used knowledge obtained in the course and knew that coyotes were not a danger to humans. It seemed like she was initially scared of coyotes but changed her beliefs after participating in the curriculum activities. This comment is intriguing given the pre interview responses where students that had seen or experienced coyotes, even if just briefly (e.g., through quick sightings), were much less likely to be scared of them. Likewise, Rickinson (2001) reported in his review of the environmental education literature that students in urban settings maintained a separation of themselves, as humans, above and apart from the non-human (or natural) world. While students without experience with nature were scared of nature and viewed it as a threatening place, inner city students who had been on trips to nature areas outside of the city were unlikely to described such places as dangerous (Rickinson, 2001). For example, the following two comments by Jermaine then Chad illustrate this dichotomy in my study:

Jermaine: I guess I am (scared) because I don't know if they are dangerous to me or not because I have never seen one.

Chad: No, I am not scared. I have seen them. I used to go camping in New Hampshire, they used to come near us where we camped.

Interviewer: But it wasn't a big deal?

Chad: No, we used to just scare them off. They probably came back later on at night when we were sleeping.

Compared to the pre survey, more people during the post delayed ($p= 0.055$) survey disagreed with the question, "Coyotes should be eliminated from where people live." Their answers remained consistent from post to post delayed surveys ($p = 0.803$), yet there was no difference shown between pre and post surveys ($p = 0.226$). Despite significance being detected, scores indicate that the average opinion ranged between mildly disagree and no opinion for the three surveys when asked if coyotes should be eliminated from where people live (Figure 5.4). During interviews, two people agreed that coyotes should be eliminated near people, twelve disagreed (including 70 % of post interviewees), and six were not sure (Appendix 3). The most frequent responses to why they should not be bothered were they have a right to live here, they have nowhere else to go, and they aren't dangerous. For example, some students were not quite so sure about having coyotes around as Evelyn indicated during the pre interview:

Evelyn: I don't know. I'm not really sure to why they are around. Like where they put into the community (i.e., reintroduced). Like are they killing stuff that is bad for the people. I don't know what they are doing.

Other students were just not familiar with coyotes, even during post interviews, so they were unsure how to answer the question, as Eve indicated:

Eve: I really don't know because in my community there is no coyotes. I have never experienced a place where there is coyotes. Okay, so. So I can't give you a specific answer.

Interviewer: Okay, so you would have to be around them to get an opinion.

Eve: Yeah, I would have to live in a place like in Maine. Where it is like, you know how it is in Maine. But there is animals roaming around. I have never lived in that type of condition before. I have lived in the city life. I have never seen coyotes in the city except that time you showed us on TV how...about the coyote running in Everett. Yeah that is the only time.

Despite some of the students not being familiar with coyotes after the unit as Eve’s example attests to, just as many appreciated coyotes. The post-interview comments made by Melissa and Dave, two students that were there nearly the entire unit, was representative of many of the students opinions after the unit finished:

Melissa: No they shouldn’t be eliminated because animals were here before us; they deserve to live wherever they want.

Dave: There are barely no coyote attacks so let them be. Leave animals inside. They don’t bother nobody so let them be.

There was little difference between surveys to the question, “Coyotes are accurately depicted in the media.” Unfortunately, we didn’t have much time to spend specifically on this topic (e.g., showing videos from actual news clips on coyotes) which probably contributed to the neutral scores during the surveys (Table 5.1, Figure 5.4). However, I did often talk about how they are misunderstood in the media and I am somewhat surprised by the students’ neutral stances. I like this question and think that I should make it a priority to discuss this to the students in more detail in subsequent units because coyotes are often inaccurately portrayed or sensationalized in the news. For example, like some of the students requested (Appendix 3), if I had an extra week this would definitely be one of the things that I would talk about.

Students scored mediocre during all three surveys when asked if, “Coyotes can be tamed and raised like a domestic dog,” (Table 5.1, Figure 5.4); the surveys produced average values between the “slightly disagree” and “no opinion” answers. Students seemed to be confused by this question because I hand-reared the captive coyotes at the zoo and those coyotes are as close to me as any domestic dogs are. However, some students also probably listened to my comments that despite being hand-reared the coyotes behave much differently than dogs; for instance, the coyotes live in an outside enclosure and would surely tear my house apart if they were kept inside. However, the students apathetic responses are intriguing because they talked about this exact question throughout the unit and asked me many questions related to this. In fact, four of the post interview responses (Appendix 3) dealt with coyotes and dogs. Beyonce’s comment was most directly related to this question:

Beyonce: Will coyotes ever be able to be domestic animals. Like, would they be able to live at home like dogs do?

My intent was for most people to disagree with that question, since coyotes can not really be raised like domestic dogs but Beyonce's answer illustrates that students were thinking in a different manner about how I hand reared the coyotes. A more appropriate way to ask this question would be to better word it for the students. For instance, I could ask, "Coyotes can be socialized to humans if raised at a young age." In this question, I would hope for a "strongly agree" answer. Or I could word the question, "Coyotes could easily be raised inside a house just like a domestic dog," where I would expect a "strongly disagree" response. Finally, I could say, "Taming coyotes in a zoo setting is important in order to studying their behavior," and I would hope for "strongly agree" as their response.

This section demonstrates that the students in this inner-city setting positively improved their beliefs about coyotes. One benefit of this project in this setting was the education that many minorities (e.g., African Americans) (Barton, 2001; Seiler, 2001) and women (Rohrer & Welsch, 1998) received. People of color have typically underachieved in education (Norman et al., 2001; Seiler, 2001) and are subsequently woefully underrepresented in many professions, particularly those related to the sciences and technical fields (Haury, 1995). The students' optimistic statements about coyotes suggests that this curriculum unit has the potential to empower the students into caring for the coyotes and our project, in effect giving the students a sense of ownership of the project (Barnett et al., 2004; Bouillion & Gomez, 2001; Fusco, 2001). As educators and scientists we need to harness the energy of these students to promote the message that our local environment is important and that community members have a stake in these issues. One way to accomplish this is to improve student beliefs about the issue under study.

Interest and perceptions of science and coyotes

Table 5.3 depicts the statistical results from the “I want to be a scientist” scale. There were two significant differences among the eleven questions, indicating that the students became more interested in being a scientist in two of the questions (Figure 5.5). The first question, I would enjoy studying science in the future ($p = 0.019$), is important because harnessing student interest in science is important if we hope that more people choose science-based fields as a career. The second question, I hope I can stay involved with science ($p = 0.086$), indicates that we need to provide inner city students with more resources to ensure that this happens. In fact, seven percent of all positions in science and engineering are held by minorities despite constituting 24 percent of the current U.S. population (National Science Foundation, 2002). Thus, there is mounting evidence that one component of the science education reform process must be a sustained effort toward making the study of science more accessible to all students (Jones, 1997). Future work should look for correlations between the curriculum taught (e.g., coyotes) and student interest in science. Apparently, students became more interested in science after the curriculum unit than before.

Table 5.4 depicts the average scores and results from the “Scientific Methodology” scale. In this section, none of the nine questions were significant, but six had final (post-delayed test) values over 4 (agree). Despite the lack of differences between the surveys, students had a good perception of the scientific method as evidenced by the six (of nine) questions scoring over a 4 (Figure 5.6). Scores were high during the pre-surveys, effectively precluding detecting significance during post-surveys. Learning is a generative process requiring effort in which learners actively construct their own meanings that are consistent with their prior ideas rather than passively acquiring knowledge transmitted to them (Chin & Brown, 2000). This survey, through the relatively high agree scores (Figure 5.6), showed that students at Wolf High seemed to perceive the role of scientists as active members of the scientific community. This lends support to the notion that scientists might be good sources for teaching students content matter, considering that they might be good mentors to get students actively involved in science.

Overall, students in the Urban Ecology classes were surprisingly positive towards science during the interviews, with 15 of 20 (75 %) liking science and only 3 of 20 (15 %) not liking science. I say surprisingly positive, because the attendance patterns were horrendously irregular, which lead me to believe that students just didn't care. The most common answers to, "What do or don't you like about them (science courses)," was liking hands-on activities such as labs, disliking chemistry, and liking environmental/life science courses (Appendix 3). Jermaine summarized the positive aspects of science with his comment:

> Jermaine: Yes, I like science because it is more hands-on. I generally like all classes where I have active involvement.

Derek liked the adventure of some aspects of science. Likewise he didn't like certain types of science:

> Derek: I like doing research about animals and discovering new things. I don't like chemistry and the human body. I like more life science related classes like Urban Ecology.

These statements underscore the importance of hands-on learning being an important component of the learning process for students. Kahle et al. (2000) found students in inner city areas could learn science effectively and became more involved when using inquiry-related science activities. Importantly, inquiry based activities are an important national and state framework for the science standards (National Research Council, 1996, 2002).

Although I previously gave examples of why students liked science, not all wanted to pursue a career in science. In this study, while four students did not want to and six were not sure during the pre-interviews, three wanted to, three didn't want to, and four were not sure in the post interviews (Appendix 3). The most common answer was not sure what they want to do (7 total of the 20 interviews) followed by being a nurse, possibly pre-medical and a host of other answers. Melissa's response was interesting in that she drastically changed her response from the pre to post interviews:

> Melissa (pre): No, I do not want to pursue a career in science. I have no specific plans yet, but definitely not science.
>
> Melissa (post): I think I want to work with wild animals. I am not sure yet.

Interviewer: Cool, hmmm, so did this course do anything to.....have you always felt that way?

Melissa: I had always wanted to work with animals but I had never thought of going to college for it but now I am thinking about it.

Interviewer: Great, because you realize that you can actually study them for a living.

Melissa: Ummm, hmmmm..(i.e., yes). Like you are with the (captive) coyotes; that is how I want to be with the animals.

Because of the student's unfamiliarity with coyotes, the most common (n = 5) answer to "What do you find interesting about coyotes" during pre-interviews was, "I don't know, I don't know anything about them and want to learn more." Additionally, two people each responded by saying that they liked how coyotes are sneaky and mysterious and that they are like dogs but wild (Appendix 3). Jack's comment is representative of the first set of interviews:

Jack: I like dogs, I have always liked dogs for my whole life. And they are the same family and such. Hmmm, I don't know. I don't know much about them so I want to find out about them.

There was a more diverse array of responses during the post interviews with sociality (n = 5) being the most prevalent theme of response. Students had eleven different reasons about what they found interesting about coyotes; sociality related responses occurred five times. For instance, Eve liked a couple of different particular aspects of coyotes, illustrating how students used examples from the course in their responses:

Eve: I liked that they shed in the summertime then they grow back their hair. And then they are scared of people. That was interesting. I thought they were, like, eaters, like they eat cats and dogs and stuff like that but they are actually scared of us. So I didn't know that part.

Nineteen of the twenty (95 %) students interviewed answered that they would be interested in going to a zoo to see coyotes. Not surprisingly, the main reason was to see them up close but also learning more about them, observing behaviors directly, and seeing the difference between captive and wild coyotes were also important reasons for students wanting to visit the coyotes at the Stone Zoo (Appendix 3). A typical response during the interviews was made by Jermaine:

Jermaine: Yes, to learn more about them because I don't have any information on them.

Interviewer: So, to see what they look like and to get a perspective compared to other animals.

Jermaine: Yeah.

Wolf High never had an opportunity to visit the zoo during the curriculum unit and the post interviews indicated that students had enough virtual or simulated coyote experiences through powerpoint slides, pictures, posters, and videos, and they clearly wanted to see some live ones. Clearly providing an up-close personal experience of seeing coyotes would be very meaningful and authentic (Bencze & Hodson, 1999; Chinn

& Hmelo-Silver, 2002) to these students. Keisha's comments represent the need for informal experiences like visiting the zoo:

Keisha: I want to see them in more than on videos. It would be kind of interesting. I could study them better and see them face to face.

Science activities that tend to infuse meaning cause students to value the learning experience. Because 53 % of African-Americans live inside cities and 88 % reside in metropolitan areas (United States Census Bureau, 2001), it is critical to engage and motivate urban students to learn science in order to achieve many of the goals of the National Science Foundation (2002), such as diversifying the workforce. The literature indicates that providing resources (Spillane et al., 2001) and valuing relevant active learning environments in classrooms is important for students to be able to engage in the practicing culture of science learning in urban settings (Fusco, 2001). Therefore, science learning and experimentation must take place in urban schools (Bouillion & Gomez, 2001) as well as in informal (i.e., zoos), more traditional science learning environments (Hofstein et al., 1997). Students in this study indicated that direct involvement with coyotes, such as going to the zoo, would be important to maintain their interest in the unit. It is the job of educators and scientists to heed their comments and to provide learning opportunities that accounts for their interests.

Especially because of the noted interest in scientific work by the students (Table 5.3, Figure 5.5), future work must be geared to trying to get students more interested in wanting to become scientists. Significantly, students at Wolf High seemed to perceive the role of scientists as active members of the scientific community, as evidenced by the high scores given during the Scientific Methodology survey scale (Figure 5.6). This lends support to the notion that scientists might be good sources for teaching students content matter, considering that they might be good mentors to get students actively involved in both science and in pursuing science as a career trajectory.

Student learning and preference

The most popular way of learning was through hands-on activities with 14 combined (pre and post interview) responses. Visual mechanisms, lecture/notes, multiple ways, reading, and videos were also some of the responses (Appendix 3). Students typically gave short responses to this question with many often just saying, "Hands-on." Marcy's response was typical:

> Marcy: I don't like learning in any particular way. I like hands-on the most, but also like taking notes, so multiple ways.

Keeping a curriculum unit diverse is clearly advantageous to the different kinds of learners as evidenced by the following statements. While some students like to watch videos and or see live demonstrations, others would rather read about the classroom related activities:

> Chad: I am a visual learner. I watch somebody do it, then do it on my own.
>
> Keisha: I like to learn by studying like the way we did with the coyotes. With videos and we got to read about them. We go to see what we learned.

"What would be the best way to learn about coyotes?," was deliberately an open-ended question in order to see what they came up with on their own. Most students thought that to see, observe or study them live would be the best way including in a zoo, studying them in the wild, or even bringing a coyote(s) to school. Additional responses included to get out of the classroom and be involved, to read about them, multiple ways, to see them on TV, to live with them, and having notes. The following two answers were among the many given by the students:

Evelyn: Seeing one up close and studying them, like how they interact with each other. Also reading about them in science books.

Interviewer: So doing multiple different things but seeing them might be the most important?

Evelyn: Yeah.

Keisha: To go to the zoo and have your teacher explain everything. To touch them if I can. Bring the coyotes to school (she says while giggling).

Interviewer: Bring the coyotes to school. No, that is fine. And that would let you see them up close.

Keisha: Yup, we would study them and it would be fun.

Interviewer: Wow, that is great. That is perfectly reasonable to say (reflecting on her giggles throughout that statement).

Student behavior can be very indicative of how a curriculum unit is taught. If students do not pay attention, then motivating them through different teaching strategies would be difficult (Teel et al., 1998). My field notes on 2 December noted the students' rowdy behavior and amazing rate of absence:

> Today was a more difficult day than the previous ones. (Tanya) even noted that they were much more antsy today than yesterday. There are kids that

> were absent yesterday or today which makes it difficult to have any continuity with the class – except for the core group of ~50% that is present everyday. I usually have to repeat many of the previous lecture concepts because some students ask question that other students have already learned. The kids are very interested in the material but have no attention span – literally the person that makes a comment or asks me a question will be talking to someone else as I try to answer them.

In essence, the dilemma of teaching this inner city class was to figure out how to overcome their lack of focus and talking during class in order to effectively teach them. The students mentioned how important hands-on activities are for their learning. However, on 16 December I experienced what it was like to involve them in something more than just sitting and watching videos. On that day they were involved in an inquiry-based activity where they participated in a simulated game of tracking coyotes (see Appendix 1). For the exercise, each student had to find 10 index cards labeled with a coyote's name that I have tracked in the field (there were five different coyotes in the exercise). The objective was to learn how biologists estimate territory and home ranges of coyotes in the wild. My field notes follow from that day:

> The first class was a royal pain in the butt. They don't know how to listen to people. I repeated myself 2-3 times on every single piece of instruction and still some weren't paying attention. It was really aggravating and I raised my voice a few times telling them that they should at least be partially interested in doing hands-on work. The class had so many interruptions, I only made them

responsible for the core terms before the bell rang. Most questions, such as "Mister, can you help me, I don't understand," were because students were not paying attention.

National standards stress the need for inquiry based ideas (National Research Council, 1996, 2002). With students that do not pay attention, or that talk and do not listen, it was actually much more difficult to do inquiry-based activities than a standard traditional lecture. In other words, inquiry based exercises, by their nature, make the class much more unstructured which makes a rowdy and undisciplined class much more difficult to handle. In the coyote tracking activity, I was unable to determine the value of the exercise compared to what I hoped it would be. Although students' prefer learning by hands-on activities it might not be the best way in certain situations, such as these classes.

In this section we learned that multiple ways of learning, ranging from reading to hands-on activities are crucial to maintain student interest in science. Having a curriculum that is diverse will reach a larger and more assorted audience. The students involved must be considered and despite the importance of inquiry-based activities, these types of teaching practices might not be feasible in all settings. Future research should examine how realistic it is to practice different teaching strategies (Teel et al., 1998) in varied settings.

Applied Knowledge of Coyotes

Results from this section focus on using knowledge of coyotes and applying that understanding in order to answer important questions related to their ecology and behavior. When asked what questions the students would want answered about coyotes, a diverse array of answers was presented during pre and post-interviews (Appendix 3). The most common answers during pre-interviews was, “Are they dangerous?” and wanting to know more about coyote ecology in the city. Some answers were simple, as Jermaine’s response indicated:

Jermaine: Are they dangerous to people?

However, some students asked more in depth questions before the curriculum unit started such as such as Keisha’s statement:

Keisha: I want to know about their reproduction. Their reaction to people and like… other animals around them. Where do they live and everything. And then, during seasons where do they live in the same place… Do they change (move?) animals around them. Then I would also like to answer where they came from.

During the post-interviews students generally had more specific and thoughtful questions. Three students wanted to know what a coyote and dog hybrid would look like, two wanted to know why people have a bad perception on the, and five other questions were asked once each by the students (Appendix 3). These questions, such as Melissa’s, were taken directly from our classroom discussions and the lectures that were given:

Melissa: If a coyote and dog had babies what would it (they) look like and act like. Like would it be more wild or more domestic?

Interviewer: Interesting. There are some experiments on it but I don't know too much about it. I think that they say that they, over time, start to look more like dogs. It would be interesting to do with our (captive) coyotes if we had a place to house the dogs, or the hybrids I should say.

Keisha was very direct in her answer and wanted to know why coyotes are so often killed by people. After experiencing the unit, she seemed to realize that coyotes are not a bad thing:

Keisha: The way that they have been treated by the, hmmm... wildlife managers. Because they (coyotes) kill animals, like domesticated animals, so...

Interviewer: So you are saying that even though you kill domestic animals you want to know why they are killed the way that they are?

Keisha: Yeah, I mean, it is like, animals kill other animals. It (coyotes) is like humans. So.

Interviewer: I understand you, so why, like, single out coyotes?

Keisha: Yeah, why try to get them out of the way but they are good for our environment. They're animals so they have their importance also in our society.... in our culture and stuff.

The examples given by Keisha and Melissa illustrate how students used knowledge of coyotes obtained during the course and applied their findings to elaborate on a question or point of interest. Learning is a generative process requiring effort in which learners actively construct their own meanings that are consistent with their prior ideas rather than passively acquiring knowledge transmitted to them. If prior knowledge and disciplinary knowledge do not connect and intertwine, learning of scientific knowledge is reduced to rote memorization of facts (Chin & Brown, 2000).

Students gave a variety of responses to the question, "Do you have any recommendations for pet/cat owners," with keeping pets inside, don't let your cat out, and "I don't know, I haven't seen coyotes before" as the three most popular responses. During post interviews, students provided more detailed responses compared to the beginning of the curriculum unit. For instance, Derek's comment reflects the lack of knowledge about coyotes during the pre interviews:

> Derek: If I know more about them then....Like if they (people) have chickens don't let them (coyotes) get in. I don't know about other animals.

Other students, such as Jack, gave acceptable responses but continued to separate where they live from coyote country. Notice how his use of the word suburbs is like a different place from where he lives:

> Jack: I don't own a cat so I don't know how they would act but I probably wouldn't let it out of the house. Like in the suburbs.

During the post interviews, some students felt more compassionate to protect coyotes, yet they still wanted to protect pets. Marcy got straight to the point answering with a short, accurate statement about living in coyote country:

> Marcy: Keep their pets inside or if they take them outside make sure they are on a leash and don't let them go to far from you.

It is important for people to understand the potential conflicts that coyotes can cause. Coyotes are often in the news for causing depredations on pets and an important component of coexisting with these creatures is to follow advice by Marcy and to avoid encounters before they occur.

There was little difference in response rates between the pre and the post interviews (Appendix 3) for the question, "What would be some research questions if you could study coyotes?" As the answers below indicate, most of the questions that students came up with related to ecology or behavior-based inquiries. Most students never got that in depth with their explanations during both sets of interviews; for a good answer, I was looking for a good two to three sentence scientific explanation of what question(s) they would investigate. Chad's pre-interview response relates to his interest that they just live in the city:

Chad: I would like to study them in a suburban area then study them in a city area, to see if we can find them in a city area.

Interviewer: So to see if they are there, in the city, then to see if there are any differences compared to other areas?

Chad: Yeah.

For others, the coyote – dog connection was still very relevant as Derek's comment illustrates:

Derek: Like the question in the pre test, can we take them (coyotes) as a pet?

During post interviews, students used class information to craft their answers. Although many of the statements were not terribly detailed, the students assimilated knowledge of coyotes when they described some of their research questions. Comments from Jack and Melissa illustrate student answers particularly well:

Jack: Why do people have such of a bad perception of them? And why do people have such strong feelings to get rid of them and just trying to eliminate them.

Melissa: Probably the mating with the dogs and, ahhhh, I don't know, how they differ. Like suburban and urban. How they differ from each other.

The relationship between coyotes being domesticated into a pet was another common theme that students mentioned throughout the unit (Appendix 3). I believe that it would be beneficial to bring a live coyote into the classroom in order to show the difference between a coyote and a dog and how coyotes generally do not make good pets. The following section of Dave's interview transcript reflects this interest:

Dave: Can you tame one? You probably can. People have tigers and lions. I don't know if you heard about a guy in New York City, Harlem, that had a tiger and crocodile. It is kind of cool but also weird, having one up in Harlem.

Interviewer: Yeah, I heard about that. I actually worked at the Bronx Zoo and lived there for seven months.

My classroom observations on 15 December on trapping and collaring coyotes was illustrative of how students applied their knowledge to the learning process, both through behavior and questions raised:

> Because the trapping and collaring of coyotes is by necessity a hands-on activity, the students were very interested and active during the two days that we discussed this topic. A couple of students in particular (Jamal in class 1; Nadia in 2) seemed very interested and don't act up anymore. This week Nadia

> has sat behind the lap top, I think to not talk to other students (mainly Keisha). Jamal hasn't talked and pays attention. Melissa and Marcy are also pretty good, especially this week. Interesting questions were raised during this topic such as, "Couldn't you cover up the trap with branches?" And, "Could you use wood instead of the metal traps so it smells more natural for the coyotes?" Students were clearly asking questions to make capturing coyotes more effective – I like their thought processes.

This section indicates that students improved their knowledge on coyotes and thus applied that knowledge to ask questions related to the curriculum unit. Students seemed to empathize with coyotes and many moved beyond simply wondering how and why coyotes lived in the city to specific questions about their ecology and/or behavior. Chin and Brown (2000) noted that when students engage in meaningful learning, they are purposeful and constantly monitor and reflect on the process of learning to evaluate the results of their own learning efforts. A deep learning approach, they noted, is associated with intrinsic motivation and interest in the content of the task, a focus on understanding the meaning of the learning material, and personalizing the task. Examples of students talking about domesticating coyotes, although difficult to do, indicate an interest in interacting with these creatures, in effect personalizing the subject for the students.

Students' perceptions about the coyote curriculum

Throughout the unit, but especially at the end of the intervention, students were encouraged to give their opinions on the curriculum unit. As indicated throughout this chapter, students learned a good amount about coyotes in a short period of time.

However, uncovering reasons why students liked or disliked certain aspects is important to make the curriculum more usable in the future.

Videos and other positive outcomes of the curriculum unit

Overwhelmingly, students wanted to watch home videos on coyotes rather than a nature video or documentary on them (14 of 20 responses; Appendix 3). The students thought that the home videos were more authentic and meaningful and they were not biased compared to nature videos. However, three (15 %) thought that a TV program would be better and two (10 %) thought that watching both would be best. Additionally, I forgot to ask one student this question (during the pre-interviews). The personalized nature of the home videos (i.e., actual video that we have taken in the field) was very important and meaningful to the students, as this statement from Melissa attests to:

Melissa: Because we were there. We did it. It was us doing it.

Evelyn thought that the home videos were good because you could see them in more places than just in the wilderness. Her comment reminds us that there is wildlife in the city:

Evelyn: I think that the home videos are more accurate… The TV ones are more biased. Like they live in the wilderness and kill animals, but if you see them on home videos then you see both sides of them probably. I guess.

Rather than learning science in field or natural settings (Bouillion & Gomez, 2001; Fusco, 2001), student participation in this study allowed them to obtain coyote facts in the classroom which could make the curriculum unit transferable in the future where the unit could be brought into many classrooms as opposed to the difficult task (because of time, logistics, and costs) of trying to bring many classrooms into the field. Jack's statement reflects the importance of local, place-based field experiences that are meaningful and authentic to students:

Jack: I liked home videos because I could relate to a home video more than something on TV.

Keeping a unit diverse was also essential because students do learn in different ways (Teel et al., 1998). For instance, some students preferred to watch home videos. Chad's comment is indicative of why they felt that way:

Chad: I like TV or nature programs because they are telling you what they (the coyotes) do, how they react or whatever. And if you are watching a home video the video just shows them running around and while the nature video tells exactly what they are doing.

Interviewer: So more polished than the home videos?

Chad: Yeah.

The teacher, Tanya Ortiz, even commented to me on the value of both types of videos. For instance, her comment after class on 1 December was representative of her thinking:

Tanya: The Wild E. Coyote clip to start each class then the video segments mixed in with the powerpoint slides is a great way to engage them.

During the capture techniques lecture I had a revelation, potentially figuring out why all of the students liked the videos so much. I summarize it here, written on 14 December:

Field Notes: I think I have FIGURED OUT why students like the videos: it is an inactive, hands on-like type of activity. In other words, students can feel involved in an authentic experience but don't have to do a thing besides just sit there and be lazy. Of course, this is just like watching TV at a house. I also do think, though, that the videos greatly assist visual learners. I know that I remember a lot from visual experiences.

This lazy, yet visually active way of learning might be one reason why most students seemed to enjoy the videos. This statement hints at Barab and Hay's (2001) discussion of authentic science in a simulated manner. Rather than directly participating in an activity with a scientist, the students have the material brought to them. Students mentioned that they liked the videos because it illustrated how we studied them, it showed the difference between the captive and wild ones, and it was more authentic/more meaningful having videos closer to home. Beyonce's comment represents the importance of the videos:

Beyonce: I liked, actually, seeing the video of the coyotes in the wildlife (she means seeing the coyotes in the wild). Like, actually seeing that. It gives you like... You would think that, you were so close (referring to me) to them, almost on them. And they didn't do anything to you. That is why I am not scared of them because I've seen the videos, and...

When asked what the students liked most about the curriculum unit, a diverse array of answers was presented with the videos shown during class and the students liking the case study approach on coyotes as the two most popular answers (see Appendix 3). The following discussion with Jack is illustrative of some of the students' responses:

> Jack: I liked studying more in depth on how coyotes act and their habitat and stuff like that.

Jack seemed to like how the class focused on one topic in particular for the two weeks that I was there. He was able to learn the habits of one creature in particular. I think that Jamal was stressing these points in his statement as well:

> Jamal: The day to day facts on coyotes is what I liked. Hmmm, actually seeing videos of their behavior and... being able to ask questions.

The videos illustrated many of the things that we discussed in class. As the students indicated, it gave the students an accurate depiction of what coyotes are like. In one way or another, these students felt that the unit was authentic and that is how it helped them learn. Jack's statement is representative of that thinking:

> Jack: Like I said, just because they were actually taken by people I knew and that was taught in the classrooms. It was easier to relate to.

By the end of the intervention students thought that the home videos taken on coyotes brought some meaning to the unit. They seemed to like this simulated mode of learning about coyotes because they were able to learn about how scientists study animals without having to do anything active. The case study focus on just coyotes throughout the unit was also appealing because it allowed the students to learn in depth about one creature. Future research should continue to investigate the efficacy of different types of authentic learning (Barab & Hay, 2001) environments such as comparing a group of students that learns in a simulated manner compared to a group that works alongside scientists in the field.

Student dislike of the unit

After asking students what they like about the curriculum unit I focused on also understanding what they disliked about it. The most common answer to this question was nothing/no problems/liked everything (8 of 10 responses). Other responses included wanting a field trip, seeing the operation procedure where a coyote pup was surgically implanted with a transmitter, and seeing the foothold traps (Appendix 3). Keisha and Jack's responses characterized the students:

Keisha: Everything was really fun, I really enjoyed it.

Jack: It was pretty much all good. I didn't have a problem with it.

Other students wanted to get more involved and knowing that other students in different schools (e.g., see Chapter 4) were directly involved in the project, some took offense to that:

Jamal: It was always in the class, I would have liked to take a trip somewhere.

Interviewer: Okay, so it would have been great if we fit in that field trip (to the zoo), kind of during the two weeks, or whatever?

Jamal: Yeah.

Similar to when the students were asked to say what they disliked about the curriculum unit, when asked to comment on giving any recommendations for future curriculum development, most students said they liked the unit with seven saying keep it the same or don't make any changes, while five thought that it could maybe be a little longer (like three weeks instead of two). Additionally, two students thought that they should get more students involved in the study, one couldn't wait to go to the zoo, and one thought that the unit should maybe be a little bit shorter (Appendix 3). Marcy's comment was the norm for the class:

Marcy: I think it should go a little bit longer than two weeks.

Similar to what Jamal disliked about the curriculum unit, Lisa wanted to get a more hands-on approach:

Lisa: Maybe if you had more students involved helping you out like you do with the other schools. Help you track them down and get...catch them and put on radio-collars. I think getting more students involved in doing it would get more students interested in science.

Similarly, Eve thought that the unit was just the beginning of learning about coyotes if students wanted to get involved:

Eve: If someone is really interested in coyotes, I think that is too short. I found it a brief introduction to learning more about coyotes. 'Cause if you want to learn more you have to go to the zoo, go to labs, go to the places where the coyotes are, tracking…

Similar to the students' reactions to the curriculum unit, Tanya was very up-beat about the curriculum unit when I asked her on the last day of the unit:

Tanya: I thought that the students were very positive and relatively attendant during the two weeks that you were there. I say relatively attendant because keep in mind that these are inner city kids and they do not have

> the best respect for authority. Even though many of the students were sometimes rude, rowdy, inattentive, and/or late, they would act like that no matter who was in the room. You have a few students interested which is about as much as you could realistically hope for. Now you get to see what it is like to work in an inner city classroom.

The curriculum unit was liked by the majority of the students as evidenced by many of the students' enjoying the unit and complaining that I was leaving too soon and that I could make the unit longer if anything. One of the major complaints was that the students in these classes never had an opportunity to visit the zoo. The hands-on nature of going to the zoo seemed to be a much desired opportunity. Overall, though, keeping the unit diverse and illustrating the materials with videos were important factors in the success of the curriculum unit.

Summary

The curriculum unit was liked by the majority of the students as evidenced by many of the students' enjoying the unit and complaining that I was leaving too soon and that I could make the unit longer if anything. One of the major complaints was that the students in these classes never had an opportunity to visit the zoo. The hands-on nature of going to the zoo seemed to be a much desired opportunity. Keeping the unit diverse and illustrating the materials with videos were important factors in the curriculum's success. The videos seemed to give students the opportunity to learn about the science without having to spend the time directly participating in the research. This strategy can greatly facilitate the content being delivered to students. This lazy, yet visually active way of learning might be one reason why most students seemed to enjoy the videos. This statement hints at Barab and Hay's (2001) discussion of authentic science in a simulated manner. Students mentioned that they liked the videos because it illustrated how we studied them, it showed the difference between the captive and wild ones, and it was more authentic/more meaningful having videos closer to home.

The need for scientists and schools to form partnerships is important and potentially beneficial for all sides (Waksman, 2003; Wormstead et al., 2002), especially when engaging in an authentic scientific project, either through direct participation or simulated studies (Barab & Hay, 2001; Hay & Barab, 2001). Evidence from this section demonstrates that students were capable of improving their knowledge content of coyotes when taught by a scientist. Both rubric based answers during the pre and post interviews showed significant improvements after students were exposed to the curriculum unit. In addition, eight of the 15 (53 %) survey questions had significant and one (6.7 %) had marginally significant results. Many of these responses showed high post delayed survey scores (Figures 5.1 and 5.4). Kahle et al. (2000) found students in inner city areas could learn science effectively if their teachers are well prepared and use standards based teaching practices. However, the results from the interviews should be treated conservatively because many of the students' responses (Table 5.2; Figures 5.2 and 5.3) were still fairly low compared to the design of the rubrics (Tables 3.9 and 3.10). Still, this study is important because there is mounting evidence that one component of the science education reform process must be a sustained effort toward making the study of science accessible to more students (Jones, 1997), including the inner-city students in this study.

Even though results were not overwhelmingly high on the rubrics, the positive gains achieved by the students in a short time period is noteworthy.

This chapter also demonstrated that the students in this inner-city setting positively improved their beliefs about coyotes. One benefit of the coyote project in this setting was the education that many minorities (e.g., African Americans) (Barton, 2001; Seiler, 2001) and women (Rohrer & Welsch, 1998) received. People of color have typically underachieved in education (Norman et al., 2001; Seiler, 2001) and are subsequently woefully underrepresented in many professions, particularly those related to the sciences and technical fields (Haury, 1995). The students' optimistic statements about coyotes suggests that this curriculum unit has the potential to empower the students into caring for the coyotes and our project, in effect giving the students a sense of ownership of the project (Barnett et al., 2004; Bouillion & Gomez, 2001; Fusco, 2001). As educators and scientists we need to harness the energy of these students to promote the message that our local environment is important and that community members have a stake in these issues. One way to accomplish this is to improve student beliefs about the issue under study.

Hands-on learning was an important component of the learning process for students in this study. Kahle et al. (2000) found students in inner city areas could learn science effectively and became more involved when using inquiry-related science activities. Importantly, inquiry based activities are an important national and state framework for the science standards (National Research Council, 1996, 2002).

Especially because of the noted interest in scientific work by the students (Table 5.3, Figure 5.5), future work must be geared to trying to get students more interested in wanting to become scientists. Science activities that tend to infuse meaning cause students to value the learning experience. Because 53 % of African-Americans live inside cities and 88 % reside in metropolitan areas (United States Census Bureau, 2001), it is critical to engage and motivate urban students to learn science in order to achieve many of the goals of the National Science Foundation (2002), such as diversifying the workforce. The literature indicates that providing resources (Spillane et al., 2001) and valuing relevant active learning environments in classrooms is important for students to be able to engage in the practicing culture of science learning in urban settings (Fusco, 2001). Importantly, students at Wolf High seemed to perceive the role of scientists as active members of the scientific community, as evidenced by the relatively high scores given during the Scientific Methodology survey scale (Figure 5.6). This lends support to the notion that scientists might be good sources for teaching students content matter, and for getting students actively involved in both science issues and in pursuing science as a career trajectory.

In this section we learned that multiple ways of learning, ranging from reading to hands-on activities are crucial to maintain student interest in science. Having a curriculum that is diverse will reach a larger and more assorted audience. The students involved must be considered and despite the importance of inquiry-based activities, these types of teaching practices might not be feasible in all settings. Future research should examine the logistics of different teaching strategies (Teel et al., 1998) in varied settings.

With students that did not pay attention, or that talked and did not listen, it was actually much more difficult to do inquiry-based activities than a standard traditional lecture.

Future research should continue to investigate the efficacy of different types of authentic learning (Barab & Hay, 2001) opportunities such as comparing a group of students that learns in a simulated manner compared to a group that works alongside scientists in the field.

Table 5.1. Average scores and statistical differences between pre, post, and post-delayed surveys at Wolf High School for each coyote related question. For all comparisons degrees of freedom (df) between groups (i.e., the different surveys) was 2 while within groups the df = 64-67 (different values reflected different sample sizes amongst individual questions). For all questions a score of 1 = strongly disagree, 2 = mildly disagree, 3 = no opinion, 4 = mildly agree, and 5 = strongly agree.

			Pre		Post		Delayed	
Question	F =	P =	M	SD	M	SD	M	SD
Knowledge related questions:								
Wild coyotes exist on Cape Cod	3.50	0.036	3.8	1.0	4.5	0.7	4.2	1.0
Wild coyotes exist in metro. Boston	0.73	0.485	3.5	1.2	3.7	1.0	3.3	1.3
Coyotes live most of their adult life alone	0.36	0.699	3.0	1.1	2.7	1.5	2.9	1.3
Coyotes often move long distances	2.83	0.066	3.7	1.0	4.3	1.0	4.1	0.9
Coyotes are mostly active at night	3.81	0.027	3.9	1.0	4.6	0.9	4.4	1.0
Coyotes howl to scare people away	6.37	0.003	2.7	1.2	1.7	1.1	1.8	1.0
Coyotes are more like foxes than wolves	4.43	0.016	3.3	1.0	3.1	1.2	2.4	1.1
Coyotes in the eastern U.S. are different than coyotes in western	2.13	0.127	3.1	0.9	3.8	1.3	3.7	1.4

U.S.								
Coyotes are very difficult to trap	1.20	0.308	3.1	0.9	3.6	1.2	3.2	1.5
<u>Belief related questions:</u>								
Coyotes are accurately depicted in the media	0.90	0.413	3.1	0.7	3.2	1.2	2.8	1.0
Coyotes are important	2.53	0.087	3.2	0.9	3.8	1.4	3.9	1.2
Coyotes are dangerous to people	8.99	0.000	2.9	1.3	1.9	1.3	1.6	0.7
Coyotes are interesting	1.63	0.204	4.1	0.8	4.2	1.2	4.6	0.7
Coyotes can be tamed and raised like a domestic dog	0.67	0.517	3.1	1.0	2.6	1.6	3.0	1.5
Coyotes should be eliminated from where people live	3.02	0.056	2.9	1.1	2.3	1.5	2.0	1.3

Table 5.2. Rubric scores (1-4) and statistical values from pre and post content related interview questions at Wolf High School.

Question	Pre Interview		Post Interview		T value	P =
	M	SD	M	SD		
Why do or don't coyotes all act the same?	2.2	0.79	2.9	0.32	-3.280	0.010
Why do or don't you think that coyotes can be eliminated from an area?	1.7	0.48	2.5	0.97	-3.207	0.011

Table 5.3. Average scores and statistical differences between pre, post, and post-delayed survey questions at Wolf High School for the “I want to be a scientist” scale. For all comparisons degrees of freedom (df) between groups (i.e., the different surveys) was 2 while within groups the df = 66 or 67 depending on the student sample size per question. For all questions a score of 1 = strongly disagree, 2 = mildly disagree, 3 = no opinion, 4 = mildly agree, and 5 = strongly agree.

			Pre		Post		Delayed	
Question	F =	P =	M	SD	M	SD	M	SD
I want to be a scientist questions:								
I would enjoy studying science in the future	4.203	0.019	3.0	1.2	3.9	1.3	3.9	1.3
I like to learn about new birds and animals	0.380	0.686	3.3	1.5	3.6	1.4	3.6	1.2
Scientific work would be too hard for me	1.120	0.332	2.5	1.4	2.1	1.2	2.0	1.0
I would like to work with other scientists to solve scientific problems	0.028	0.972	3.4	1.3	3.3	1.1	3.3	1.4
Students like me can use science to answer questions about the world around us	0.773	0.466	3.8	1.1	4.1	0.9	3.9	1.2

I may not make great discoveries, but working in science would be fun	0.124	0.883	3.6	1.3	3.4	1.5	3.6	1.4
I would like to be a scientist	0.381	0.685	2.4	1.2	2.6	1.3	2.7	1.3
Working in a science laboratory would be fun	0.084	0.919	3.9	1.1	4.0	1.0	3.8	1.1
I hope I can stay involved with science	2.540	0.086	3.0	1.2	3.7	1.3	3.7	1.1
We need to have a lot more science in our schools	0.097	0.908	3.4	1.1	3.3	1.2	3.5	1.5
Working as a scientist in the field would be fun	0.194	0.824	3.6	1.2	3.5	1.3	3.4	1.4

Table 5.4. Average scores and statistical differences between pre, post, and post-delayed survey questions at Wolf High School for the “Scientific Methodology” scale. For all comparisons degrees of freedom (df) between groups (i.e., the different surveys) was 2 while within groups the df = 65-67 depending on the student sample size per question. For all questions a score of 1 = strongly disagree, 2 = mildly disagree, 3 = no opinion, 4 = mildly agree, and 5 = strongly agree.

			Pre		Post		Delayed	
Question	F =	P =	M	SD	M	SD	M	SD
Scientific Methodology questions:								
Scientists are always interested in better explanations of things	0.144	0.866	4.4	1.1	4.6	0.7	4.5	1.3
Scientific questions are answered by observing things	0.241	0.786	4.1	0.8	4.2	1.0	4.0	0.8
Good scientists are willing to change their ideas	0.020	0.980	3.9	1.1	3.9	1.3	3.9	1.2
Ideas are the important result of science	1.284	0.284	3.8	1.2	4.2	0.9	4.1	0.9
A major purpose of science is to produce new medicines and save lives	0.897	0.413	4.0	0.9	4.3	1.0	4.3	0.9

Scientists must report exactly what they observe	1.053	0.355	4.2	0.9	4.3	1.0	4.5	0.8
Science tries to explain how things happen	0.136	0.873	4.3	0.7	4.3	1.1	4.2	1.2
A major purpose of science is to help people live better	0.292	0.748	3.7	1.1	4.0	1.0	3.8	1.2
The senses are one of the most important tools a scientist has	0.050	0.951	3.7	1.4	3.8	1.3	3.8	1.1

Figure 5.1. Average scores for pre, post, and post-delayed survey questions at Wolf High School addressing coyote knowledge.

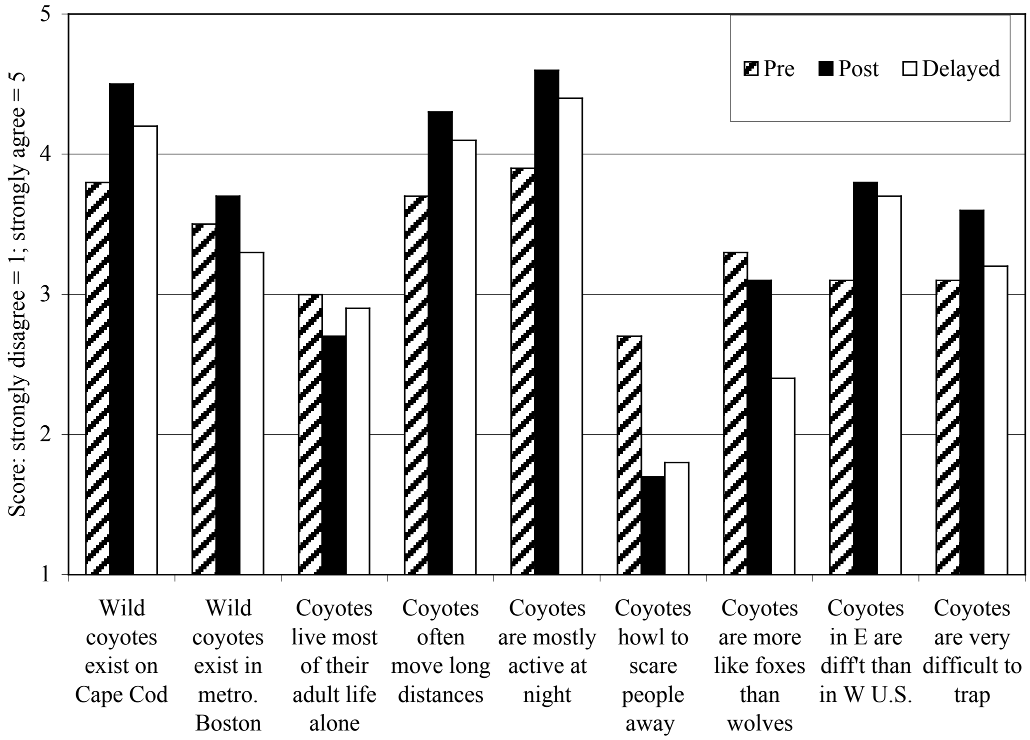


Figure 5.2. Frequency of rubric scores at Wolf High School for the pre and post interview question, “Why do or don’t all coyotes act the same?”

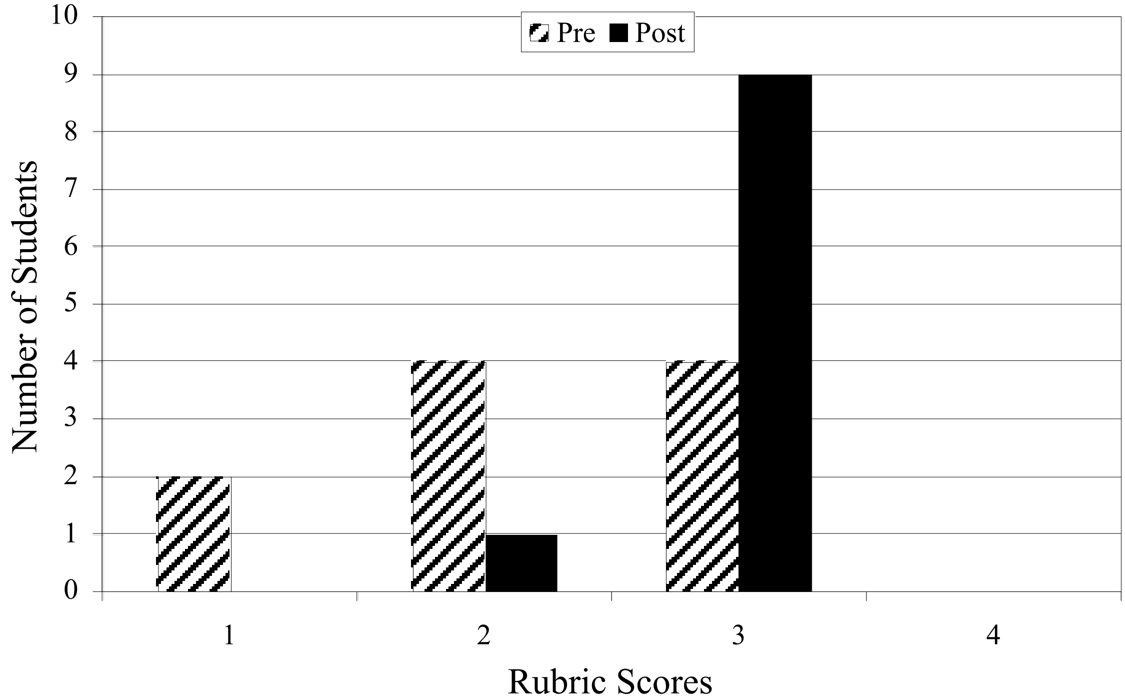


Figure 5.3. Frequency of rubric scores at Wolf High School for the pre and post interview question, "Why do or don't you think that coyotes can be eliminated from an area?"

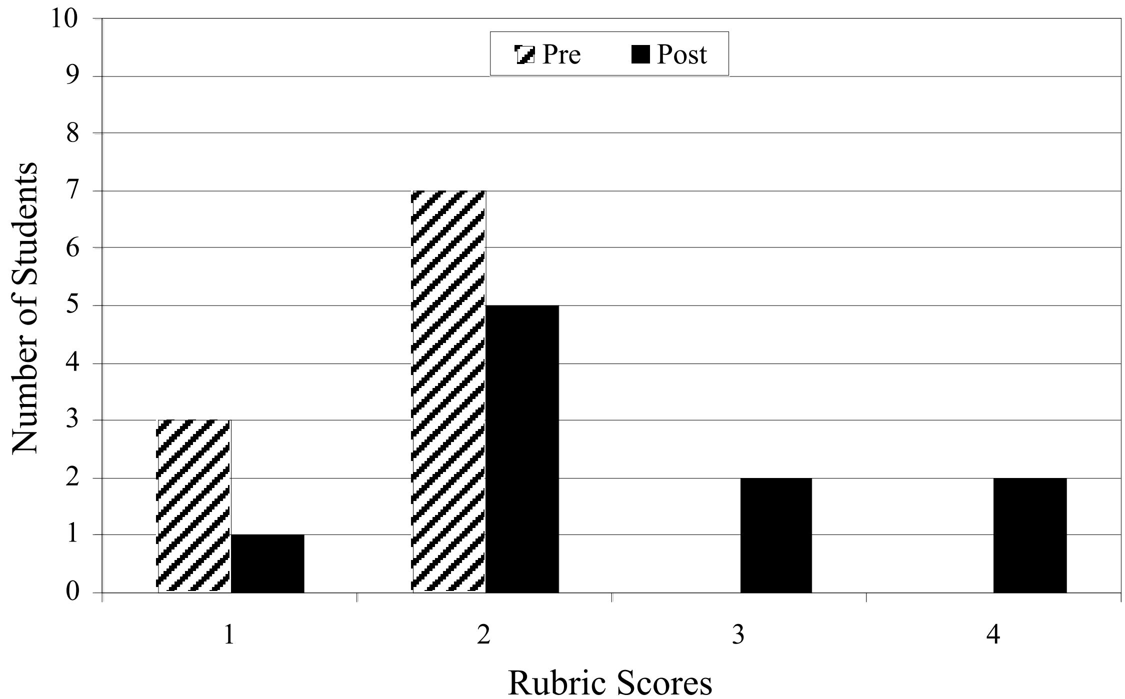


Figure 5.4. Average scores for pre, post, and post-delayed survey questions at Wolf High School addressing coyote beliefs.

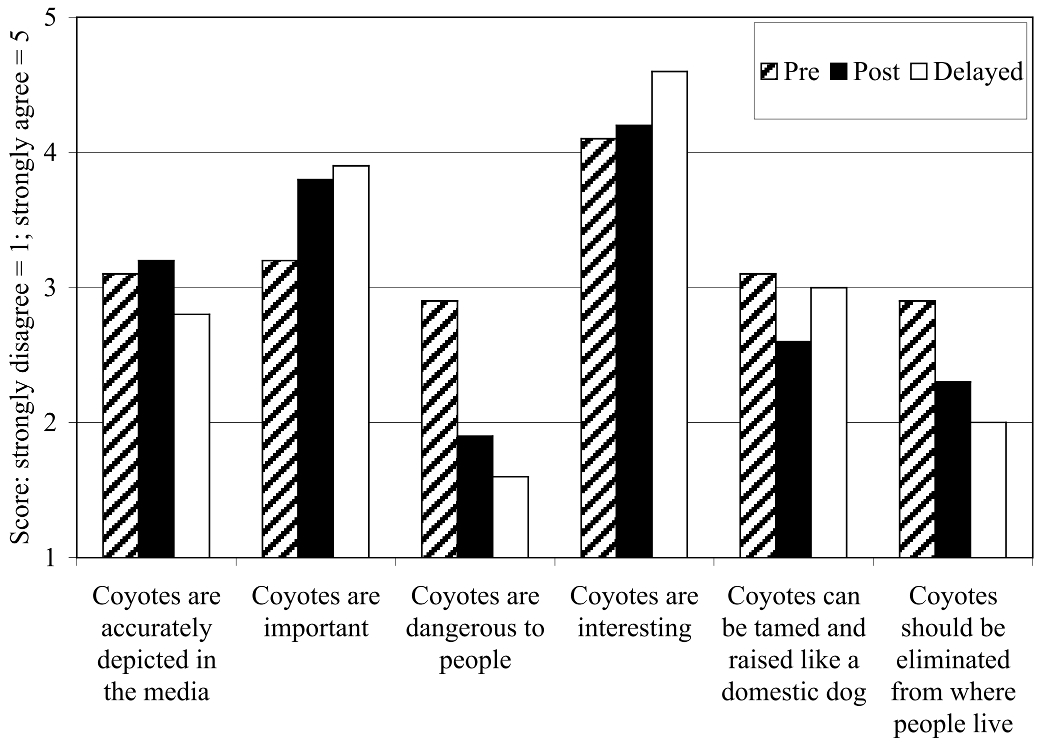


Figure 5.5. Average scores for pre, post, and post-delayed survey questions at Wolf High School for the "I want to be a scientist" scale.

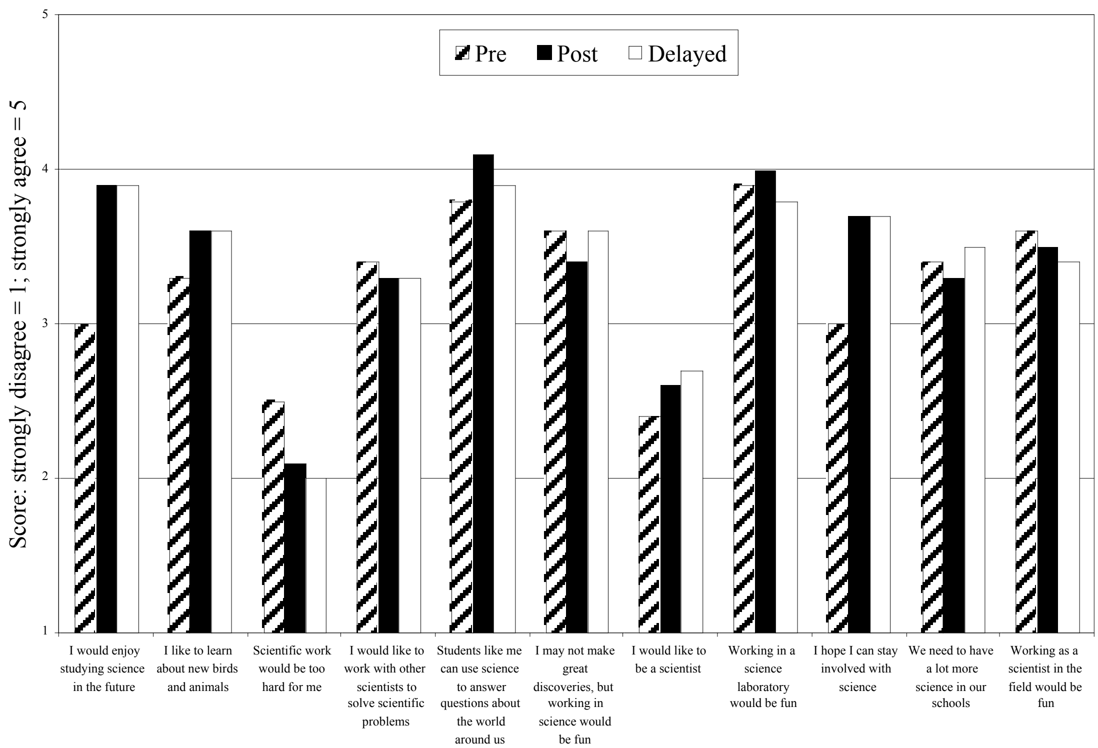
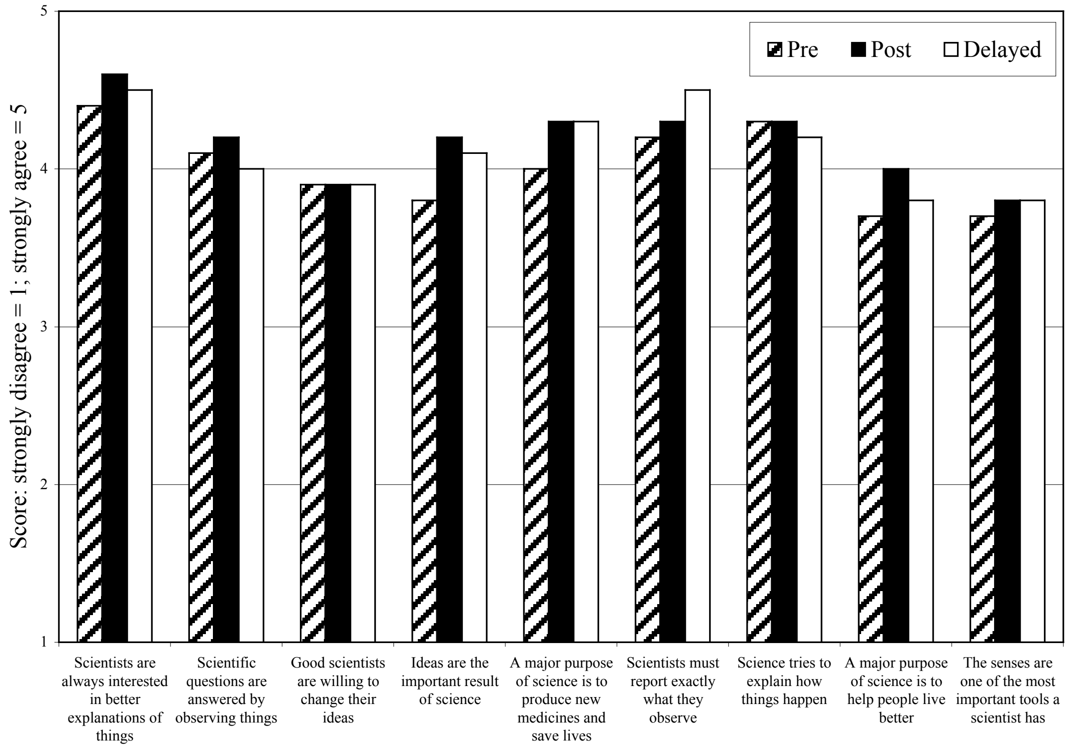


Figure 5.6. Average scores for pre, post, and post-delayed survey questions at Wolf High School for the "Scientific Methodology" scale.



Chapter 6

CONCLUSIONS AND IMPLICATIONS

The purpose of this chapter is to compare the common themes from Coyote (Chapter 4) and Wolf High Schools (Chapter 5) in order to give implications towards the importance of these studies. Like Chapters 4 and 5, this section is divided into six parts: coyote knowledge, beliefs/affective components, interest and perceptions of science and coyotes, student learning and preferences, applied knowledge of coyotes, and students' perceptions of the curriculum unit.

The major findings of this dissertation, which will be elaborated on in the following sections, are:

- Using coyotes as a tool to teach science facilitated students' learning science and got them interested in socio-scientific issues.
- Place-based local setting of the coyote project was important because it was authentic and meaningful for the students.
- Technology enhanced presentations (videos) were important, especially when illustrating concepts; it gave students a hands-on experience even when not in field.
  - The simulation model to learning might provide potential scalability to other locations
- Seeing live coyotes that are part of a study and interacting with me was very important for student appreciation of coyotes; it made the unit more personal.

Coyote Knowledge

Both classes showed a significant increase in student knowledge from before to after the curriculum unit and that knowledge was retained during post-delayed surveys 10 weeks after the curriculum unit ended in each classroom. Of the nine knowledge related question, four were significant and two were marginally significant at Coyote High and five and one were significant and marginally significant at Wolf High School. There were differences in four questions from pre to post surveys at both schools: one, Coyotes exist on Cape Cod; two, Coyotes often move long distances; three, Coyotes howl to scare people away; and four, Coyotes are more like foxes than wolves.

Despite similar improvements in the unit's survey questions, Wolf High School generally had much lower survey scores, both pre and post curriculum unit. For example, a comparison of rubric-based questions indicated that of the four pre and post-interview comparisons, all but one showed significant differences between Coyote and Wolf High Schools (Table 6.1). In other words, all other things being equal (like knowledge obtained from their teachers, and curriculum unit covered) Coyote High School students scored much better than Wolf High did. Students at both schools had a poor understanding of why coyotes lived in the city. Most thought that it was unnatural for them to be in these urban areas and did not correctly describe how they use the more wooded areas and behave much like coyotes from other areas in these habitats.

Given that students learn well with multiple performance opportunities (Teel et al., 1998), such as participating actively in the unit (Fusco, 2001; Rahm, 2002), it is not surprising to see good learning outcomes from these two schools. Barab and Hay (2001) discussed the difference between simulation and participation models to authentic science learning. In the current study, a major advantage of the simulation model is that video of coyotes was taken from the field by a scientist and brought into the classroom, therefore giving students the opportunity to learn about the science being taught without having to spend the time directly participating in the research. This strategy can greatly facilitate the content being delivered to students. However, a major disadvantage is that students do not appreciate the effort and time that it takes to get that data/video and for trapping that can literally be months just to capture one coyote. In general, students in both settings learned from the curriculum unit and improved their knowledge about coyotes in a short (2 weeks) amount of time.

The need for scientists and schools to form partnerships is important and potentially beneficial for all sides (Means, 1998; Waksman, 2003; Wormstead et al., 2002), especially when engaging in an authentic scientific project, either through direct participation or simulated studies (Barab & Hay, 2001; Hay & Barab, 2001). Evidence from this section demonstrates that students were capable of learning important terminology taught by a scientist. Similarly, Kahle et al. (2000) found students in inner city areas could learn science effectively if their teachers are well prepared and use standards based teaching practices. The advantage for the students was giving them the opportunity to learn from experts (i.e., scientists) in their respective disciplines while participating in legitimate scholarly, school-based activities. This study is important because there is mounting evidence that one component of the science education reform process must be a sustained effort toward making the study of science accessible to more students (Jones, 1997), including the urban-based students in this study.

The results from this study should be treated conservatively because many of the students' responses, especially at Wolf High (Table 6.1) were still fairly low compared to the design of the rubrics (Tables 3.9 and 3.10). However, even though results were not overwhelmingly high on the rubrics, the positive gains achieved by the students in a short time period are noteworthy.

Beliefs/Affective Components

Because of the low initial scores at Wolf High School on all assessment pieces, three of the six belief related survey questions showed a difference during the post-surveys. At Coyote High School, very positive opinions from the start (i.e., pre-surveys) of the unit failed to detect any differences. At Wolf High more students after the unit thought: one, Coyotes are important; two, Coyotes are not dangerous to people, and three, Coyotes should not be eliminated from where people live.

This section demonstrates that students in an urban setting positively improved their beliefs about coyotes. A benefit of the curriculum unit was the education that many minorities (e.g., African Americans) (Barton, 2001; Seiler, 2001) and women (Rohrer & Welsch, 1998) received. People of color have typically underachieved in education (Norman et al., 2001; Seiler, 2001) and are subsequently woefully underrepresented in many professions, particularly those related to the sciences and technical fields (Haury, 1995). The students' optimistic statements about coyotes suggests that this curriculum unit has the potential to empower the students into caring for the coyotes and our project, in effect giving the students a sense of ownership of the project (Barnett et al., 2004; Bouillion & Gomez, 2001; Fusco, 2001). As educators and scientists we need to harness the energy of these students to promote the message that our local environment is important and that community members have a stake in these issues. One way to accomplish this is to improve student beliefs about the issue under study.

Interest in science and coyotes

Many of the students noted that hands-on learning was an important component of the learning process for students. Kahle et al. (2000) found students in inner city areas could learn science effectively and became more involved when using inquiry-related science activities. Importantly, these inquiry based activities are an important national and state framework for the science standards (National Research Council, 1996, 2002). Teel et al. (1998) noted that inappropriate teaching strategies often cause poor performance. A way to improve student outcomes is to involve students directly in real world community science projects (Fusco, 2001; Rahm, 2002; Rickinson, 2001) where students can feel involved in the learning process.

Although a majority of the students at both schools claimed that they liked science, not many wanted to pursue a career in science. However, many did note that they would be interested in studying science in the future and they hoped to stay involved with science. There is mounting evidence that one component of the science education reform process must be a sustained effort toward making the study of science accessible to more students (Jones, 1997). For example, it was found that only 7 percent of all positions in science and engineering were held by minorities despite constituting 24 percent of the current United States population (National Science Foundation, 2002). This study attempted to empower traditionally impoverished regions by bringing science into classrooms; however, additional work needs to be done in order to figure out how to make the science more interesting to the students such that they might want to make a career out of it. There is no single explanation for the gap, but (Haury, 1995) lists two factors with black students that have to do with the disparity: first, African Americans experience more obstacles along the path to careers in science; and second, they have fewer opportunities to see people like themselves in the sciences. Likewise, George (2003) showed that students had fairly positive attitudes about the usefulness of science but future research needs to focus on students' attitudes about the utility of science and why fewer and fewer students pursue careers in science. Importantly, in this study, students seemed to perceive the role of scientists as active members of the scientific community. This lends support to the notion that scientists might be good sources for teaching students content matter, and for getting students actively involved in both science issues and in pursuing science as a career trajectory.

Science activities that tend to infuse meaning cause students to value the learning experience. Current emphases on interactive, hands-on, or inquiry-based learning is influenced by the constructivist approach which acknowledges the student as actively making his or her knowledge (Zady et al., 2003). Students in this study indicated that direct involvement with coyotes, such as going to the zoo, was important to maintain their interest in the curriculum. Wolf High never had an opportunity to visit the zoo during the curriculum unit and the post interviews indicated that students had enough virtual or simulated coyote experiences through powerpoint slides, pictures, posters, and videos, and they clearly wanted to see some live ones. However, providing an up-close personal experience of seeing coyotes was very meaningful and authentic (Bencze & Hodson, 1999; Chinn & Hmelo-Silver, 2002) to students at Coyote High.

Because 53 % of African-Americans live inside cities and 88 % reside in metropolitan areas (United States Census Bureau, 2001), it is critical to engage and motivate urban students to learn science in order to achieve many of the goals of the National Science Foundation (2002), such as diversifying the workforce. The literature indicates that providing resources (Spillane et al., 2001) and valuing relevant active learning environments in classrooms is important for students to be able to engage in the practicing culture of science learning in urban settings (Fusco, 2001). Therefore, science learning and experimentation must take place in urban schools (Bouillion & Gomez, 2001) as well as in informal (i.e., zoos), more traditional science learning environments (Hofstein et al., 1997). It is the job of educators and scientists to heed their comments and to provide learning opportunities that accounts for their interests.

Student learning and preference

Student involvement in the learning process can affect student interest in science (Bouillion & Gomez, 2001). Thus knowing how students like to learn is important. It was found that keeping a curriculum unit diverse was critical to engage as many students as possible. Hands-on activities, reading, visual (e.g., videos) mechanisms, and multiple ways were all ways that students learned best. Students thought that reading about coyotes, learning in multiple ways, and having a person with experience studying them would be valuable ways to learn about coyotes.

Student behavior can be indicative of how a curriculum unit is taught. If students do not pay attention, then motivating them through different teaching strategies would be difficult (Teel et al., 1998). For example, hands-on activities were an often mentioned tool that helped students learn. While the inquiry-based activities at Coyote High School seemed to be successful judging by student comments and learning from the exercises, the undisciplined, often difficult to teach, students at Wolf High made these same lessons very difficult to successfully implement. National standards stress the need for inquiry based ideas in classrooms (National Research Council, 1996, 2002). I found that with students that did not pay attention, or that talked and did not listen, it was actually much more difficult to do inquiry-based activities than in a standard, traditional lecture. In other words, inquiry based exercises, by their nature, make the class much more unstructured which makes a rowdy and undisciplined class much more difficult to handle.

This section makes additional arguments beyond the previous section on student interest in science and coyotes advocating that we must listen to students in order to appease their learning preference. Here we learned that multiple ways of learning, ranging from reading to hands-on activities are crucial to maintain student interest in science. For example, students learned best when they watched videos, saw the coyotes at the zoo, and got to learn about them with traditional, lecture based materials (e.g., powerpoint presentations). Lastly, some students noted that bringing a live coyote to the classroom would be a great way to see and learn about coyotes up-close. To me, this last scenario seems like a special type of simulated learning discussed by Barab and Hay (2001) where the science is brought into the classroom. Future research should investigate the effects of these types of learning environments.

Applied Knowledge of Coyotes

Results from this section focused on using knowledge of coyotes and applying that understanding in order to answer important questions related to their ecology and behavior. The examples given by students at both schools illustrated how students used knowledge of coyotes obtained during the course and applied their findings to elaborate on a question or point of interest. Learning is a generative process requiring effort in which learners actively construct their own meanings that are consistent with their prior ideas rather than passively acquiring knowledge transmitted to them. If prior knowledge and disciplinary knowledge do not connect and intertwine, learning of scientific knowledge is reduced to rote memorization of facts (Chin & Brown, 2000).

Student comments throughout the unit underscored the importance of the place-based (Hungerford et al., 1998; Woodhouse & Knapp, 2000) nature of the study where they were able to experience coyote behavior directly (e.g., at the zoo or on video). This learning strategy is consistent with Rahm's (2002) vision of doing place-based authentic studies. The results from these studies underline how children can become masters of the science embedded in their everyday communities and practices if provided with opportunities to do science that is meaningful and real to them (Rahm, 2002). I can't think of a better way to illustrate this point then the way that the students applied their knowledge of coyotes to produce the important questions that we saw in Chapters 4 & 5.

This section indicated that students improved their knowledge on coyotes and thus applied that knowledge to ask questions related to the curriculum unit. Students seemed to empathize with coyotes and many moved beyond simply wondering how and why coyotes lived in the city to specific questions about their ecology and/or behavior. Chin and Brown (2000) noted that when students engage in meaningful learning, they are purposeful and constantly monitor and reflect on the process of learning to evaluate the results of their own learning efforts. A deep learning approach, they noted, is associated with intrinsic motivation and interest in the content of the task, a focus on understanding the meaning of the learning material, and personalizing the task. Many of the examples in Chapters 4 and 5 showed how students personalized the material to make meaning of their subjects under study. Similarly, Crawford et al. (2000) found that learning science was constructed as a social accomplishment with students interested in topics because it had meaning for them.

Students' perceptions about the coyote curriculum

In my opinion, this was one of the most important sections in the whole research study. Finding out what students liked about a learning experience and capitalizing on that in the future is critical in order to support teaching and learning gains and positive experiences. One of Rickinson's (2001) major findings of his review of the environmental education literature indicated that understanding how students like to learn is very important. Most students in my study seemed to like the curriculum unit and, in particular, the videos. The students thought that the home videos were more authentic and meaningful and they were not biased compared to nature videos. The videos seemed to give the students a more hands-on feel to learning in the classroom.

The videos seemed to be interactive to the students allowing them to actively learn about coyotes without having to go do their own studies. This statement hints at Barab and Hay's (2001) discussion of authentic science in a simulated manner. Rather than learning science in field or natural settings (Bouillion & Gomez, 2001; Fusco, 2001), student participation in this study allowed them to obtain coyote facts in the classroom. This could make the curriculum unit generalizable (Schofield, 1990) or transferable in the future where the unit could be brought into many classrooms as opposed to the difficult task (because of time, logistics, and costs) of trying to bring many classrooms into the field.

By the end of the intervention it seemed apparent that students thought that the hands on nature of the videos brought the coyotes to life. They very much liked this simulated mode of learning about coyotes – when I showed these video clips, it seemed to mentally take them into the field. This lazy, yet visually active way of learning might be one reason why most students seemed to enjoy the videos. Additionally, providing informal learning opportunities (like visiting the zoo) was also important underscoring the importance of creating a diverse and varied curriculum unit.

The curriculum unit was liked by the majority of the students as evidenced by many of the students' enjoying the unit and complaining that I was leaving too soon and that I could make the unit longer if anything. One of the major complaints was that the students at Wolf High never had an opportunity to visit the zoo. The hands-on nature of going to the zoo seemed to be a much desired opportunity. Overall, though, keeping the unit diverse and illustrating the materials with videos were important factors in the curriculum's success.

Implications

Students need both real-world experiences (e.g., viewing coyotes at a zoo) and simulation (e.g., videos) learning opportunities to both understand and appreciate coyotes. While the simulation concept seems to be effective and more transferable to other settings, a trip like going to a zoo and seeing live coyotes gave the unit additional meaning. It is important for researchers and educators to note that designing place-based authentic experiences to give students meaning is critically important, but that doesn't mean that it has to exclusively occur outside (i.e., it can occur in classrooms).

Research has documented the importance of hands-on, inquiry-based curriculum that is conducted outdoors and related to the environment (American Institutes for Research, 2005). An American Institutes for Research (2005) study revealed that participation in outdoor school was associated with higher ratings of conflict resolution skills, cooperation, and environmental behaviors. The authors also found evidence that students that participated in a week-long outdoor school had better measures of self-esteem, conflict resolution, relationship with peers, problem solving, motivation to learn, behavior in class, and they scored 27 percent better on science knowledge related questions. This knowledge was maintained six to ten weeks following the program participation. Thus providing students with experiences and examples from the real world is important towards their understanding of science. Similar, the students in my study felt a richer connection to the curriculum unit when they were able to visit a zoo that held real coyotes that were part of a study.

The importance of understanding students' interests and preferences in learning about coyotes and science in general was a significant component of this study. Rickinson's (2001) review of the literature on learners and learning in environmental education found that the evidence base provides more information about students' environmental knowledge and attitudes than about their educational experiences and preferences. In other words, while it is important to access student performance and understanding of science concepts, we also have to understand how they prefer to learn and what interests them in the science issues under study. For example, because students obtain much of their environmental information from television (Rickinson, 2001), the videos used in my curriculum unit might have been an effective tool to teach students about coyotes not only because the videos illustrated the materials very well (based on student comments) but also because students normally obtain much of their information from these type of media sources.

The need for scientists and schools to form partnerships is important and potentially beneficial for all sides (Means, 1998; Trumbull, Bonney, Bascom, & Cabral, 2000; Waksman, 2003; Wormstead et al., 2002), especially when engaging in an authentic scientific project. In the partnership described in this study, students were afforded the opportunity to learn from a scientist while participating in legitimate scholarly, school-based activities. This partnerships was important because: one, it introduced students to a socio-scientific issue and a person that works in that field; two, the students gave many positive remarks about the unit, which potentially might increase student interest in science; and three, students were able to see how scientists investigate phenomena which might help guide aspiring future scientists. Thus, a major benefit of the curriculum unit was having a scientist (myself; see Figure 1.1) deliver accurate and hands-on scientific information related to coyotes to the students.

The coyote curriculum unit described in this dissertation was successful because it was designed from a local, place-based study that was authentic in the students' eyes, it used a diverse array of teaching tools to maintain student interest and to encourage their learning and beliefs about coyotes, and it involved a trained scientist teaching the unit. Future studies, using scientists specialized in different subjects (e.g., other animals besides canids) to teach students about animal behavior, should be evaluated to elucidate the differences in student interest in varied curriculum units related to animal behavior. This would enable one to detect differences in the success of certain curriculum pieces that have specific subjects (e.g., coyotes), different instructors, and different materials such as videos.

Much of the rhetoric in support of student-scientist projects assumes that participants will increase their understanding about the process of doing science (Means, 1998; Trumbull et al., 2000). Yet, very little research on the educational impact of such projects has been carried out. Designing curriculum to engage student interest in science and animal behavior is important (Margulis et al., 2001) and potentially one way to increase student understanding of science concepts. It is important to test students' conceptions of scientific processes and reasoning in order to understand how they learn

(Tytler & Peterson, 2004). The use of technology, such as the videos in this study, can be used to scaffold students, or provide support to enable learners to succeed in more complex tasks, and thereby extend the range of experiences from which they can learn (Golan et al., 2002). As Golan et al. argued, this scaffolding is needed since students often do not possess some of the tacit knowledge required to plan and conduct scientific investigations. Observing animals, whether in the wild or on video, is an activity most students have had some experience with. Thus, animal behavior affords an easier entry into the world of scientific inquiry since students are already familiar with some of the key elements of the domain, such as common animals (e.g., dogs, squirrels) and behaviors (e.g., playing, running) (Golan et al., 2002).

The public often views large carnivores (e.g., wolves and tigers) as flagship or charismatic species that generate much interest and because they are familiar to many people (Caro, Engilis Jr., Fitzherbert, & Gardner, 2004; Golan et al., 2002; Walpole & Leader-Williams, 2002). The fact that coyotes are a relatively large, furry mammal that is closely related to dogs, suggests that they may naturally arise interest in students. As noted by Caro et al., flagship species often are used in a strategic role to raise public awareness and have been variously defined as: one, a popular charismatic species that serves as a symbol and rallying point to stimulate conservation awareness and action; two, a species that draws financial support more easily; three, a species that has become a symbol and leading element of an entire ecosystem campaign; and four, normally a charismatic large vertebrate that can be used to anchor a conservation campaign because it arouses public interest and sympathy. Due to their predatory habits and presence in urban areas, the public is very aware of coyotes which make them an ideal subject for science education. Because of the coyote's continent-wide range (Parker, 1995), they potentially could be used by science educators in quite diverse settings. I argue that coyotes could serve as an excellent flagship for engaging students in science education and ecology-related issues and to empower students' to care about their local environment, especially in urbanized settings. Similarly, environmental education programs on bats in the Indian Ocean region empowered residents to protect native forests and bats in those places (Trewhella et al., 2005).

The success of this intervention seemed to have much to do with the authentic experiences that students had throughout this unit. As described by Barab and Hay (2001), students did not have to be in the field to learn about their subject. In essence, that was my job as a scientist as I spent many long hours in the field to obtain useful video that could be shown to the students. This type of simulated way of learning allowed the students to understand important concepts related to coyotes without having to do anything but sit in a classroom and listen. Smith and Blankinship (2005) also showed that students could engage in scientific discourse around video data. While the ultimate way to eventually learn about coyotes would be to have them do their own field studies on wild or captive coyotes, this is not a usable teaching tool that could be used in many circumstances (Schofield, 1990); however, bringing video, powerpoints, and other tools into a classroom can be used wherever one has a video-projector. In Figure 8.1, I present an illustration of the different ways of authentic learning. In fact, future studies might find that simulated learning is the best way to teach students a large amount of information in a short period of time before they go into the field to do their own studies. The curriculum unit had two of the three components of authentically studying coyotes; it was beyond the scope of this project to study students participating directly with scientists but about 10 students from Coyote High School do participate in the free-ranging component of the coyote study every year.

This study was similar to other studies that have successfully involved students in real science that was authentic and meaningful to students (Barab & Hay, 2001; Barnett et al., 2004; Bouillion & Gomez, 2001; Fusco, 2001; Rahm, 2002). Place-based activities of studies ranging from urban gardening (Fusco, 2001; Rahm, 2002) to coyotes (this study) overwhelmingly shows that students can be empowered to care for their surroundings when they are interested and encouraged to do so. Additionally, Krupa (2003) noted the importance of using naturalists to teach students science. Thus, it is important to ensure that there is adequate funding for these types of curriculum units to take place allowing scientists to work with teachers and their students in more numerous and varied settings to give students the opportunity to capture an interest and generate some level of excitement with science. Using coyotes, a potential flagship or charismatic species for learning and caring about science education issues, is one way to generate an enthusiasm of science in our classrooms.

In conclusion, I believe that my curriculum unit is important and useable in multiple contexts because:

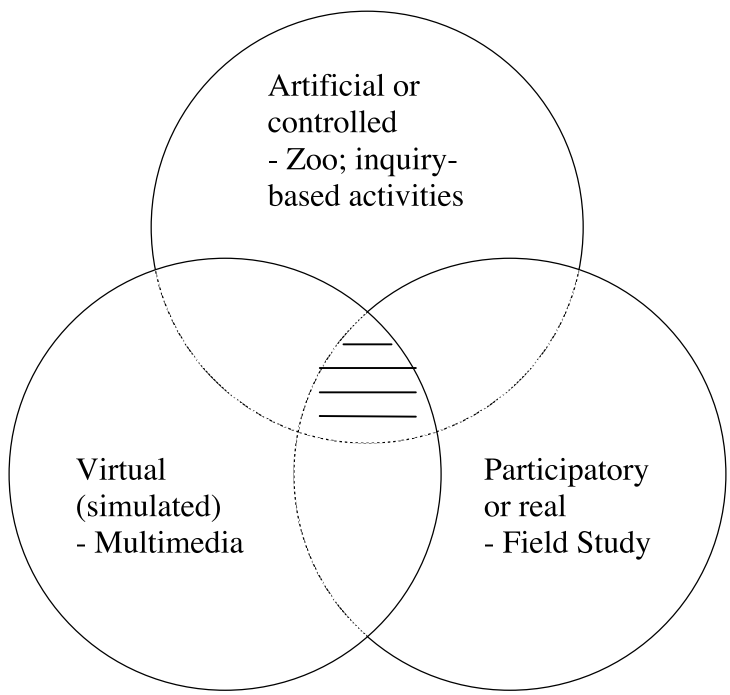
1. Learning about a predator like a coyote naturally seemed to capture an interest in the students.

2. Coyotes are familiar to many people because they are closely related to domestic dogs. Thus, it might not take much effort to engage students in the subject.
3. The diverse instructional techniques were important and meaningful to students and produced significant student learning in a relative short period of time.
4. A scientist was involved in the curriculum development and used teaching tools such as videos that scaffolded student learning of animal behavior.
5. The curriculum unit was locally relevant and which might help students to care about protecting, conserving, and learning about the environment around them. The unit may also help to teach people how to learn how to coexist with other species.
6. Because of the coyote's adaptability and continent wide distribution, this unit is potentially transferable to numerous and varied settings ranging from rural to urban environments.

Table 6.1. Rubric scores (1-4) and statistic values comparing pre and post interviews at Coyote and Wolf High Schools.

	Coyote High		Wolf High			
Question	M	SD	M	SD	T value	P =
Why do or don't coyotes all act the same?						
Pre-interview	2.60	0.52	2.2	0.79	2.449	0.010
Post-interview	3.50	0.53	2.90	0.32	3.674	0.011
Why do or don't you think that coyotes can be eliminated from an area?						
Pre-interview	1.90	0.32	1.70	0.48	1.500	0.168
Post-interview	3.40	0.70	2.50	0.97	3.857	0.004

Figure 8.1. Illustration of different types of authentic learning related to the coyote project ranging from real participation with a scientist, to controlled settings (like at a zoo), to virtual (such as multi-media tools). Stippled areas represent where all three types of learning experiences interact (for example, in a field studies course that has active participation and lecture-based activities).



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Appendix 1

A sample curriculum unit daily lesson plan from the coyote unit. Note: the first three pages of this activity can be handed out to the students although most of it is shown in the accompanying powerpoint slides following this description.

Lesson: Coyote tracking activity

Objectives: After completion of this project, students will: 1) learn techniques to estimate home range and population sizes of coyotes; 2) learn characteristics of 5 actual coyotes being studied in the wild on Cape Cod, Massachusetts; and 3) learn the different social classes of coyotes and correlate social status to home range use.

Activity: Students become simulated coyote biologists during the class period and gain knowledge of important terminology before actually going into the field.

Background: Coyotes are ubiquitous in that they live in 49 of 50 U.S. states (Hawaii is the exception). They live in all types of habitats from pristine wilderness to urban areas, including most of Boston. Despite being very elusive, the coyote's continental wide distribution makes them an ideal case study for almost any classroom in the United States.

Biologists study coyotes by trapping and putting a radio-collar on as many animals as possible. Biologists then repeatedly find each collared coyote over the course of months (and years, if possible) to understand basic coyote ecology. One of the most important pieces of information that biologists discover when studying wildlife is **home range size**, that is, the area that the animal uses. Home range size is usually measured in square miles (or square kilometers).

Biologists have discovered that coyotes have large home ranges (about 12 square miles) in suburban areas on Cape Cod. They have been found to be **territorial**, that is, coyote groups (called packs) defend these home ranges against other groups. Groups on Cape Cod typically consist of 3-4 coyotes. There is the **breeding male** and **breeding female** (sometimes called **alphas**) and usually 1 or 2 pups (called **juveniles**) that stay in their natal home range to help raise the next years litter of pups (their younger brothers and sisters, assuming that both parents are still alive). These "**helper**" coyotes are typically called **resident associates or betas** once they are a year old. Coyotes that do not belong to a family (typically animals 1-2 years old that have left, or dispersed from, their natal group) are termed **nomads or transients**. These animals usually roam over large areas until they find a suitable territory and a mate to establish a family (or pack) of their own.

Thus, biologists can estimate coyote populations based on average territorial size, number of coyotes/territory, number (or percent) of nomads comprising the population, and available habitat (that is, where can coyotes live in a given area).

Prior to participating in authentic field experiences in the Boston and Cape Cod areas, students will take part in this activity to learn how coyotes are studied in the wild.

Materials: 50 index cards (5 coyotes x 10 locations each), a map of a study site (a classroom for these purposes with exaggerated scales so the classroom is about 100 square miles), a pencil or pen/group, chalk and chalkboard, TV and VCR, and video-footage of actual coyotes.

Procedure:

1. Show a brief 5 minute introductory clip of our research. This is done to introduce students to our project in a relaxed atmosphere.
2. Make students responsible for the appropriate terminology such as defining home range and the different social classes of coyotes.
3. Place 50 index cards on the ground each labeled with a coyote's name and number of location (10 locations/coyote). Know ahead of time approximately how large you want each coyote's range to be. Then, put the cards on the ground according to that home range size. Make sure the map of the classroom is simulated at about 100 square miles so as to allow different sized coyote home ranges to be represented.
4. Arrange students in 5 groups. Have each group find all 10 cards (i.e., locations) for a particular coyote.
5. Have each group plot the 10 locations on their respective maps and have them estimate the home range size for their coyote on their maps and then on the blackboard. They estimate the home range by drawing a polygon around the outer data locations.
6. Have everyone participate in examining some factors that might help estimate how many coyotes live in their town.
7. Have students watch 5 short video segments of actual footage of these coyotes in the wild and have them identify (based on verbal descriptions, i.e., additional information provided, over each video segments) which coyote is in each video segment, and which social class it belongs to (based on my description and based on its home range use/size).

Extensions:

1. Students can estimate distances traveled by each coyote by adding the distances between each point. The students can then correlate these distances to a time span (given to the students) of when (date and time) these locations were collected. Thus, they can figure out approximate distances traveled per day for each coyote.
2. Have them read information about coyotes (books, theses, scientific papers) and have them do a research report on a selected aspect of coyote behavior.
3. Have them surf the web to find additional information on coyotes.

4. Have them contact authorities on coyotes to learn more about coyotes in their area or about coyote behavior in general.
5. Have them play "Who wants to be a millionaire" based on coyote terminology.
6. Most importantly, have students actually go out into the field and have authentic scientific experiences with wild coyotes.

Evaluation: For homework, have them write a short paper describing the techniques used to study coyotes and the important terminology that they learned or give them an in-class activity grade for participating.

Skills Used: Science (ecology, biology), Math, English, Geography, & Technology

References: I used the Project Wild book as a model, and specifically p. 134-137 "How many bears can live in this forest?" for the setup for this paper/project. However, the idea and description of this exercise comes from my personal experience of studying coyotes in the wild on Cape Cod.

Western Regional Environmental Education Council. 1992. Project wild: K-12 activity guide. 5430 Grosvenor Lane, Bethesda, MD 20814. Phone:(301)493-5447. Fax:(301)493-5627. Email: natpwild@igc.apc.org.

Ideas from this curriculum piece stem from:

Way, J. G., Ortega, I. M., & Auger, P. J. (2002). Eastern coyote home range, territoriality and sociality on urbanized Cape Cod, Massachusetts. *Northeast Wildlife, 57*, 1-18.

<u>**Teacher's Guide for Coyote tracking activity**</u>

<u>**Index Cards:**</u> When deploying index cards put the cards out to approximate each coyote's home range:

Kett – about 12 mi^2

Mizz – about 8 mi^2

Sill – about 20 mi^2

Glope – about 80 mi^2

Kash – about 3 mi^2

<u>**Answers:**</u>

1) A list of possible answers for **population estimate discussion**:

1. Town/region area must be known to estimate populations.
2. Home range must be known accurately. Need a large sample size of locations in order to not underestimate home range sizes.
3. Need to know if coyotes are territorial. That is, do they guard their home range?
4. How many coyotes live in a given territory (group size).
5. Habitat availability. Is all of the town/region available habitat for coyotes?

2) **Video**:

<u>Social classes</u> of coyotes to choose from:

Breeding male (Alpha male)

Breeding female (Alpha female)

Juvenile

Nomad/transient

Resident associate (beta)

<u>**Student activity:**</u> Determine each coyote's social class through the clues below and the video shown in class.

<u>Clues: (Also refer to the home range maps):</u>

Segment 1. My name is Mizz. Although I am a weird looking coyote, I regularly attend my pups but I also have to travel throughout my home range to obtain enough food such as rabbits, squirrels, mice, and possibly cats. However, I regularly have to return to and nurse my pups.

Segment 2. My name is Kett. I have lived here for over 3 years. My boundaries are well established. I regularly patrol them while my mate nurses the pups.

Segment 3. My name is Glope. Formerly I used to roam the study area, but I recently joined the group you are watching. I can be seen in the back watching 2 of my packmates interact. Then you can see me traveling alone while running around on a golf course. What was my social status before joining this group?

Segment 4. My name is Sill. Although not a dad yet, I still bring food to my younger packmates (siblings). I live mostly on my natal home range, but occasionally leave it to explore surrounding areas.

Segment 5. My name is Kash. I am impatient and howl with my siblings when I want food. I wait around the den and play with my siblings for most of my waking hours. I don't explore much – Yet! I was captured when 4 months old.

Answers:

Kett = breeding male

Sill = resident associate (beta) or helper

Mizz = breeding female

Kash = Juvenile

Glope = Nomad/Transient

Powerpoint lecture slides of Coyote Tracking activity:

Slide 1:

Coyote tracking

Slide 2

Today’s activity

- Today you will be a virtual coyote biologist in charge of tracking and identifying your study subjects’ pack status.
- You will be given clues to help you identify the animals status but it is up to you to figure out the answer.
- We will use real/actual coyotes that have been tracked on our study areas.

Slide 3:

Terminology

- Home range size – the area that an animal uses. Measured in square miles (or kilometers). On Cape Cod we have found that coyotes typically have 10 -12 mi^2 home ranges.
- Territory – the area that coyote packs (or groups) defend against other groups.
- Dispersal – an animal that leaves its natal area/place of birth (that is, its parent’s territory)

Slide 4:

More Terminology

- Typically 3-4 adult coyotes guard and keep other coyotes away. These coyotes (usually the parents and 1 -2 older offspring) raise a litter of on average 5 pups, born in April, within their territory.

- Territoriality is the reason that coyotes do not become overabundant in a certain area.

Slide 5:

Coyote social classes – Write down

- Breeding male and female – sometimes called alphas. They are the parents or breeding members of a coyote social unit (called either a pack or group). The 2 can be called a mated pair.
- Juveniles – pups of the year
- Resident associate coyotes – also called betas. Coyotes (usually offspring of the mated pair) that remain with the mated pair to form a pack.

Slide 6:

Coyote social classes

- Resident associate coyotes continued
  - These coyotes are typically called helper coyotes when the breeding female gives birth.
  - The pups of the year are generally their younger siblings.
- Nomads or transients – coyotes that have dispersed and now roam large areas (>100 mi^2) in search of suitable territory
  - Objective: to find a mate and establish a pack of their own.

Slide 7:

Population estimates

- Biologists can estimate coyote populations based on knowledge of:
  - Average territory size
  - Coyotes per pack within each territory
  - Percent of nomads in a population
  - Available habitat (that is, where can coyotes live in a given area – on Cape Cod it is most of the area except downtown urban areas like Hyannis).

Slide 8:

A note

- A coyote can be all social classes (except switching sexes…But who knows) during the course of its lifetime.
  - For instance, a coyote is obviously born a pup or juvenile. It then becomes a beta as it delays dispersal for a year and helps raise its young siblings. Then it disperses and becomes a transient until finally finding a vacant territory (100 miles away) where it finds a mate and becomes a breeder.

Slide 9:

Class Activity

1. Divide into equal groups of five or individually. One team chooses to be Kash, Sill, Mizz, Glope, or Kett.
2. Take the study area (a map of the classroom) and find the 10 locations from “your” coyote. <u>Do not touch or move index cards!</u>
3. Draw a polygon around the outer data points & estimate the animal’s home range size using data collected.
4. Watch video clips and guess its social class based on the clues read a loud (very important) & #3 above (home range size).
5. Fill out and hand in the worksheet including marking all 10 coyote locations.

Slide 10:

Show

- Segments 1 – 5
- Answers on next slide

Slide 11:

Answers

- Kett = Segment 2, breeding male
- Sill = Segment 4, resident associate (beta)
- Mizz = Segment 1, breeding female
- Kash = Segment 5, Juvenile
- Glope = Segment 3, Nomad/Transient

Appendix 2

Interview responses from Coyote High School students during pre and post interviews on the coyote curriculum unit. NA = Not Applicable.

Interview questions and responses		Pre	Post
General science questions	Number of students:	11	10
1. Do you like science classes? What do or don't you like about them?			
Yes		11	9
No		0	0
Somewhat		0	1
Dislike chemistry		6	4
Likes chemistry		2	2
Likes life sciences		9	8
Likes space		1	0
Dislikes physics		4	3
Dislikes math aspect of science		3	2
Likes most/all science		2	2
Dislikes science fair		1	1
Likes anatomy		1	0
Dislikes cells/biology		1	0
Chemistry is difficult but doesn't mind it		0	1
Dislikes Environmental science		0	1
2. Do you like learning in any particular way?			

Working in groups	1	0
Hands-on activities	8	8
Field studies	2	1
Labs	1	0
Zoo visit	0	1
Lecture/notes	2	2
Multiple ways	1	0
Visual	4	5
Reading	1	1
Movies/videos	0	1
3. Do you like animals? Which ones?		
Yes	11	10
Birds	1	0
Dogs	3	2
Cats/big cats	3	6
Nothing in particular	4	3
All but dogs	1	1
Reptiles/lizards	0	1
Mostly just domestic animals	0	1
No	0	0
4. Do you have a pet? What kinds?		
Yes	9	8

Cat(s)	4	4
Dog(s)	4	3
Fish	1	1
Turtles/reptiles/lizards	3	3
No	2	2
5. Do you want to pursue a career in science?		
Yes	6	6
No	4	3
Not sure	1	1
Don’t know yet	2	3
Computer related sciences	2	0
Chemistry	1	0
Engineering	1	0
Applied science	1	0
English	1	0
Field biology/zoology	1	1
Marine biology	1	1
Forensic science	1	1
Veterinarian	1	1
Psychology	1	1
Communications	1	1
Physical therapy	0	1

General coyote questions		
1. What question(s) would you want answered about coyotes?		
Living in the city – why/how do coyotes	5	0
People's interaction with them	2	0
Are they dangerous	1	0
Population ecology	1	0
Behavior	1	3
Group interactions (social)	1	2
Communication	0	1
Nothing specific; I just want to learn about them or questions were answered	4	4
What is the real story behind them	1	0
How/can they interbreed with dogs	1	0
Their habits	1	0
Hunting behavior	0	1
How they became the eastern coyote	0	1
Method of locomotion	0	1
Difference between captive and wild	0	1
2. What do you find interesting about coyotes?		
Behavior	5	6
Social	4	3
Communication (howling)	2	1
Coyotes around me (captive coyotes)	0	3

How they are scared of people	0	1
Ecology	3	3
Food habits	1	0
In an urban environment near people	1	2
Like a wolf	2	0
Especially eastern coyotes (potential hybrids)	1	0
Seem tame like dogs	2	1
Because they live in the city/near people	1	0
Because they can interbreed with dogs	1	0
Appearance	2	0
Very cool looking animals	1	0
Size	1	0
Are they dangerous to people	1	0
Difference between captive and wild coyotes	0	2
Everything	0	1
3. Would you be interested in going to a zoo to see coyotes? Why?		
Yes	11	10
To see them	11	10
To see/observe behaviors	6	5
To compare to dogs	1	0
Would go but has problems with zoos	1	0
Be involved; more hands-on	0	2

Want to go back again	0	3
No	0	0
4. What would be the best way to learn about coyotes?		
Movies (videos) on them	1	5
Study/see them	9	9
In the wild	5	2
In captivity	5	8
Read about them	2	1
Multiple ways	3	4
Have a person with experience studying them to talk about them	3	2
Interact with them – like a live animal in a classroom	1	2
5. Would you rather watch a TV program or home videos on coyotes?		
Television	4	1
Better explanations	2	0
More organized	1	1
Home video	10	10
More meaningful/personal/authentic	9	10
Not biased/edited	2	5
Raw footage	2	3
More information provided/Very specific	1	2
Both	3	1

Specific coyote questions		
1. Do all coyotes act the same? Why?		
Yes	0	0
No	11	10
Provided examples (e.g., dominance hierarchy, personalities)	4	9
All animals are individuals	6	5
But have similar/general patterns of behavior within a species	4	0
Similar to why humans are different/all species are not the same	3	3
2. Should coyotes be eliminated? Why?		
Yes	0	0
No	10	10
No threat	3	2
They are a part of the landscape	6	5
People need to learn to live with them	2	3
They were here first	1	1
Unless they/individuals cause problems – like have rabies	1	1
People do not even know they are there	2	1
People need to be aware of surroundings	0	2
People can prevent problems from occurring	0	1
They are afraid of us	0	1
Neutral – no opinion	1	0
Could be good or bad depending on scenario	1	0

3. Can coyotes be eliminated? Why/How?		
Yes	3	1
Would be difficult though	2	1
Would be wrong though	1	0
But others would move into the area	0	1
No	7	8
Ecosystem effects	1	1
Others would come back	5	8
Too much effort	1	0
Neutral – no opinion	1	0
Can not remember; probably not, but wolves were eliminated so…	0	1
4. Recommendations for pet/cat owners		
Do not know	1	0
Do not leave them out late/at night	7	3
Watch your pet when outside	3	5
Keep them leashed	1	2
Do not leave it outside; keep it inside	3	8
Keep them fenced/contained	3	2
Use common sense	0	4
Do not be stupid; be responsible	0	2
Learn about coyotes	0	1
5. Do coyotes occur in your backyard?		

Yes	4	4
Live near a wooded area	2	2
Coyotes are very prevalent	0	1
No	5	5
But nearby	2	3
They live in a more wooded area	1	2
My yard is fenced in	0	2
Never lost a pet	1	1
Maybe/do not know	2	1
Possibly nearby though	1	1
6. Research questions if you could study coyotes		
Ecology-based	5	2
Movements/travel	1	2
Habitats	2	0
Population questions	1	0
Diet	1	0
Activity	1	0
Interactions with people	2	0
Behavior	6	9
Dominance	1	4
Social interactions	5	6
Captive raised ones and people	0	1

Can they be tamed	1	0
Comparing captive to wild coyotes	2	2
Are they hybrids with wolves	1	0
Diseases	1	0
Mange	1	0
Just to observe them	1	0
In captivity	1	0
Differences between western and eastern coyotes	0	1
7. Are you scared of coyotes? Have you seen one before?		
Yes – No	2	2
Because scared of dogs	1	1
Yes – Yes	0	0
No – No	7	6
Not in wild but have seen one in captivity/zoo	1	4
No – Yes	1	1
Do not know yet - No	1	1
8. What did you like about the curriculum unit?		
Felt involved in an actual study (place-based)	NA	2
Repeating information at end from beginning – repetition was good	NA	1
The videos illustrated the notes well	NA	8
Wile E coyote clips was a clever idea	NA	1
Liked it all	NA	1

Liked the zoo	NA	5
It was fun	NA	1
Liked the readings	NA	1
8b. What did you like about the videos? How did they help you learn?		
Brought the coyotes closer (seeing them); hands-on like learning; engaged	NA	4
A step between the real thing and the notes	NA	6
It illustrated the stuff that we talked about; connected concepts	NA	7
They were personal	NA	1
Got to see actual behaviors	NA	1
They are just enjoyable to watch	NA	1
9. What did you dislike about the curriculum unit?		
When Mr. Earnest and I went off on tangents; not very relevant	NA	2
Nothing really	NA	7
Easy to comprehend	NA	2
Liked it all	NA	3
You are leaving too soon	NA	1
The notes – but realized that they were needed	NA	1
Too much about other canids (e.g., wolves); needed more on the study	NA	1
10. Suggestions/comments about the curriculum unit?		
Be more focused	NA	1
It was great/ a really good lesson (unit)	NA	6
Make it longer (e.g., 3-4 weeks instead of 2)	NA	4

Loved the videos and how they related to the slides	NA	2
Continue classroom activities; like hands-on stuff	NA	2
I would love to touch/be with one	NA	1
Multiple learn opportunities are important	NA	1
Focus mostly on research and not other species; use home videos	NA	1
Additional questions they asked		
Captive coyotes	2	1
Why take them out of the wild	1	0
Coyote Late's abnormal development	1	0
Have I been attacked	0	1
Has it deterred you from being with them	0	1
Communication (howling)	1	0
Do you think that animals have feelings?	0	1

Appendix 3

Interview answers from Wolf High School students during pre and post interviews on the coyote curriculum unit. NA = Not Applicable.

Interview questions and responses		Pre	Post
General science questions	Number of students:	10	10
1. Do you like science classes? What do or don't you like about them?			
Yes		7	8
No		1	2
Some of them/A little bit		2	0
Likes environmental/life sciences		4	0
Likes hands-on/Labs		1	6
Likes all/most classes		1	3
Likes biology		3	1
Likes marine biology		3	0
Likes animal science		1	0
Dislikes chemistry		5	1
Likes field trips		1	0
Doesn't like sitting in classroom		1	1
Doesn't understand science		1	0
Likes health		1	0
Likes anatomy/human body		2	0
Dislikes cells		1	0

Likes doing research on animals	1	0
Likes discovering new things	1	0
Doesn’t like anatomy/human body	1	0
Doesn’t like biology	1	1
Likes math	0	2
Likes English	0	1
Dislikes writing part	0	1
Science is boring	0	1
Likes when teachers teach something	0	1
Likes geography	0	1
2. Do you like learning in any particular way?		
Hands on/active	7	7
Field trips	0	1
Something interactive	0	1
Labs	0	1
Projects	0	1
Multiple ways	3	2
Notes	2	1
Videos	1	2
Visual	1	1
Someone talking about them/lectures	1	2
By studying or researching something	2	0

Reading	0	1
3. Do you like animals? Which ones?		
Yes	9	9
No	1	1
All animals	2	2
Cats/big cats	3	2
Dogs	4	5
Bears	1	0
Dislikes birds	1	0
Likes hamsters	0	1
Dislikes snakes	0	1
Likes domestic animals	0	1
4. Do you have a pet? What kinds?		
Yes	5	4
No	5	6
Dog(s)	4	4
Cat(s)	3	2
Birds	2	1
Used to have dog(s)	3	4
Used to have cat(s)	0	1
Used to have hamsters	0	1
5. Do you want to pursue a career in science?		

Yes	0	3
No	4	3
Not sure	6	4
Wants to be a cop	1	0
Not sure what wants to do	3	4
Wants to be a fashion designer	1	0
Possibly a marine biologist	1	0
Possibly a musician	1	0
Wants to be a sociologist	1	0
Wants to be a pediatrician	1	0
Wants a high paying job	1	0
Wants to work with wild animals	0	1
Wants to be a nurse	0	2
Possibly pre-medical	0	2
Wants to be a pediatrician	0	1
Wants to go into business	0	1
General coyote questions		
1. What question(s) would you want answered about coyotes?		
Why they make noises/howling?	1	0
Are they dangerous?	3	0
Longevity in city	2	1
Ecology in the city	4	0

Why they attack other animals?	1	0
Reproduction questions	1	0
Where they came from (i.e., to live in the city)?	2	0
Their reaction to people	1	0
How is it different from dogs and wolves?	1	0
Why active at night?	1	0
Why people have a bad perception on them?	0	2
What would a coyote and dog hybrid look like?	0	3
Difference between male and female coyotes	0	1
Nothing, I know just about everything about them	0	1
Can they be domesticated?	0	1
Is a wolf or a coyote fiercer?	0	1
2. What do you find interesting about coyotes?		
Their howling	1	0
I don't know, I don't know anything about them and want to learn	5	0
That they are animals	1	0
They are sneaky/mysterious	2	0
They are like dogs but wild	2	2
Their intelligence	1	0
They are interesting animals	0	1
Sociality	0	5
They are loyal/they help each other raise young	0	1

The way they play with each other	0	1
They travel in packs	0	2
Difference between captive and wild coyotes	0	1
That they kill other animals	0	1
They shed/their appearance	0	2
They are scared of people	0	1
They look like wolves	0	1
3. Would you be interested in going to a zoo to see coyotes? Why?		
Yes	9	10
To see them up close	9	10
To learn more about them	3	3
It gets me out of school	1	0
To see the difference between captive and wild ones	0	2
To observe them	0	2
To see them in real life rather than on video	0	1
No	1	0
Zoo is like jail for them	1	0
4. What would be the best way to learn about coyotes?		
To see/observe/study them live	9	8
In a zoo	4	3
To study them in the wild	2	4
Bringing the coyotes to school	0	1

To get out of the classroom and to be involved	1	0
To read about them	1	0
Multiple ways	2	0
Have teacher talk about them	1	1
To touch one	1	0
To see on TV	1	0
To live with them	1	1
In the wild	1	0
In captivity	0	1
Having notes	0	1
Anything hands-on	0	1
5. Would you rather watch a TV program or home videos on coyotes?		
Television	1	2
Explains more about them	1	2
More authentic	0	1
Home videos	7	7
More real/authentic/meaningful	6	7
TV ones are more boring	1	0
Less biased/more accurate	1	0
Gives more information/more in depth	2	0
Both/either	1	1
Whatever gives more information	1	0

Both have good reasons	0	1
<u>Specific coyote questions</u>		
1. Do all coyotes act the same? Why?		
Yes	2	0
No	6	10
Not sure	1	0
No reasons why	1	0
They are the same animal	1	0
Coyotes are different in different localities/environments	3	2
They are like humans – everybody acts different	4	5
They have different characteristics	0	1
Gives examples	0	4
Experiences affect behavior	0	1
2. Should coyotes be eliminated?		
Yes	1	1
If they are a problem	1	0
They should be kept in zoos	0	1
It might be unsafe for coyotes and people (i.e., with coyotes around)	0	1
No	5	7
As long as they leave people alone	1	0
They were here before us	1	1
They aren't dangerous	1	2

They have nowhere else to go – Losing habitat	2	0
They have a right to live here also	1	3
But keep them away from other animals	0	1
No reason why	0	1
Don’t know	4	2
Need more information on them	1	0
Have never seen one	1	1
But if they kill other animals than they shouldn’t be around	1	0
Move if dangerous/disturbing people	1	1
They have a right to be here, especially if not dangerous	1	1
3. Can coyotes be eliminated?		
Yes	7	6
People might kill them	5	2
People might move them	1	0
But they shouldn’t be	1	1
It has happened so often before with other animals (like grizzly bears)	1	1
Habitat loss	1	0
Because some people don’t like them	0	1
But let them be	0	1
Humans can do anything	0	1
No	0	4
They reproduce fast	0	1

You wouldn't get them all	0	2
Large populations, so another one will appear if one is killed	0	1
Because people always complain about them becoming extinct	0	1
Wouldn't want them to become extinct even though I don't like animals	0	1
Don't know	2	0
Need to learn more about them	1	0
Move them somewhere else, don't kill them	1	0
4. Recommendations for pet/cat owners		
Don't know, need to learn more about coyotes	1	0
Don't know, I haven't seen coyotes before	3	1
Keep dogs on a leash	1	1
Don't let your cat out	3	0
Keep all pets inside	2	6
Before dark	1	0
Or supervised outside	0	2
Lock your doors, close your windows	1	0
Don't let coyotes get in (to the pets, like chickens)	1	0
Don't walk dogs at night	1	0
Don't let kids out at night	1	0
Don't let them go far	0	1
Keep pets in a cage	0	1
Domesticate coyotes so they can be friends with cats	0	1

Watch your pets	0	1
Set up traps if you don't want your animals killed	0	1
5. Do coyotes occur in your backyard?		
Yes	0	2
But you can't see them because they hide	0	1
Because I have seen other animals (e.g., raccoons)	0	1
No	6	8
Not in the city where I live	1	6
But nearby	0	2
I don't know	1	0
It is possible	2	0
6. Research questions if you could study coyotes		
Examining communication	1	1
Howling	1	0
Ecology/behavior	4	4
How do they survive in the city?	1	0
To compare city versus suburban coyotes	1	2
Diet	1	0
Habitat	2	0
How they live	0	1
Their denning behavior	0	1
Longevity	2	0

How big a female gets compared to a male	1	0
Why people have a bad outlook on them	1	1
To see if they are dangerous	1	0
Can they be tamed/domesticated	1	2
Their anatomy	2	2
Difference between male and female	1	1
Why they have yellow eyes	1	0
How they grow	0	1
To look at the internal difference between dogs and coyotes	0	1
To look at dog-coyote hybridization	0	1
Everything – understanding their natural history	0	1
I don’t know, I am not interested in studying coyotes	0	1
7. Are you scared of coyotes? Have you seen one before?		
Yes – No	2	0
I don’t know if they are dangerous or not	2	0
Yes – Yes	0	0
No – No	2	3
But have seen them on TV	1	0
No – Yes	4	4
Have seen them in zoos	1	3
Have seen them while camping	1	0
Have seen them in many different locations	1	1

Have seen them nearby	1	0
I would be amazed if I saw one	0	1
Not sure yet - No	2	3
Know they aren't dangerous but still might be scared	0	2
8. What did you like about the curriculum unit?		
Liked the case study approach on coyotes	NA	3
Liked that it was about animals; I like animals	NA	1
Liked learning about the captive coyotes	NA	1
Everything; I just liked learning about them	NA	1
The videos	NA	5
The cartoons (Wile E)	NA	1
Of the wild coyotes	NA	1
Seeing my (referring to me) interactions with the coyotes	NA	1
Wild coyotes	NA	1
Captive coyotes	NA	1
8b. What did you like about the videos? How did they help you learn?		
How they were authentic/more meaningful	NA	1
Showing the difference between the captive ones and the wild ones	NA	2
It gave a different perspective on coyotes; now I know a lot about them	NA	1
It illustrated how we study them	NA	5
Because they were funny (Wile E. coyote clips)	NA	1
Showed how similar they were to dogs	NA	1

9. What did you dislike about the curriculum unit?		
Nothing/no problems with it/Liked everything	NA	8
I really enjoyed it	NA	1
But just another segment of school	NA	1
Would have liked a field trip	NA	1
Seeing the surgical operation (i.e., the implant procedure for the pups)	NA	1
The foothold traps	NA	1
10. Suggestions/comments about the curriculum unit?		
Maybe a little longer in more in depth	NA	5
Keep it the same/No changes	NA	7
Get more students involved in the study	NA	2
Can't wait to go to the zoo	NA	1
Maybe a little bit less/shorter	NA	1
Additional questions they asked		
Do you still track in the wintertime?	0	1