

## **How does a curriculum intervention that anchors instruction to the study of urban coyote behavior affect student learning?**

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### Abstract

One component of the science education reform process must be a sustained effort toward making the study of science more interesting and meaningful to students, especially in urban areas. Creating authentic learning opportunities where a scientist instructs the curriculum intervention is one way to make science lessons more relevant. This project involved assessing student cognitive gains on a locally relevant science topic: eastern coyotes (*Canis latrans*). This study used a mixed methodological (qualitative – quantitative) framework for students from two urban environmentally-based high school science courses in the Boston area. Both classroom interventions tended to show meaningful learning gains when assessed before and after the short (two to three week) curriculum unit. Furthermore, students retained much of this knowledge during a post-delayed survey ten weeks after the curriculum unit finished. Coyotes and other common wild animals could potentially be used as flagship or charismatic species to trigger increased interest and a knowledge base of the environment in which students live.

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### Introduction and Purpose

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 the fact that minorities constitute 24 percent of the current United States population (National Science Foundation, 2002). Furthermore, reports indicate that United States students rank very low in science scores, with 18 out of 20 nations outperforming them in international tests (Glenn Commission, 2000). When race is considered, the difference is even more pronounced, While 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). But despite this disparity, documents (e.g., National Research Council, 2002) clearly put forward the idea that all students, regardless of culture, gender, and/or race, are capable of understanding and learning science. Because 53 percent of African Americans live inside cities and 88 percent 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), such as involving students in scientific activities similar to those engaged in by scientists (Barab & Hay, 2001). While ‘authentic’ means different things to different authors (Chinn & Hmelo-Silver, 2002; Hay & Barab, 2001), I view authentic science activities as opportunities 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 of research activities (indirect participation) that are brought into the schools.

One way to involve students in an authentic project is to choose a topic of interest because of its local relevance (Rickinson, 2001). For example, coyotes (*Canis latrans*) are often in the news (e.g., Nejame, 2005) across the country due to their nationwide range (Parker, 1995), and some students who normally wouldn’t be interested in a standard science issue might be attracted to coyotes because of their notoriety and the fact that they are a wild, relatively large, and potentially dangerous predator. By giving urban students the opportunity to experience a curriculum unit on eastern coyotes, an animal found where they live, they and their teachers will be exposed to many of the goals and objectives of education, such as providing educating to all citizens with the technology to increase the understanding of scientific topics (see American Education Research Association, 1998; Goodlad, 1993; Pine, 2002).

This paper will examine how choosing a locally relevant topic, eastern coyotes, affects student learning. Therefore this paper will attempt to fill in gaps in the education literature by addressing:

What happens to students’ knowledge of eastern coyotes after participating in a curriculum unit on them?

The objectives of the coyote unit were:

1. To improve student knowledge and understanding of coyotes.
2. To have students gain an appreciation of the local wildlife around them.
3. To have students understand key terms associated with coyotes.

## Background

### *Urban Science Education*

There has been a relative dearth of studies with 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 are important for students to be able to engage in the practicing culture of science learning in urban settings (Fusco, 2001). Active learning environments are often inquiry-based or hands-on in nature and involve students becoming engaged either in classroom activities, such as labs, or in informal (e.g., zoos), out of the classroom experiences (Hofstein, Bybee, & Legro, 1997). To be

successful, science learning and experimentation must take place both in urban schools (Bouillion & Gomez, 2001) and in less structured formats to give students a range of hands-on experiences.

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. 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, unsurprisingly, black students receive proportionally fewer degrees than their white counterparts with only 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 more students directly in real world, place-based science projects (Fusco, 2001; Rahm, 2002; Woodhouse & Knapp, 2000) such as the eastern coyote curriculum unit that is the focus of this paper.

#### *Student Learning of Animal Behavior/Science Concepts*

While it is important to involve students from all backgrounds and living environments (e.g., cities and rural areas) in science projects, it is just as important to document the effectiveness of these collaborations and/or the subsequent student learning (or lack thereof) 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 topic 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. (2000) found that students could participate in science by designing virtual reality models of gorillas; these authors noted that students became aware of basic rudiments of gorilla behavior, but more effort was needed for the students to understand gorilla social behavior such as body postures and dominance interactions. The use of technology, such as classroom videos, was found to scaffold student learning, or provide support to enable learners to succeed in more complex tasks, thereby extending the range of experiences from which they could learn (Barab & Hay, 2001; Golan et al., 2002). Margulis et al. (2001) found that a zoo field trip was a very good way to supplement student learning initiated in the classroom. All these studies suggest that combining simulation (e.g., videos) and real-world authentic experiences are important to engage students in learning about animal behavior. Finally, Way and Eatough (2008) found that students could effectively learn about wildlife in the classroom, but it was difficult to involve them and their teachers in an authentic wildlife study without having additional funding to provide for a full-time scientist to implement and design adequate scientific research protocols that incorporate teachers and their students.

Surveys of young people in several countries report low levels of factual knowledge relating to environmental issues, often coupled with poor understanding of such matters (Rickinson, 2001). But studies reveal that participating even in week-long outdoor residential field courses with a local environmental focus, effected positive changes in students' environmental knowledge, attitudes, conflict resolution skills, cooperation, and environmental behaviors (American Institutes for Research, 2005; Rickinson, 2001).

As exemplified by these studies, providing students with experiences and examples from the real world is important toward their understanding of science. Numerous studies that have focused on student participation in outdoor scientific activities show the importance of the local environment in a child's life (Barnett et al., 2004; Bouillion & Gomez, 2001; Fusco, 2001; Rahm, 2002; Sobel, 2004). Odom (2001) also noted that outdoor-based activities are not the exclusive domain of exotic wilderness settings. Rather, worthwhile field projects can be performed 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).

### Study Context

This study focused on two teachers' classrooms and their students from two schools in the Boston area during fall 2004. The participants in this study were the students of the two high school environmental science classes taught by teachers who worked with the Urban Ecology Institute (UEI) at Boston College. The north Boston school (Coyote High School, pseudonym) was urban, while the south Boston school (Wolf High School, pseudonym) was inner-city based. I focused on studying one class from Coyote High School (14 students) and two classes from Wolf High School (totaling 40 students). These classes ranged from low to intermediate level (i.e., at Wolf High) to advanced placement (Coyote High) classes.

### *Team Members*

*Doug (pseudonym)*. Doug, from Coyote High School, was directly involved in the field research component of the coyote study. He was a full-time science teacher and collaborated with the researcher during the capture, collaring, and monitoring of our radio-collared subjects (see Way & Eatough, 2008). Doug also had worked in partnership with the UEI for the past five years in various inquiry-based learning projects, including the coyote study. The curriculum intervention was implemented 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 gave a presentation to the class in the coyote exhibit with the three resident eastern coyotes.

*Tanya (pseudonym)*. Tanya, of Wolf High, had worked closely with UEI since its inception in the late-1990s. She taught science at Wolf High but did not directly participate in the ecological study of coyotes with Doug and the researcher. However, she allowed the curriculum unit to be taught to her class. The curriculum unit was given to two of Tanya's classes (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 courses designed to help students gain a science credit to graduate high school. 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." Tanya's two classes greatly fluctuated in size with people routinely coming and going, almost like the course was optional (which it was not). Combining the two class periods, on average 20 people were regularly in class on a consistent basis, even though about 40 were signed up. I did not take daily attendance records because of our focus on the curriculum and assessments (classroom observations), and also because students frequently left early or entered the class tardily which made it difficult to keep track of who was present or absent.

### *The Researcher's Role*

The researcher worked on a hybrid doctorate at Boston College which involved scientific (Way, 2007; Way, Ortega, & Auger, 2002; Way, Ortega, & Strauss, 2004) and education (e.g., Way, 2005; Way & Eatough, 2008) components with the goal of conducting an authentic field study of coyotes in urban Boston. Thus, the author acted as lead scientist and educator (who designed the curriculum unit and the assessments) of the coyote study. Other staff at UEI assisted with logistic issues.

I was an active participant in the study, teaching the curriculum unit in a teacher/researcher role. As teacher/researcher, I sought to understand an emic (insider) view of the classroom in order to uncover the perspectives and viewpoints of participants (Pine, Under review for publication; Rossman & Rallis, 1998). This insider perspective allowed the researcher to immerse into the classroom's culture and work directly with my human study subjects. Despite the aforementioned insider point of view, I also could be viewed as an outsider to the schools since I was a scientist/educator coming from outside of both settings and therefore never fully experienced the classroom cultures. Therefore, 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). As an outsider in this sense, I was in the position to relate the participants' experiences to a larger audience (Barnett, 2003).

### *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. 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. There are 6,984 people per square mile in the city. 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 similar statewide averages of 229, 228, and 226, respectively.

*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 school is a small learning community school in Boston with 390 enrolled students that is theme-based on environmental science. 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. In spring 2007, MCAS scores at Wolf High indicated that 0% were advanced, 21% proficient, 69% needed improvement, and 10% failed the English Language Arts test compared to state averages of 22%, 49%, 24%, and 6%, respectively. For Mathematics, 12% were advanced, 17% proficient, 35% needed improvement, and 37% failed compared to state averages of 42%, 27%, 22%, and 9%, respectively. For Science/Biology, 0% were advanced, 2% proficient, 43% needed improvement, and 55% failed compared to state averages of 8%, 34%, 34%, and 24%, respectively.

#### Curriculum Unit: The Study in a Nutshell

##### *Development*

During summer 2004, I developed and implemented a two to three week technology-enhanced curriculum intervention that was designed to support students in learning and caring about coyote behavior. The unit was co-developed and co-taught with participating teachers. The curriculum used PowerPoint presentations (Microsoft corporation, [www.microsoft.com](http://www.microsoft.com)) and Windows Media Player videos (Microsoft corporation, [www.microsoft.com](http://www.microsoft.com)) of coyotes as multimedia tools (Way, 2005). The unit covered 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 curriculum was 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 participated in two in-class activities where they were virtual coyote biologists for the day. Finally, the students were provided the opportunity to visit the Stone Zoo and directly observe live coyotes that I hand-reared (Way, 2005).

##### *Piloting*

Prior to collecting data, I used two of Peter Auger's (no pseudonym) Ecology classes and his students at Barnstable High School on suburban Cape Cod, as a pilot for this study. I was in his classes for 3 full weeks from 20 September to 8 October 2004. I covered all 10 of the daily lesson plans that I created during the three week unit (see Way, 2005). The three week experience taught me to be flexible in time spent on issues

and the order of topics covered based on student and teacher interest in particular topics. The differing 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 handling other things like attendance), as well as frequent student questions, altered the structure of the class, which made it imperative to be adaptable by answering questions to maintain interest and to satisfy students' curiosity. Nonetheless, I focused primarily on relevant student comments related to the daily activities.

The varied structure of the class (for example, lecture, activity, and field trip to the Stone Zoo) was desirable for the students. Individual students liked different parts (e.g., more lectures versus hands-on related learning) of the curriculum unit making it important to give them multiple learning opportunities. Most importantly, the students seemed to like the curriculum unit. They asked lots of questions, loved the videos, and told me that they thought the videos (in Windows Media Player .mpeg format) illustrated what we talked about very well during the PowerPoint presentations. Because of these comments, I concluded that the curriculum was authentic to the students. Students were especially interested in the videos because it provided a sense of reality and being physically present. 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 to better understand why and how the videos helped them learn.

### Methods

The methodological framework for this project attempted to engage in an ongoing, evolving design or teaching experiment (Barnett, 2005; Cobb, 2000; Collins, 1992; Dede, 2004; Kelly, 2004; Lesh & Kelly, 2000; Shavelson, Phillips, Towne, & Feuer, 2003). This study relied on mixed methods with a naturalistic, qualitative component (Lincoln & Guba, 1985; Rossman & Rallis, 1998; Schram, 2003) along with some quantitative measures (Scriven, 2000). I triangulated data to gain insight into the effectiveness of the curriculum intervention.

#### *Design Experiments*

Design experiments are intended to transform classrooms from academic work factories into 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 feedback and guide it (Cobb, 2000). Research is best conceived of 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. This was put into practice by the researcher presenting the curriculum unit and, taking into account student/teacher comments and suggestions, revising it accordingly for subsequent class periods or curriculum interventions.

### *Data Sources*

Student evaluation was assessed with pre- and post-interview data and pre-, post- and post-delayed survey data. Additionally, teachers came up with their own evaluation related to their course. Standard tests (multiple choice/short answers) and quizzes were given on the material. Homework/class work grades were recorded for participating in the curriculum unit. Lastly, students at Wolf High individually made a mini-book or journal of a compilation of the notes given during the unit (Tanya didn't give them traditional tests).

*Qualitative Data Collection.* Interviews and my journal/field notes (i.e., classroom observations) were used to obtain qualitative data. By studying two high school science teachers' classes, a description of their students' perceptions and knowledge of coyotes was obtained. The researcher also used tenets of ethnographic research such as observation and participation where the researcher studied and contributed to the culture of the classroom involved in the assessment of the coyote curriculum (Rossman & Rallis, 1998; Schram, 2003). .

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. Informal interviews were on-going (on average one or two a day, usually after a class period ended) as I formatively documented the observations and experiences that the teachers and their students had during the course of the coyote unit. I also conducted semi-structured interviews (Merriam, 1998) with 10 students from each class before and after the curriculum unit was implemented. For consistency, I attempted to use the same 10 students per class for both interviews; in reality, this did not always occur (Table I). Interviews were digitally taped and audio-data backed up in a personal computer. An interview sheet was used, which consisted of questions in three major sections: one, general science interest; two, general coyote knowledge; and three, specific coyote knowledge (Way, 2005). In addition to taping the interview the researcher occasionally jotted down important notes, such as critical parts of the interviews. I used Escribe software (Express Scribe, 2004) to transcribe the entire interviews onto a laptop computer.



Table Ia.

*Students (pseudonyms) 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. \* denotes students interviewed both Pre and Post.*

<u>Pre-Interviews</u>		<u>Post-Interviews</u>	
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*			

Table Ib.

*Students (pseudonyms) 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.*

<u>Pre-Interviews</u>		<u>Post-Interviews</u>	
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

For each daily 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. I analyzed classroom notes (usually just short phrases written down) made into a curriculum binder and added those thoughts to the summary of each class. Each journal entry was dated 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.

*Quantitative Data Collection.* I gave pre-, post-, and post-delayed content surveys and assigned rubric values to two of the interview questions (Appendices 1 and 2) to test students' knowledge of coyotes before and after the curriculum intervention. A follow-up post-delayed survey was given 10 weeks after each intervention to assess student retention of the curriculum. 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 of five possible multiple-choice answers (strongly disagree – mildly disagree – no opinion – mildly agree – strongly agree) and consisted of three sections with 35 questions total, two of which were developed and used by UEI. The 20 UEI questions are presented elsewhere (Way, 2005). For purposes of this paper, I only discuss the knowledge related questions ( $n = 9$ ) on the coyote scale. This scale, specifically designed for this study, intended to uncover students' understanding of coyotes (Way 2005). It ranged from general questions like coyote distribution and range to specific questions on their sociobiology (Tables II and III). Results from this quantitative section should be taken conservatively due to small sample sizes, and should be viewed as trends to support the more in-depth qualitative component of this research.

*Triangulation.* I triangulated information from multiple sources (Yin, 2000) of evidence by bringing together information from the researcher's field notes/reflexive journals, interview data, documents/data recovered during the project, and pre, post, and delayed surveys. This was done to holistically gain insight into the efficacy of the curriculum unit on student learning of animal behavior.

### *Data Analysis*

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 among the codes to be recognized. Accordingly, the researcher 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 coyote 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 (see Way 2005).

For two of the interview questions related to knowledge of coyotes, the researcher initially created a rubric from 1-5 and scored those questions based on appropriateness of response (Appendices 1 and 2). For each score (i.e., 1, 2, 3, 4, or 5) the researcher 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 used 1 – 5 instead of 0 – 4 for simplicity in converting the data to SPSS. In order to obtain a reliability index of the rubrics that were created, a graduate student in the Urban Sciences Research and Learning Group (USRLG) at Boston College then scored the same answer. Poor correlation (e.g., 40 % at Wolf High) on the first reliability index between the researcher

and the USRLG scorer resulted in a modification of the rubric into four categories (Way, 2005). I used correlation analysis to examine consistency in response between the two scorers, and the second iteration of the rubrics produced better correlations with an average of 77% (81% and 73% for the two rubric questions) agreement. I used the scores that the researcher obtained (i.e., not the USRLG scorer), then used a paired t-test (SPSS Inc., Chicago, IL) to compare rubric scores from pre and post interviews.

Additionally, 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 among the three testing periods. I considered  $P < 0.05$  to be significant for all of the tests described herein and  $P = 0.05-0.10$  as marginally significant. Again, results from this quantitative section should be taken conservatively due to small sample sizes.

#### *Cross-case analysis*

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). Therefore, I examined data from the two schools and searched for themes that cut across cases by:

- Listing important or main themes from each dataset and looking for similar groupings of themes between the two cases and using the established codes to help the researcher in this process.
- Summarizing and grouping the important concepts into a partially ordered meta-matrix.
- Comparing the rubric scores from each school using a paired t-test.

## Results

Table II.

*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) = 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.*

Question	Pre		Post		Delayed		F =	P =
	<u>M</u>	SD	<u>M</u>	SD	<u>M</u>	SD		
Wild coyotes exist on Cape Cod	4.0	0.9	4.9	0.3	4.9	0.3	13.24	0.000
Wild coyotes exist in metro. Boston	4.1	1.1	4.6	0.9	4.7	0.6	2.13	0.133
Coyotes live most of their adult life alone	1.9	0.8	1.8	0.9	1.4	0.8	1.46	0.244
Coyotes often move long distances	3.4	1.0	4.1	0.9	4.3	0.8	3.60	0.037
Coyotes are mostly active at night	4.1	1.0	3.9	1.0	3.9	1.0	0.30	0.743
Coyotes howl to scare people away	2.1	1.0	1.2	0.4	1.0	0.0	11.48	0.000
Coyotes are more like foxes than wolves	2.9	1.1	2.5	1.0	2.0	1.2	2.54	0.092
Coyotes in the eastern U.S. are different than coyotes in western U.S.	4.1	0.7	4.6	0.9	4.7	0.6	2.41	0.103
Coyotes are very difficult to trap	3.2	0.9	3.4	0.9	3.1	0.9	0.21	0.813

Table III.

*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) = 2, while within groups the df = 64-67 (different values reflected different sample sizes among individual questions). For all questions a score of 1 = strongly disagree, 2 = mildly disagree, 3 = no opinion, 4 = mildly agree, and 5 = strongly agree.*

Question	Pre		Post		Delayed		F =	P =
	<u>M</u>	SD	<u>M</u>	SD	<u>M</u>	SD		
Wild coyotes exist on Cape Cod	3.8	1.0	4.5	0.7	4.2	1.0	3.50	0.036
Wild coyotes exist in metro. Boston	3.5	1.2	3.7	1.0	3.3	1.3	0.73	0.485
Coyotes live most of their adult life alone	3.0	1.1	2.7	1.5	2.9	1.3	0.36	0.699
Coyotes often move long distances	3.7	1.0	4.3	1.0	4.1	0.9	2.83	0.066
Coyotes are mostly active at night	3.9	1.0	4.6	0.9	4.4	1.0	3.81	0.027
Coyotes howl to scare people away	2.7	1.2	1.7	1.1	1.8	1.0	6.37	0.003
Coyotes are more like foxes than wolves	3.3	1.0	3.1	1.2	2.4	1.1	4.43	0.016
Coyotes in the eastern U.S. are different than coyotes in western U.S.	3.1	0.9	3.8	1.3	3.7	1.4	2.13	0.127
Coyotes are very difficult to trap	3.1	0.9	3.6	1.2	3.2	1.5	1.20	0.308

*Survey questions related to coyote knowledge*

Of the nine survey questions related to knowledge of coyotes, three (33%) and four (44%), respectively, at Coyote (Table II) and Wolf High Schools (Table III) produced statistically significant results, with another two (22%) at Coyote High and one (11%) at Wolf High being marginally significant. There were differences in five questions from pre- to post-surveys: (1) Coyotes exist on Cape Cod; (2) Coyotes often move long distances; (3) Coyotes howl to scare people away; and (4) Coyotes are more like foxes than wolves; and (5) Coyotes are mostly active at night. There was a trend for students to score better after students were exposed to the curriculum unit, and students retained much of that knowledge well after the unit finished (i.e., during the post-delayed surveys).

*Wild Coyotes exist on Cape Cod.* Differences were 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. At Wolf High, Bob believed that the Cape was wooded (compared to Boston) and that is why coyotes live there:

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

Tanya, teacher of Wolf High, noted that the students certainly knew that coyotes were found on Cape Cod. Her comment highlights this point:

Tanya: Well, Jon. It is certainly clear that students know about coyotes on the Cape. A couple of students have asked me when they might be able to go to the Cape and see some coyotes. I tell them that we will look into funding for a school bus to take a trip down there.

*Coyote Howling.* Large differences existed at Coyote High 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 (Tables II and III). Interestingly, the curiosity to this question began during the first class at Wolf High:

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

Coyote High's teacher, Doug, also commented about the frequency with which howling was mentioned in class. He made the following comment to me at the end of the first week of the curriculum unit:

Doug: You know, Jon, it is pretty amazing how many questions the students have asked you in this first week of you being here, especially regarding coyote communication. I tried to tell them how cool this research was but it seemed to go in one ear and out the other. Now students are mentioning that they can't wait for you to come back and answer their questions. I am amazed how howling interests them. They know what it sounds like but have no idea why coyotes do it.

*Wild Coyotes in Boston.* Despite seeing videos of coyotes from urban areas around Boston, students did not believe that they inhabited Boston. I believe this was the case because the students have never observed coyotes near where they live before, and even though I showed video from nearby areas (i.e., towns surrounding Boston-proper), they didn't associate that with coyote presence in their immediate area (i.e., the town/district where they live). For example, during the interview question, "Do coyotes occur near your backyard?," Beyonce's answer was typical of student responses:

Beyonce: No, because I live in the 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...

Doug's comment illustrates the students' confusion with this question:

Doug: A few of the students live by the cemetery where we track some of the radio-collared coyotes. They know that coyotes go in and out of their yards because they live in cul-de-sacs. However, a few of the students live within a short walk of the cemetery but on the other side of the road dividing the cemetery with houses. Over there, there is high density housing and the coyotes rarely, if ever, seem to go over there. Those students, despite their proximity to the cemeteries, don't feel like coyotes occur in their immediate area because they don't see them in their backyard even though they only have to take a five minute stroll to where coyotes are regularly observed.

Following the comments made by Doug I made a note in my journal to reformat the question.

Journal: To be clearer to students, in the future the question should be revised to say something like, "Wild coyotes exist in the Greater Boston area." This may affect results as it seems that many people think of their yard (often in the middle of the city) as their physical backyard and not a nearby park where coyotes may actually live.

*Capturing Coyotes.* There was no difference at both schools to the survey answer to, "Coyotes are difficult to trap." Students gave the most neutral pre- (3.21), post- (3.36) and post-delayed (3.14) responses of any question at Coyote High (Table II). 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. I was very curious how Doug felt about this question since he worked with me on the wild coyote component of the study.

Researcher: Doug, I don't know how to go about grasping this question. We spend so many exhausting days tending traps before and after school, you would think that the students realize how much effort and hence how difficult it is to trap these critters.

Doug: I agree with you, but you have to remember that you are showing so much video of coyotes captured in traps, then getting collared and measured, and then finally released, that even as I sat in the back of the classroom, it looked like a routine activity, which of course it isn't. The fact that we capture them only about one percent of the time is meaningless to them, and I don't blame them.

*Rubrics related to coyote knowledge*

In addition to the surveys, two of the questions during the interviews were quantitatively scored based on a rubric (Appendices 1 and 2). Both questions produced significantly different responses at both schools (Tables IV and V).

Table IV.

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

Question	Pre Interview		Post Interview		T value	P =
	<u>M</u>	SD	<u>M</u>	SD		
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 V.

*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 =
	<u>M</u>	SD	<u>M</u>	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

*Do All Coyotes Act the Same?* Students provided better and richer examples during post-interviews to this question, hence the significant difference observed. The following excerpt from Marcy at Wolf High 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. Coyotes are social, group living carnivores (e.g., Way et al. 2002), but they still are individuals just like any animal is. After the curriculum intervention, students clearly gained a better understanding of the question, as noted in my journal:

Journal: Students approached me before and after classes at both schools. They were giving examples of coyotes and could this or that scenario occur with wild coyotes. The nature of the questions varied, but I repeatedly responded with a similar comment noting that just like you and I are different, so are wild animals.

Beyonce, in the post interview at Wolf High, provided a detailed answer where she gave good examples, explained individual distinctiveness, and compared their (coyote) 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.

Tanya noted how her students improved their knowledge of this question at the end of the unit:

Tanya: You know Jon, you are really instilling in them the knowledge that coyotes, or any animal for that matter, are individuals just like you and I are. By showing video of the captive coyotes and you interacting with them, you clearly noted how different each individual was. Like how you said that [captive coyote] Cane will fight for possession of your lap, yet is the best hunter in the group... That is really neat that they got to see video of that and hear your experiences first hand.

*Can Coyotes be Eliminated?* Most students inaccurately answered this question during the pre-interviews but seemed to comprehend the question better and hence scored significantly higher during post-interviews (Tables IV and V). Because of the short length of the curriculum intervention the researcher and teachers could not have possibly expected them to understand coyote terminology completely accurately (like discussing dispersal or territoriality). Pre-intervention 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, it is unclear as to what kind of power Matt is referring to (and no follow-up question attempted to clarify this). I suspect he meant 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, as indicated with Jack's statement:

Jack: Very easily (they can be eliminated). It has happened so many times in the past; like grizzly bears, they are almost gone.

Students initially do not realize the difference between coyotes and other predators and how coyotes can quickly colonize new areas, have high reproductive potentials, and don't need as much space as larger species do. However, student understanding of coyote ecology increased after the curriculum unit. Some students 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 at Coyote High was notable among the interviewees:

Rachel: No, because of what you told us in class. 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. You can get rid of individuals but not coyotes in general.

The researcher noticed that some students were grasping the important concepts of the course and the futility of killing coyotes. For example, on 22 October 2004, 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.

Melissa, during the post-interview at Wolf High, also understood the concept by noting:

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.

### *Cross-case Findings*

Both classes showed increases in student knowledge during the curriculum unit and that knowledge was retained during post-delayed surveys 10 weeks after the curriculum unit ended in each classroom. Despite similar improvements in the unit's survey and rubric questions (Tables II–V), Wolf High School generally had lower survey scores such that all but one rubric showed significant differences between the two schools (Table VI). This performance difference might be expected since Coyote High School was an advanced course (with more prepared students) while inner-city Wolf High's were lower-level classes with many students on the verge of not graduating. Tanya's comment is illustrative of this:

Tanya: You know Jon, the students really liked the time that you spent with them. They really learned new stuff in a fairly short amount of time. It might be frustrating for you to come into an inner city setting like this and not have students always paying attention, but 20 of the students completed their field journal based on your notes and activities. That is an accomplishment for them.

Doug's comments summarize his students' experiences with the curriculum unit at Coyote High:

Doug: I am really impressed with my students' performance while you were here. They learned and comprehended the material that you gave them and made many positive comments to me, such as asking when are you coming back and wishing the curriculum unit was longer. My gut reaction was that the students really learned something while you were here, and the excellent test scores are now proving that!

The curriculum unit was suitable for multi-level learners, as experienced during the two interventions. My journal notes from Wolf High reflect my continued desire to disseminate this unit to more classrooms:

Journal: I am very happy with both classes at Wolf High and Coyote High. It is clear that this curriculum unit is transferable in a multitude of settings. While Coyote High had higher level learners due to the AP class, students at Wolf High still managed to learn a good amount from the intervention. I hope I can find funding and implement this in other, more diverse areas.

Table VI.

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

Question	Coyote High		Wolf High		T value	P =
	<u>M</u>	SD	<u>M</u>	SD		
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

## Discussion

The curriculum unit improved students' knowledge of coyotes and helped change some of the students' preconceived notions about coyotes and coyote behavior. The advantage for the students was for them to get the opportunity to learn from an expert (i.e., the researcher/scientist) in his respective discipline while participating in legitimate scholarly, school-based activities. While it was beyond the scope of the study to determine if the researcher/scientist was more effective in delivering content than, say, the students' own teacher, the literature indicates that these type of school – university/scientist partnerships are important (National Research Council, 1996; Richmond, 1996). In order to address improving student learning, a number of partnerships have emerged recently in science related issues (e.g., Clark, 1996; Fradd et al., 1997; Hay et al., 2000; Lasley, Matczynski, & Williams, 1992; Sterling & Olkin, 1997; Tallman & Taylor, 1997), and providing students with authentic experiences (e.g., showing video of local coyotes) has been a common theme and a critical component for these partnerships to succeed. Student and teacher interview comments from this paper indicated that students were able to learn and grasp important components of coyote behavior in a fairly short period of time, likely a product of involving students in real science that was authentic and meaningful to them (Barab & Hay, 2001; Barnett et al., 2004; Bouillion & Gomez, 2001; Fusco, 2001; Rahm, 2002). Place-based studies, ranging from urban gardening (Fusco, 2001; Rahm, 2002) to coyotes (this study), overwhelmingly show that students can effectively learn about and/or be empowered to care for their surroundings when they are interested and encouraged to do so.

Importantly, local and national learning standards were addressed during this curriculum intervention. Specifically, this unit addressed Ecology Concepts 6.1, 6.2, & 6.3 and Evolution 5.2 for the Massachusetts frameworks. It also addressed multi-discipline issues in Mathematics by using extrapolation, rate pairs, and by calculating home range, territory sizes, and population sizes. English standards were addressed by reading scientific papers and other literary sources. Finally, scientific inquiry skills standards were met by students designing and conducting scientific investigations and observing the world (i.e., the wild) around them. Students also learned how to graph results from a simple experiment done in class (Massachusetts Department of Education, 2001, revised 2006).

The positive learning gains achieved by the students in this study in a short time period were noteworthy. More effort is needed to teach students and community members alike that it is perfectly natural for coyotes (and other wildlife) to inhabit urban areas. Urban areas (just like any other ecological habitat) can give individual coyotes a chance to raise a family of their own, since coyotes might already live in nearby, more rural environs. Teacher comments and my journal indicated that students better grasped why coyotes live around them at the end the curriculum unit.

Given that students learn well with multiple performance opportunities (Teel et al., 1998), such as participating actively in the intervention's varied activities (Fusco, 2001; Rahm, 2002), it is not surprising to see good learning outcomes from these two schools. A major advantage of this study is that video-clips of coyotes were taken from

the field by a scientist and brought into the classroom, thereby 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. 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 coyote curriculum unit described here was successful because it was designed from a local, place-based study, 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 knowledge 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.

### Implications

Much of the rhetoric in support of student-scientist projects assumes that participants will increase their understanding and/or knowledge of a science topic (Means, 1998; Trumbull, Bonney, Bascom, & Cabral, 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 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). 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 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 and wolves, suggests that they may naturally arouse interest in students. As noted by Caro et al. (2004), flagship species are often used in a strategic role to raise public awareness and have been variously defined as: (1) a popular charismatic species that serves as a symbol and rallying point to stimulate conservation awareness and action; (2) a species that draws financial support more easily; (3) a species that has become a symbol and leading element of an entire ecosystem campaign; and (4) 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 could potentially be used by science educators in quite diverse settings. I argue that coyotes could serve as an excellent flagship species for engaging students in science education and ecology-related issues. Future studies should examine these types of curriculum units and assess the ability to empower students to learn and care about their local environment and wild inhabitants, especially in urbanized settings. For example, environmental education programs on bats in the Indian Ocean region empowered residents to protect native forests and bats in those places (Trehwella et al., 2005). It is logical then that this could also happen with common species in diverse areas ranging from rural to urban locales.

It is critical to ensure that there is adequate funding for curriculum units on the natural history of different species, as natural science studies are gradually being replaced by molecular research (Louv, 2006). It is also important to promote scientists working with teachers and their students in more numerous and varied settings to give students the opportunity to capture an interest and/or better learn about science topics near where they live.

#### Limitations of the study

There were some obvious limitations with this study. First, I only studied two high school teachers' classes. Despite the potential usability and generalization that this curriculum might provide, this particular study cannot demonstrate conclusive and widespread results with such 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), this shortened time frame would likely make it difficult to notice any long-term learning gains. Third, I taught the unit to different audiences, ranging from inner-city to suburban-like city-based students. These students clearly had different levels of experience with nature. Fourth, the researcher's presence may affect the future usability of this material. Being a content specialist on coyotes I will most likely be able to respond to any potential problems or questions that arise. Though this material is in effect a pilot for 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.

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### Appendix 1.

*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 at another point.
- 3) Partial Understanding: Students know the basic concept that coyotes do not all act the same. They either give examples by saying they are 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, both giving 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. 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.

### Appendix 2.

*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. Students may also note that if we kill them, then they can be eliminated. They may state that we have done that with many other animals in the past. Or students correctly answer that coyotes cannot be eliminated but do not describe how this can happen. Some students use a questionable rationale that has nothing to do with recolonizing a territory, such as that it is difficult to kill each and every coyote.

- 3) Partial Understanding: Students know the basic concept that coyotes cannot 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 cannot 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) an entire population in a given area.